SELECTED PROCEEDINGS FROM THE WORKSHOP

ANALYSIS AND CONTROL IN THE CANADIAN MINERAL RECOVERY

AND

METAL PRODUCING INDUSTRY

***

UNIVERSITY OF WESTERN ONTARIO MAY 11-13, 1972

ARRANGED BY

NATIONAL RESEARCH COUNCIL ASSOCIATE COMMITTEE
ON AUTOMATIC CONTROL

***

WITH THE COOPERATION OF:

DEPT. ENERGY, MINES & RESOURCES
DEPT. INDUSTRY, TRADE & COMMERCE
THE SCIENCE COUNCIL OF CANADA

ASSOCIATE COMMITTEE
ON AUTOMATIC CONTROL

COMITÉ ASSOCIÉ D'AUTOMATIQUE

PLEASE REPLY TO:
EXPÉDITEUR:

NATIONAL RESEARCH COUNCIL OF CANADA
CONSEIL NATIONAL DE RECHERCHES DU CANADA

To Participants in the Workshop Concerned with Analysis and Control in the Canadian Mineral Recovery and Metal Processing Industries

---

I would first like to thank you for participating in the Workshop held at the University of Western Ontario May 10 - 13 concerned with the Canadian mineral recovery and metal processing industries. We have had many favourable comments and some constructive criticisms of the operation; the latter will assist us in making future workshops even more useful.

The main purpose of this letter is to provide you with the enclosed summary of recommendations made at the Workshop. While our main responsibility is to make these known to the National Research Council, we have also directed them to the other sponsoring bodies, to the deans of engineering and technology in our universities and colleges, and to research institutes across Canada. The working party set up for this study hopes that each of our participants will consider possible activities within his organization that may arise from these recommendations.

We are most anxious to have your comments on our summary, and any further recommendations for possible action that you can make. These should come to me, and if possible before the end of August.

A very positive step towards the implementation of some of these recommendations has been the formation of a subcommittee of the Canadian Institute of Mining and Metallurgy to be called the "Computer Applications and Process Control (CAPC) Committee". The following have been named to date, with the understanding that additional numbers will be added as necessary

L. Maclean - Stelco
A. Mular - Queens University
R. Ferguson - Sheritt-Gordon
L. Nenonen - National Research Council
A. Gillieson- Dept. Energy, Mines & Resources

I am sure that any of these men would be very pleased indeed to hear of your suggestions for their activities, one of which we hope will be to convene Workshops similar to the one held at Western from time to time.

At our May workshop many participants requested further information on support available from government agencies in Ottawa for research and development activities; we have included some of this with this letter, along with information for obtaining further details.

Also enclosed are copies of some of the presentations made at the Workshop, which had special interest to the participants.

Again I would like to express my personal appreciation for your participation in this study. I look forward to watching the activities of the new CAPC committee with great interest.

Best personal regards,

Yours sincerely,

Al Johnson

A. I. Johnson.

Suggested Summary of Discussions and Recommendations of the Workshop Concerned with the Mineral Recovery and Metal Processing Industries of Canada

1. General Needs

The following were the overall needs of the industry with the priorities shown:

1.1 Improved sensing and better observations
1.2 More information on economic justification for use of Automatic Control and other advanced techniques
1.3 Improved control and regulation
1.4 Model development

2. Activities Directed Toward Technical Societies or Associations

2.1 It was proposed that the Canadian Institute for Mining and Metallurgy form a technical sub-committee with the material discussed in this workshop.

2.2 The proposed sub-committee should carry out surveys, periodically, of the type carried out in this study and hold similar workshops after each survey.

2.3 The sub-committee should prepare a manual to define terms and scope of analysis, control, and design activities relating to further studies.

2.4 The sub-committee should establish an index of known process models relating to the industry and should undertake an evaluation of these models. From time to time workshops or courses on these models should be held.

2.5 The sub-committee should establish a list of individuals with their knowledge and skills relating to the topic under discussion.

2.6 The sub-committee should develop a list of companies willing to provide opportunities for faculty members to obtain industrial experience.

2.7 Produce a compendium of sensors similar to the ISA Transducer Compendium.

2.8 Develop guidelines and reference manuals in the control area similar to those that are understood to exist for the steel industry.

3. Activities Directed Towards the Government

3.1 A centre for sensor evaluation and development for control in the Canadian mineral recovery and metal processing industries should be established, possibly in the form of a Centre for Advanced Technology at a university or as part of an appropriate government department or agency.

3.2 This centre should co-operate closely with sensor developers and with the user industries; the latter should undertake field tests of new or improved sensors with the close co-operation of the centre.

3.3 The government should make greater effort to ensure that industry knows about the various programs of assistance to industry and should provide evaluations of typical projects, successful and unsuccessful.

3.4 Statistics from Statistics Canada should be better defined and presented in more industry usable terms.

3.5 The Dept. of Energy, Mines and Resources should prepare a report on sampling techniques.

3.6 The possible greater use of the NRC hybrid computer facility by industry was noted.

4. Activities Directed Towards Universities

4.1 Universities and possibly the colleges, should become more involved with the development of new or improved instrumentation.

4.2 Students enrolled in mining or metallurgy courses should be encouraged to take management science options.

4.3 Computer science programs at the university should include some applications subjects.

4.4 Universities should use appropriate industry personnel more in their courses.

4.5 A shortage of personnel with expertise in modeling has been noted; the universities should take note for the development of undergraduate and graduate courses and programs in this area, and for the creation of short courses suitable for people from industry.

4.6 Universities should base their models on plant flow sheets and tackle real processes.

5. Activities Directed Towards Industry

5.1 Industrial personnel should be encouraged to attend managerial seminars.

5.2 Computer manufacturers or software houses should develop better on-line diagnostics and more reliable peripherals, particularly for teleprocessing.

5.3 Techniques for improved mine evaluation and planning continue to be developed. The use of graphic techniques for such studies should be developed.

5.4 Techniques for optimisation need to be developed for the special needs of this industry.

5.5 Instrument manufacturers should provide "computer compatible components" as well as "whole systems"; this remark seemed to be directed particularly toward x-ray analysis.

5.6 A specific area recommended for development was temperature sensor development for molten metal baths.

5.7 There was also an expressed need for devices for temperature measurement of very hot gases.

5.8 Slurry flow measurement was considered to be one of the most inaccurate in the industry. A special program should be launched to encourage development.

5.9 Corporate economic models should continue to be developed with adequate testing.

5.10 Instrument suppliers should make better use of government grants to develop sensors for the industry.

WORKSHOP PROGRAM

"The Use of Computers and Automatic Control in the Canadian Mineral Processing Industry"

University of Western Ontario May 11-13, 1972

In late 1971 and early 1972 a study was made of Operations Analysis Process Design, and Process Control in the Mineral Recovery and Metal Production Industries in Canada. The sponsoring bodies for this study were:

NRC Associate Committee on Automatic Control

Department of Industry, Trade and Commerce

Department of Energy, Mines & Resources

Science Council of Canada

More than 20 of the major mining and steel companies in Canada participated in the study and returned the completed 18 page questionnaire which was employed. Following visits to many of these companies a report was issued by the study committee to document and communicate the results. Copies of this report were distributed to the previous participants and many others in April 1972.

To provide a forum for further communication, discussion, planning and to make specific recommendations, a three day workshop is to be held at the University of Western Ontario, May 11-13, 1972. Attendance at the workshop will be by invitation. The workshop will be attended by representatives of industry, government departments and agencies, research institutions and universities actively engaged in related research, selected computer and control equipment suppliers and consultants. Total attendance will be limited to approximately 65 to encourage maximum participation by all attendees.

Purpose

The purpose of the Workshop will be:

1. To provide a forum for communication and discussion of the survey results
2. To further formulate the areas of greatest potential benefit to Canadian industry and to select specific areas of development.
3. To further define goals in these specific areas and suggest a time table for ther achievement.
4. To recommend how best to achieve the set goals using the combined resources of government, industry, research institutes and industry groups.

Most of the workshop sessions will be organized in the following manner:

a) A few brief technical papers, typically of an experience or survey nature, presented primarily to identify problems and stimulate discussion.

b) Parallel discussion groups of 10-12 people each. Each discussion group will have a chairman leader and secretary who will record the main points generated.

c) A plenary "parliamentary session". Each discussion group chairman will report the main points generated by his group. Following these brief summaries the workshop session will arrive at composite recommendations and action plans by formal motion and vote. Recommendations for future action by government, universities, consultants and suppliers will carry the authority of knowledge of those present, rather than any conveyed authority of position. It is anticipated however that some clear action guidelines to the year 1980 will result, supplementing those of the survey.

Based on needs identified in the questionnaire replies, the following sessions and topics are planned:

SUMMARY OF WORKSHOP AGENDA

University of Western Ontario, London, Ontario

Wednesday May 10

6:00 - 10:00 p.m.	Registration, Sydenham Hall (Residence)
7:00 - 10:00 p.m.	Reception, University Club Lounge (Somerville House)

Thursday May 11

7:30 - 8:30 a.m.	Breakfast (Residence)
9:00 a.m.	Opening Session. Survey Report. Papers.
12:15 p.m.	Luncheon. Rainbow Room. Speaker: J.M.Hay, Dow Chemicals.
2:00 p.m.	Session. Modelling, Simulation, Control, Economic Justification.
7:00 p.m.	Dinner. University Club. Room 219 Speaker: R. Hindson, General Director Materials Branch, DITC

Friday May 12

7:30 - 8:30 a.m.	Breakfast (Residence)
9:00 a.m.	Session. Operations Research & Computers In Business Management.
12:15 p.m.	Luncheon. Rainbow Room
1:45 p.m.	Session. Sensors for Process Measurement
5:00 p.m.	Workshop Adjournment.

Saturday May 13

(Optional to those wishing to remain)

7:30 - 8:30 a.m.	Breakfast (Residence)
9:00 - 12:00 a.m.	Tutorial & Questions. Everything you wanted to know about computers and automatic control but were afraid to ask.

Note: All morning and afternoon sessions start in Room 210 of the School of Business.

Further registration will be possible Thursday morning 8:00 - 9:00 a.m. at the entrance to Room 210

WORKSHOP AGENDA

Thursday May 11, 1972

Session Chairman - Dean A. I. Johnson, University of Western Ontario

Session Developer - J. Scrimgeour - Dept. Industry, Trade & Commerce

9:00 a.m.	Introduction and welcome to the Workshop Dr. Williams - President, University of Western Ontario Dr. Johnson - Dean of Engineering Science	
9:20 a.m.	Resumé of the Survey Results - - Company Participation, Survey Scope & Projections for Personnel Growth - - Recent Technical Development & Industry Needs - - Present & Future Projections for Automatic Control -	 F. Kelly - D.E.M.R. L. Nenonen - N.R.C. J. Scrimgeour - D.I.T.C.
10:20 - 10:45	Coffee Break	
10:45 - 11:10	The Role of NRC in the Development of Automatic Control in Canada	Dr. J.A.Tanner - NRC
11:10 - 11:35	The Program for Advancement of Industrial Technology	- D. Murison D.I.T.C.
11:35 - 12:00	Computer & Control Related Activities at DEMR	- W. Gow D.E.M.R.
12:15 p.m.	Luncheon - University Club Computer & Automatic Control Developments in the Chemical Industry: a Look Ahead for the Mineral Processing Industry.	- J.M. Hay - Dow Chemical

WORKSHOP AGENDA (Cont'd)

Thursday May 11, 1972

Process Modelling, Simulation, Control and Economic Justification

Session Chairman - A. Mular, Queen's University
Session Developer - J. Scrimgeour, .D.I.T.C.

2:00 - 2:20 A survey & Comparison of Flotation Plant Process Models
Dr. H. Smith, University of Toronto

2:20 - 2:40 Computer Control of the Flotation Plant at Ecstall
M. Amsden, Ecstall Mining

2:45 - 3:45 Parallel Work Shop Sessions

No.	Leader	Theme
1.	H. Smith	Modelling, Simulation & Control of Flotation Circuits
2.	F. Kelly	Modelling, Simulation & Control of Grinding Circuits
3.	L. Nenonen	A review of Smelting Models & Control
4.	J. Scrimgeour	Economic Justification for Computer Control. Is Automation Good for Canadians?
5.	R. Wood	Modelling Techniques for Process Control and Plant Design

3:45 - 4:00 Coffee Break
4:00 - 4:20 Leaders reports of the parallel sessions
4:20 - 5:00 Discussion, Industry Priorities, Recommendations & Workshop Resolutions
5:00 Adjourn
7:00 Dinner - University Club
Speaker: R.D. Hindson
General Director, Materials Branch
Dept. Industry, Trade & Commerce

WORKSHOP AGENDA (Cont'd)

Friday May 12, 1972

"Operations Analysis and Business Management"

Session Chairman - J. N. Grassby INCO

Session Developer - L. K. Nenonen NRC

9:00 - 9:10	Introductions, Statement of Objective
9:10 - 9:30	"Economic Modelling" N. Arden, STELCO
9:30 - 9:50	"Mine Planning" D. Madge, COMINCO
9:50 - 10:50	Parallel Discussion Sessions

1. Economic Modelling	Dr. R. Stahlberg, INCO
2. Mine Planning	D. Madge, COMINCO
3. Operations Scheduling	M. Kretzschmann, Falconbridge Nickel
4. Management Information for Control	R. A. Ferguson, Sherritt-Gordon
5. Computer Problems	F. Oswin, Algoma Steel

10:50 - 11:00	Coffee
11:00 - 11:30	Reports from Discussion Leaders
11:30 - 12:15	Full discussion, specific recommendations
12:15	Luncheon - University Club

WORKSHOP AGENDA (Cont'd)
Friday May 12, 1972

Sensors for Process Measurement Session

Sensor Session Chairman - Dr. H.W. Smith, University of Toronto
Session Developer - F.J. Kelly, Dept. Energy, Mines & Resources

1:45 - 1:55	Chairman's Opening Remarks
1:55 - 2:15	Survey Paper: "The Stages in the Development of a Process Sensor" by F.A. MacMillan of Electronic Associates of Canada Ltd., Toronto
2:15 - 2:35	Survey Paper: "On the Use and Operating Problems Encountered with On-Line X-Ray Analyzers in the Mineral Processing Industry" by Dr. A.H. Gillieson, Mineral Science Div., E.M.&.R.
2:40 - 3:45	Parallel Workshop Sessions

1. On-Line X-Ray Analyzers: A. Molinari Sala Machine Works, Mississauga, Ontario
2. Slurry Flow Measurement: R.J. Brailey Falconbridge Nickel Mines Ltd., Falconbridge, Ontario
3. Particle Size Measurement: B. Osbourne Milltronics Ltd., Peterborough, Ontario
4. Temperature Measurement: Dr. Roy Littlewood Steel Co. of Canada Ltd., Hamilton, Ontario
5. On-line Gas Analysis: To be arranged on an ad hoc basis

3:45 - 4:00	Coffee
4:00 - 4:20	Group Leaders Report on Parallel Sessions
4:20 - 5:00	Parliamentary Session: Discussion, Industry Priorities, Recommendations and Workshop Resolutions

The attached page was inadvertently omitted from "Selected Proceedings From the Workshop - Analysis and Control in the Canadian Mineral Recovery and Metal Producing Industry", held at the University of Western Ontario from May 11-13, 1972.

Will you please insert it as the eleventh page.

Saturday May 13, 1972

Session Chairman - Prof. W. Svrcek - University of Western Ontario

Session Developer - J. Scrimgeour

Tutorials and Instructors - IBM Corporation
- Canadian General Electric
- Prof. R. Wood - University of Alberta

9:00 - 10:30 "Everything you wanted to know about computers and automatic control and were afraid to ask"

10:30 - 10:45 Coffee

10:45 - 12:00 Session Continued

<u>Adjourn</u>

Note: It is intended to make this your ideal opportunity to learn more about computers and automatic control. This is an opportunity to get real answers to your questions and we have assembled a highly competent team of instructors to provide this. The session will be informal, and for example, may divide into 2 or 3 parallel groups with one or two instructors in each for efficient communication if the areas of interest lend themselves to this.

NOTES FOR DISCUSSION GROUP LEADERS

It is expected that each discussion group will consist of 10 to 12 participants. Each group will have one hour to arrive at conclusions for selected or set topics. Consequently it will be necessary for the leader to direct the discussion towards the objectives and prevent it from going off on tangential paths or becoming mired in small details.

Some general guidelines are:

1. Introductory Phase: (5 minutes). The discussion leader states the session topics and objectives and starts the discussion by drawing from his own experience with the related process measurement.

2. Discussion Phase: (45 minutes). The group discusses the suggested topics or others pertaining to the subject with the leader injecting a spark now and then or guiding the discussion towards desired objectives. The recording secretary notes down the conclusions and recommendations as arrived at by the group and maintains a chronological set of notes of the groups commentary.

3. Summary Phase: (10 minutes). A consensus of opinion recommending specific actions is obtained from the group for proposal in the parliamentary session to follow. The discussion leader is responsible for preparing a brief report of these recommendations and a summary of the discussion commentary.

Information on Government Assistance

Programs for R & D in Industry

PROGRAM FOR THE ADVANCEMENT OF INDUSTRIAL TECHNOLOGY (PAIT)

Objectives:

To encourage industrial growth and production by supporting the development of new or improved products and processes for commercial markets.

Qualifying Activities:

Selected projects to develop new or improved commercial products or processes.

Criteria:

Products and processes which incorporate new technology and offer good prospects for commercial exploitation.

Who is Eligible:

Canadian manufacturing and processing companies.

Form of Assistance:

Shared cost, normally 50 per cent.

Allowable Costs:

Current costs (including special equipment, e.g. prototypes), and non-capital pre-production expenses.

Title to Results:

Vested in company.

Company Obligations:

Exploit results to attain maximum benefit for Canada.

Mailing Address:

PAIT Program Office
Department of Industry, Trade and Commerce
112 Kent Street
Ottawa, Ontario. KIA OH5

PROGRAM TO ENHANCE PRODUCTIVITY (PEP)

Objectives:

To encourage industrial growth and production by supporting studies to determine the feasibility of projects designed to enhance substantially the productivity or efficiency of companies.

Qualifying Activities:

Feasibility studies on selected projects, involving a significant departure from the companies' normal productivity improvement practices, and also involving only existing available technology.

Criteria:

Projects, wherein there exists a marked but unproved potential for significant productivity gains, requiring a feasibility study before a decision can be made concerning implementation.

Who is Eligible:

Canadian manufacturing and processing companies.

Form of Assistance:

Shared cost, normally 50 per cent.

Allowable Costs:

Salaries and wages for direct labour, and an equal allowance for administrative and operational costs. Also, fees incurred through contract for consultants.

Title to Results:

Vested in company.

Company Obligations:

To submit to the Department, upon completion of the approved study, the findings and recommendations of the study, and twelve months after completion of the study, information sufficient to assess the savings to be realized by the company as a result of the study.

Mailing Address:

(PEP) Program Office
Department of Industry, Trade and Commerce
112 Kent Street,
Ottawa, Ontario. KIA OH5

INDUSTRIAL RESEARCH AND DEVELOPMENT INCENTIVES ACT (IRDIA)

Objectives:

To expand scientific research and development in Canada which, if successful, is likely to benefit Canada.

Qualifying Criteria:

Research and development.

Criteria:

Research and development and determination of benefit to Canada as defined by Regulations made under the Industrial Research and Development Incentives Act.

Who is Eligible:

Taxable companies incorporated in and carrying on business in Canada.

Form of Assistance:

Tax free cash grants or credits against federal income tax liabilities equal to:

1 25 per cent of all capital expenditures during a fiscal year for scientific research and development in Canada, and

2 25 per cent of the increase in current expenditures for scientific research and development in Canada during a fiscal year over the average of such expenditures in the preceding five years.

Repayment:

None, but credits to current expenditures or recovery of grants required in certain circumstances.

Title to Results:

Vested in company.

Company Obligations:

The company must undertake to exploit the results in Canada unless it is uneconomic to do so, and must normally be free to exploit the results in all export markets.

Mailing Address:

IRDIA Program Office
Department of Industry, Trade and Commerce
112 Kent Street,
Ottawa, Ontario. KIA OH5

INDUSTRIAL RESEARCH ASSISTANCE PROGRAM (IRAP)

NATIONAL RESEARCH COUNCIL OF CANADA (NRC)

Objective - Immediate objective is to establish a number of competent research teams in Canadian manufacturing industry each year over a period of years.

Long Term - to contribute to the Government's overall effort to increase research and development in Canadian industry by means of Government financial assistance.

Qualifying Criteria - Assistance is concentrated on relatively long term (normally 3 to 5 years) applied research in the sciences and in engineering, and in the development at the laboratory level leading to potential products and processes. Fields such as quality control, testing of products and production techniques, market research and sales operations, geological or geophysical explorations and research in the social sciences and psychology are excluded. IRAP is intended to assist all companies across Canada both large and small. In the selection of projects, NRC (which is responsible for administration of IRAP) will be governed by factors such as experience and capabilities of the company's scientific and technical staff, the continuity of company interests in research, its record of competence and quality, etc.

Who is Eligible - All companies incorporated in Canada which are engaged in manufacturing operations, and give reasonable assurance that a well qualified research team will be established on a permanent basis, are eligible. The research must be undertaken in Canada. Associations of manufacturing companies incorporated in Canada are eligible if the intent is to set up a research staff in the associated group on a permanent basis.

Form of Assistance - The company applies for support of a project of their own choice. IRAP pays the salaries including the company portion of certain standard fringe benefits of the scientists, engineers and technicians who are added to the company's staff to undertake the approved project and nothing more. All other costs are the company's responsibility. By this method the cost of a project is shared on the basis of approximately equal contribution by NRC and Industry. Payment is made monthly in arrears on receipt of invoices from the company.

Repayment - None required.

Title of Results - No patent or property rights accrue to the Government of Canada as a result of the research project.

Company Obligations - the company undertakes to:

(a) maintain the research team or research positions on a permanent basis after IRAP support ceases;

(b) exploit the research results to the benefit of the Canadian economy, insofar as it is economic to do so in accordance with sound business judgement.

Mailing Address - The Secretary
NRC Committee on Industrial Research Assistance
100 Sussex Drive
Ottawa, Ontario
K1A 0S3

Contacts: Mr. G.W. Donaldson
Mr. C.H. Metcalfe
Dr. D. Willermet
Mr. D.A. Fretts
Dr. W.H. Hook

Telephone: Area Code 613, 992-1548

NATIONAL RESEARCH COUNCIL OF CANADA

SENIOR INDUSTRIAL FELLOWSHIPS

1972

In 1971 the National Research Council initiated a new program of NRC Senior Industrial Fellowships, with the intention of encouraging a mutually stimulating and productive interchange between Canadian universities and industries. Applications are invited for these Fellowships.

Under the terms of the Senior Industrial Fellowship, bona fide staff members of Canadian universities may spend a minimum period of one year with industrial organizations in Canada and with certain quasi-industrial federal corporations and provincial utilities. No restrictions will be placed on the kind of work to be carried out during tenure of the Fellowship. It is hoped, however, that the Fellow will be employed at the level of his capability. In awarding these Fellowships, priority will be given to applicants with little or no industrial experience, who have spent between two and five years on the faculty of a Canadian university.

The National Research Council will provide a component of the Fellow's salary as a supplement to the university's contribution, in order to ensure that the Fellow receives, in toto, an amount equal to his normal salary. Payment of the NRC portion will be made to the university.

In addition, the National Research Council will provide a travel grant equivalent to economy class return air fare for the Fellow and his family.

Applicants for Senior Industrial Fellowships will be responsible for making their own contacts and arrangements with the industry of their choice. Applications should include the following:

a) a curriculum vitae and other evidence of the candidate's stature as a scientist or engineer;

b) a letter from the appropriate university authority supporting the application, confirming that leave of absence will be granted, and specifying the candidate's salary level during his leave of absence and the proportion of it that the candidate will receive from the university during tenure of the award;

c) a letter from the company agreeing to accept the candidate into its organization for the specified period;

d) a general outline, prepared by the company, of the type of work to be carried out during tenure of the award, and the mutual advantages of the proposed program, and

e) a request for a travel grant, if required.

Applications should be submitted by 1 May and 1 September for consideration in May and October of each year. Address applications to Office of Grants and Scholarships, National Research Council of Canada, Ottawa, Ontario K1A 0R6.

PRAI Grants for Project Research Applicable in Industry

Through its granting function, the National Research Council has helped to establish competence in research in Canadian universities in both basic and applied science. In addition to maintaining this competence, the Council has been developing new programs to exploit the spin-off coming from basic research. PRAI Grants have been devised to enable university researchers to concentrate on a new concept, process, invention, or design and to bring it to a stage where it can be taken over by industry. One of the conditions, established during a two-year pilot program, is that proposals coming from university researchers must be of direct interest to particular industrial firms.

The grants have been established in an attempt to improve university-industry interaction. Among the general factors in the university hindering this interaction are:

(1) Inadequate definition of the research problem;

(2) Not carrying the research to the point where it is feasible for the industry to pick it up;

(3) Lack of adequate manpower and facilities;

(4) Uncertainty regarding patent rights

(5) Conflict with other research interests of the investigator and with the requirement to train graduate students;

(6) Lack of assistance and advice from experts in the particular research area.

PRAI Grants will be financed within the funds provided to NRC for supporting university research and the program will be the direct responsibility of the Vice-President responsible for university grants and scholarships.

Some specific features of PRAI Grants are:

(1) NRC will prepare a Research Agreement based on negotiations with all parties concerned, including such matters as objectives, company collaboration, work force, duration, review procedures, patents, etc. This agreement must be approved by the university concerned.

(2) Being a Grant, no provision is made for overhead expenses;

(3) Designed for short-period projects, six months to two years.

(4) Criteria of acceptance include the need or the potentiality for the proposed research, degree of interest of the company or companies involved, and the competence of the researcher to undertake and complete the program in the short time period allowed.

NOTE: This description of the PRAI granting scheme is intended for information only and is not to be considered authoritative in any way. For official information, contact the Office of Grants and Scholarships, National Research Council of Canada, Ottawa, Ontario K1A OR6.

Individual Talks and Papers

THE ROLE OF THE NATIONAL RESEARCH COUNCIL IN THE DEVELOPMENT OF AUTOMATIC CONTROL IN CANADA

by

J.A. Tanner : Assistant Director, Division of Mechanical Engineering

G.W. Donaldson : Industrial Research Assistance Program

In a program of research and development in which the objective is to apply and extend the theory of automatic control to problems of National interest, the Control Systems Laboratory of the Division of Mechanical Engineering continues to devote part of its available effort to problems of the metal production industries. These include the modelling and control of conversion processes and the development of optimal strategies for crane scheduling. Although specifically the concern of the Control Systems Laboratory, the solution of control problems frequently necessitates drawing upon the expertise of the other laboratories of the Division of Mechanical Engineering and the other Divisions of the National Research Council. Typical examples are the development of special instrumentation for the measurement of physical variables in aggressive environments, gas flow and combustion system studies.

The wide variety of requirements in industrial control often make it economically unattractive for individual companies to attack problems without some assistance. The resources of the Mechanical Engineering Division are available to industry through the following mechanisms:

1. Direct negotiation with the Division to establish a collaborative R&D program in a problem area of mutual interest and concern. (Past experience has shown that the success of any form of collaborative program depends on the degree of active participation by the company concerned.)

2. A contractual arrangement with the Division for a specific R&D project.

3. Contact with the Mechanical Engineering Division and others through the Technical Information Service of the NRC.

Further, the NRC operates an Industrial Research Assistance Program (IRAP) designed to stimulate the interest of Canadian industry in R&D and promote the establishment of new industrial research facilities and the expansion of existing facilities across Canada.

This program was established in 1961 and to March 1972 has provided some $45 million to industry to pay the salaries of scientists, engineers and technicians directly employed on 445 projects approved for support in 229 companies across Canada. Matching company costs have amounted to over $55 million in this period. Of this amount approximately 8% or $3.8 million has been provided to 31 research projects in 22 companies on sensors, process and control of-processes of application to the mining and metal processing industries.

In the current year, it is expected that IRAP assistance will amount to $11 million and will support the work of some 1100 professionals and technicians and involve 130 senior government scientists and engineers as liaison officers and over 80 university professors as consultants in nearly 150 companies. The 8% of the funds mentioned above has increased to 11% and a major part of this increase to nearly $500,000 will be in support of sensor, instrument and process control (including modelling) research specific to the mineral recovery and metal production industries. A brief description of the IRAP program follows.

THE INDUSTRIAL RESEARCH ASSISTANCE PROGRAM (IRAP) OF THE NATIONAL RESEARCH COUNCIL OF CANADA (NRC)

Objective

Immediate objective is to establish a number of competent research teams in Canadian manufacturing industry each year over a period of years.

Long Term - to contribute to the Government's overall effort to increase research and development in Canadian industry by means of Government financial assistance.

Qualifying Criteria

Assistance is concentrated on relatively long term (normally 3 to 5 years) applied research in the sciences and in engineering, and in the development at the laboratory level leading to potential products and processes. Fields such as quality control, testing of products and production techniques, market research and sales operations, geological or geophysical explorations and research in the social sciences and psychology are excluded. IRAP is intended to assist all companies across Canada both large and small. In the selection of projects, NRC (which is responsible for administration of IRAP) will be governed by factors such as experience and capabilities of the company's scientific and technical staff, the continuity of company interests in research, its record of competence and quality, etc.

Who is Eligible

All companies incorporated in Canada which are engaged in manufacturing operations, and give reasonable assurance that a well qualified research team will be established on a permanent basis, are eligible. The research must be undertaken in Canada. Associations of manufacturing companies incorporated in Canada are eligible if the intent is to set up a research staff in the associated group on a permanent basis.

Form of Assistance

The company applies for support of a project of their own choice. IRAP pays the salaries including the company portion of certain standard fringe benefits of the scientists, engineers and technicians who are added to the company's staff to undertake the approved project and nothing more. All other costs are the company's responsibility. By this method the cost of a project is shared on the basis of approximately equal contribution by NRC and Industry. Payment is made monthly in arrears on receipt of invoices from the company.

Repayment

None required.

Title of Results

No patent or property rights accrue to the Government of Canada as a result of the research project.

Company Obligations

The company undertakes to:

(a) maintain the research team or research positions on a permanent basis after IRAP support ceases;

(b) exploit the research results to the benefit of the Canadian economy, insofar as it is economic to do so in accordance with sound business judgement.

Mailing Address

The Secretary
NRC Committee on Industrial Research Assistance
100 Sussex Drive
Ottawa, Ontario
K1A OS3

Contacts: Mr. G.W. Donaldson, Mr. D.A. Fretts, Mr. C.H. Metcalfe, Dr. W.H. Hook, Dr. D. Willermet

Telephone: Area Code 613, 992-1548

How To Conduct a Feasibility Study

A. The R & D approach

Consider the merits of the project as an R & D investment, and approve it (or drop it) according to R & D investment criteria

B. The detailed economic justification study approach

Conduct a detailed economic justification study as follows:

1. Define the part of the plant or process for which the computer will be responsible. Include an entire process, with material moving from one buffer inventory or state, to another, if possible. Draw a boundary around the process.
2. List all the inputs and outputs of material and energy which cross this boundary.
3. Consider the economic cost or value of every input and output. Tabulate in dollar terms, e.g. $ per year, for each and every one. The control objective in broad terms will be to maximize the $ value of the outputs - $ value of the inputs.
4. List all the constraints which limit the plant output and every important variable. Examine each constraint critically. Is the maximum value really the maximum? On what evidence was this operating value chosen. Couldn't it be a little higher, at least part of the time? On some product grades? Under some conditions?
5. List all the upsets or events which cause the plant output per hour to not be maximum for every hour in the year. Can the duration or frequency of these outages be reduced? Assign a value to this production improvement or reduced operating cost.
6. List the disturbances which upset the process. Estimate or measure their frequency of occurence, magnitude and frequency spectrum. Estimate how well an improved control system might minimize the effect of these disturbances and assign a dollar value to this improvement.
7. Check the list of inputs and outputs for material and energy balance. Was anything forgotten? Is any input being used to excess? Assign a dollar value to the improvement expected.

. . . 2

8. Consider the product quality and dollar value of the product on a grade by grade basis. Estimate the quality improvement expected. Assign a dollar value to this*. Can more of the most valuable product grades be produced? Assign a dollar value to this.

   * This is often done by considering the statistical 2σ limits before and after control.

9. Consider the process yield which is the amount of saleable product divided by the input feed required to produce it. Can this be improved? Look especially at losses, scrap and recycled material. Assign a dollar value to any reduction expected with the new control system.

10. Similarly look at the energy and fuel costs. Look for losses and inefficiencies, e.g. fuel inputs higher than necessary in order to "play safe". Look at the cost of energy - i.e. the way you pay for it, such as the peak demand method of paying for electrical energy. Estimate the dollar value of reduced energy use, or more uniform demand due to better scheduling and control of the process operation.

11. Identify any net savings in labour and their dollar value.

12. Consider any additional intangible benefits such as faster information, more complete information, etc.

13. Total the above; compare to the system installation cost on a cost/benefit or cash flow basis and decide whether to approve the project or not.

c. <u>The proven system approach</u>

Recognizing that computer control for this process has become widely accepted and demonstrated as the "way of life", approve the installation without further delay. Put the emphasis of effort on system planning and implementation.

For further details one might see "How to Assess the Economic Justification for Process Computer Control" by J. Scrimgeour, Canadian Control & Instrumentation, April 1968

TYPICAL SOURCES OF ECONOMIC JUSTIFICATION

1. Value of increased production by means of
    - operation closer to true plant capacity and constraints
    - filling in the valleys in plant production rate
    - reduction in lost time for planned production changes e.g. grade, product specification, production rate, etc.
    - reduction in lost time for unplanned disturbances in production rate e.g. upsets, hangups, breaks, cobbles, etc.
    - reduction of scrap or off grade material made possible by improved and more consistent control
    - improved yield i.e. more product output per unit of material input
2. Reduced use of input materials by means of
    - reduction in scrap or off grade material
    - improved yield
3. Reduced use of chemicals and reagents
    - by obtaining and holding the plant at a more efficient operating point (usually with respect to temperature, pressure or reaction time)
    - by adjusting reagent feed rates closer to stoichiometric ratios by either feed back or feed forward control
4. Reduced consumption or charges for energy (steam, fuel or electric power).
5. Labour savings
6. Improved plant safety and avoidance of accidents causing equipment damage
7. Hidden or intangible benefits - benefits which either could not be foreseen or which could not be assigned a direct dollar value.

EXPLOITING OUR ADVANTAGES

YOUR ROLE AND MINE

by R.D. Hindson

to the University of Western Ontario

Tonight, I am going to talk about exploiting our advantages - your role and mine.

Although Canada has many advantages, the principal one I am going to talk about is also the most obvious one - one which you have recognized by holding this workshop on the Use of Computers and Automatic Control in the Canadian mineral industry, one which most Canadians would quickly identify and one which most foreigners envy. You will, I know, give me no argument when I say that I am referring to the major advantage that our abundant mineral resources give to Canada.

Your role and mine should be to exploit this major advantage and to recognize and exploit the many other advantages that we Canadians have, advantages that must also be exploited to the full, if we are going to succeed in maximizing our industrial growth efforts in keeping with our national objectives and aspirations. Computer technology is not the least of these. In fact, its full and proper exploitation by Canadians will be, in my opinion, the most important factor in helping us achieve these aims and aspirations.

Having advantages and even knowing about them, however, is not enough. They are in themselves empty and useless things. They may even be harmful if they lull us into a false sense of security or complacency. History proves that this can be even worse than having no advantages at all.

Exploiting and extending our advantages into an industrial base is the only way we can provide employment to the growing number of Canadians now joining the labour force. The growth of our service industry which is becoming increasingly important as an employer of people is largely dependent upon the development and growth of our manufacturing industry. Exploiting and extending our advantages is the only way we can achieve the very large increases in productivity that we require to compete with the rest of the world. For example, the aspirations that we have for wage parity with the United States can only be achieved and/or justified through major increases in productivity that can only result by exploiting all our resources and specializing in the advantages these give us.

All of you have an interest in the processing and manufacture of metals and minerals. The development of new processes and new products, not forgetting operations analysis process design and process control, is central to the growth and strength of your industry, your university and your country. All of us are involved, all of us have a role to play, and all of us will gain or lose if each one of us does not do his own thing.

...3

National ownership of resources, particularly in a country like Canada, with its small population and market, does not in itself guarantee that these resources can or will be exploited to the best advantage of the country. Canada has derived advantages from its mineral resources, primarily because of the demand of other countries. It is this demand that has resulted in the growth of Canadian exports of crude and fabricated mineral products which in 1970 surpassed $5 billion. What we should be focusing our attention on now is the future demand for Canadian mineral commodities and the acceleration in demand that is foreseen in the coming years.

The U.S. Bureau of Mines is examining the outlook of the USA and the world mineral economy have made some forecasts for future demand to the year 2000. Since I do not wish to inundate you with a lot of figures, I will confine myself to a few striking ones.

In total, the U.S. consumed in 1968, energy minerals, ferrous minerals, non-ferrous minerals and non-metallic minerals, to the value of some $33.7 billion. The rest of the world consumed some $83 billion worth of these commodities. It is now predicted that there will be a growth of some 3 to 5½ times in U.S. and world demand by the year 2000.

...4

These figures become most impressive when they are looked at in terms of cumulative demand. Over the next 32 years, cumulative U.S. demand is expected to reach between $2,000 and $3,000 billion in constant 1968 dollars. Comparing the forecast period 1968 to 2000 with the period of 1936 to 1967, it is found that cumulative U.S. demand for the next 32 years will be 3 to 5 times greater than for the past 32 years. For the rest of the world, the forecast to the year 2000 is for a cumulative primary demand figure some 2½ times greater than the U.S. figure. As attractive as the U.S. forecast is the forecast for the rest of the world indicates an exciting market potential for Canadian minerals which, hopefully, we can supply with more value added than we have in the past.

Of course we have been speaking of forecasts to the year 2000, a period of 32 years. Whether this is a long or a short period depends very much on your age. For those who can remember 32 years back to 1939 and the start of World War II, this will be a short period in the history of a country. Also it must be remembered that, because we are dealing with an acceleration in the growth of population and of G.N.P., the time span between additional amounts of demand of equal size keeps getting shorter.

If Canada continues to maintain its position as a major supplier of minerals and mineral products to the world, then a growth in demand of other countries should result in an even larger growth in Canadian output. On the basis of estimates made by my Branch, the demand for Canadian minerals and metals, exclusive of fuels, should result in a seven-fold growth by the year 2000, compared to the year 1965. This would mean that Canada will have the opportunity to supply in 35 years a cumulative amount representing some 100 times its mineral production in the year 1965. How we will exploit this market and how much Canada will gain from it depends upon the full realization of our advantages and our disadvantages and our wisdom to know the difference, when we sit down to plan our industrial growth and trade development strategy.

I have already stated that Canada's advantage in the mineral-based field is not primarily the fact that it owns mineral resources but the fact that it is able to respond to the demand of other countries for mineral commodities. To maintain its advantages, Canada must keep pace with the accelerated demand that is now in evidence and is predicted for the coming decades.

This is not to suggest, and I know of no one suggesting it, that this must be done according to previous patterns. Canada is fast transforming (not fast enough, I agree, but that's where you come in) from a producer of prime raw materials to a predominantly industrial nation. This transformation has been taking place at the same time that industry itself is being transformed and challenged by new technology, to say nothing of greatly increased international competition. These two activities of change, taking place in Canada at the same time have, I believe made it hard for us to come to terms with our changing role and opportunities. This, perhaps, is one of the reasons for some of the confusion and misunderstanding that at times seem to exist among us.

...6

Your role and mine is to make these two transformations work together for the maximum benefit of Canada, recognizing and exploiting the new advantages that can be gained without losing sight of the importance of the old. Indeed it is the old and still existing advantage that we have as a producer of prime raw materials that is creating the new advantages that we now have.

Sufficient resources of all mineral commodities exist in the world, at least until the end of the century. Certain commodities such as iron and coal are good for many centuries of world demand. To emphasize, as though I really need to, the unique and advantageous position that Canada has, it is, with one or two exceptions, the only industrialized country in the world that is not a net importer of metals and minerals. The USA at the present time imports 20% of its requirements, while Japan is almost completely dependent upon mineral imports for its manufacturing industry.

This, then, is our advantage, but also our challenge. Let's not kid ourselves - we are not alone in the race to supply the accelerated world demand for mineral commodities. We must exert every effort to maintain our competitive position with other mineral rich countries. At the same time, however, it is imperative and I mean imperative, that we exploit, whenever

...7

and wherever possible, the advantages that our rich resource base gives us in order to further develop and strengthen our industrial base. Conservation, if properly and rationally done for good and sound economic and social reasons is, of course, included in what I have just said. As I mentioned before, ownership of rich mineral resources is not enough. We must have markets. In order to invade these markets with more highly processed and manufactured mineral-based products, we must have the will, and having the will, the technological competence to perform the task more efficiently and economically than anyone else. You in this audience have an awful responsibility, for our success or failure in this task lies heavily on your shoulders.

This brings me to another major advantage that Canada has, and that is our rich reserves of technically trained people. As reported by the OECD Committee for Scientific and Technical Personnel in a study they made of Canada in 1964, "Canadian prosperity will in the long run depend on the exploitation of a judicious mixture of its rich reserves of natural resources and its equally rich - but almost wholly untapped - reserves of scientific ingenuity and technological competence". Cultivating and tapping Canada's intellectual resources and exploiting it for maximum benefit to Canada is the responsibility of all of us, but not the least it is the responsibility of higher educational institutions whose role is now assuming prime economic importance to Canada.

The economic demand and need for organized knowledge places our universities in the same position as our mineral resources of being a basic national resource which is clearly in the national interest to develop and use as an integral part of our industrial growth strategy. Compared with other countries of the world, Canada is a long way from fully exploiting this important resource advantage. Much more rapport, cooperation, communication and direction between universities, industry and governments on their respective and supporting roles and needs are required. As one foreign observer put it in speaking on this subject, "Canadians have a strong tendency - even insistence - on dealing with problems independently even though their solution would clearly be facilitated and be made more effective by a more coordinated and cooperative action."

Achievement of our social goals is dependent upon the achievement of our economic goals. Achievement of our economic goals is largely dependent on the availability of manpower with the necessary skills. These activities, however, are conducted more often than not quite independently of one another. It was demographic pressure and social demand, rather than the need of the economy for skilled manpower that has been the primary motivation for the greatly expanded higher educational facilities in Canada. Perhaps this is good or otherwise we might not have had such facilities. Now that we have them, however, let's get our industry and universities closer together and do away with the almost watertight compartment that has separated economic planning and forecasting on the one hand and educational planning and forecasting on the other.

Returning again to our reserves of scientific ingenuity and technological competence, it may surprise you to learn that an OECD survey done in 1961 showed that Canada had almost twice as many scientists and engineers, as a percentage of the labour force, as any other OECD country except the USA! A background study done for the Science Council of Canada noted that in 1970 the proportion of engineers and scientists to the total labour force in Canada amounted to 1.9%, whereas in the United States it was only 1.5%.

The Economic Council of Canada has forecast an annual growth rate for our labour force of 2.5% over the next 10 years. The science and engineering segment of the work force is continuing to grow at 9% per year or some 4 times more than the growth rate of the total labour force.

O.K., so we have a lot of scientists and engineers and many more are on the way. But just as ownership of rich mineral reserves is no advantage in itself, the availability of a large reserve of scientists and engineers is no advantage either unless they are trained and oriented to supply the technological, economic and social needs of Canada and can find a productive and useful market for their services.

Such people can be of major advantage to Canada, whether they work in industry, government, university, research institute or by themselves, helping our industry improve its technology so that it can improve its competitive position at home and abroad.

...10

When this advantage is combined with our other major advantages and opportunities, of which our metals and minerals industry is the prime example, the overall advantage becomes much greater with a consequent increased possibility for making more significant technological, economic and social gains.

Technology has become the fourth factor or production. The other three are land, capital and labour. Technology is by far the most dynamic of these, subject to constant change. Unless Canada excels and keeps ahead in the technology of metals and minerals, our rich mineral resources and our equally rich resources of technically trained people will become advantages unrealized.

Technology does not stand still. I am told that computer processing speeds are increasing 10 times every five years, that cost of memory storage is decreasing 5 times every five years, and that cost of bulk storage is decreasing 20 time every five years. Present-day technology for the exploration, mining and concentration of minerals, for the conversion of minerals to refined products, for the manufacture of mineral-based products, and for their use, is already under attack and promises to change materially in the future. The country that does this will gain a major competitive advantage, even if they don't have their own mineral resources. They will be able to buy these resources because they can process and manufacture them cheaper. They will be able to export their manufactured goods, again, because they can make them cheaper. They can even export, at a price, the technology they have developed. Technology as much as iron ore, wheat and potatoes, is an exportable product. Canada is in an ideal position to be such a country, but it won't be unless we all get together and make it so.

Just as technology does not stand still, neither do the problems of the mineral industries.

In the U.S. and Canada, the trend is towards a growing cost to exploit lower grade mineral resources. The near surface deposits of good grade ore have largely been found simply because they were the easiest to discover. New technology is needed to keep down the cost of low grade deposits. This is necessary in order to compete with higher grade mineral deposits which still exist in Australia, Asia, South America and Africa. Also, extracting lower grade mineral deposits on an economic basis usually involves production on a very large scale. This in turn calls for large capital outlays which in themselves must be justified by improved technology and higher efficiency.

Another problem they are faced with is the increased and accelerating demand for metals and minerals referred to earlier. This will require an acceleration in technological response. In other words, mines, smelters, refineries and manufacturing plants will have to increase output at an accelerated rate. When they have used up their capacity, new facilities will have

...12

to be erected in a shorter period of time than in the past. For example, new smelters may have to be built in half the time than it takes now. The recent crisis in the coal industry in the United States is an illustration of the sort of situation that can arise if the technological response cannot be geared to a changing or accelerated demand.

These problems are your problems, too. For as computer specialists you have a major role to play in their economic solution. Your technology, more than any other, needs to be exploited if we are going to maximize the advantage that our abundant mineral resources give to Canada.

Today we live in a world where knowledge in many of the most important sciences is doubling every decade. In the years immediately ahead, the pace of technological advance is going to rise considerably above the average pace in 1932-1972 speeding up all the processes of economic advance and social change. This is the way it is, the way its going to be, whether you or I like it or want it. You should like it because this will be a computer led revolution. You will notice that I have used the future tense in referring to a computer led revolution. The reason for this is that I am one who believes that computer technology has been grossly under exploited during the past ten years or so.

My Branch is doing what it can to advance the development and application of computer technology in the industry sectors we are responsible for. For example, we participated in and financially supported, along with the Electrical and Electronics Branch of our Department and the Canadian Institute of Mining and Metallurgy, the preparation of course material on the use of computers in the mining industry. Some courses have already been given to representatives from industry using this material. The number has been disappointing but perhaps this workshop here will give a spurt to further activity in this area.

My Branch is deeply involved in the establishment of a Construction Information System. In the course of this work we had one of our consultants, Demers, Gorden and Baby of Montreal do a study for us on the use of computers in the construction industry. I am going to quote a few excerpts from this unpublished report which I think are pertinent:

- "...the user can soon become increasingly more remote from computer-dependent program requirements as the new problem oriented and high-level languages permit him to define a problem solution in terms familiar to him, rather than those required by the machine. Many man-years of effort on the part of the computer industry now permit the user to concentrate on the definition of the problem solution rather than the details of how the computer will solve the problem.

...14

- It is believed that increased utilization of computers in the construction industry will be favoured when it is no longer necessary for the construction specialist to learn a different procedure, unrelated to his problem area, for each application he wants to make of the computer. To him, using the computer must be made nearly as easy and routine as using a slide rule, calculator or telephone.

- This increasing capability for every dollar invested on equipment can be realized by the user who has the knowledge and resources to use the computer directly. However, because of the contrary trends in wage costs, the user who must rely heavily on the personnel of commercial computer centre for support in the preparation of programs and other such assistance, will be unable to obtain much advantage from these decreasing equipment costs.

- The economic utilization of remote facilities is greatly influenced by the amount of data and the speed with which it must be transmitted. This cost has not followed a comparable downward trend but it is expected that significant changes in cost structures and services should occur over the next several years.

...15

This will allow greater use of facilities no matter where they are located, further reducing the cost of duplicating similar facilities in many centres.

- That the interchange of computer programs be promoted and that information on existing computer facilities and capabilities be disseminated within the industry. These activities appear to be well suited to the aims of the Department of Industry, Trade and Commerce, but, to be truly effective, the active cooperation of industry associations and professional groups must be sought and their assistance obtained.

- That industry associations and professional groups be urged to assume the initiative in determining where, within their own industry, sector, or discipline, the computer can be profitably utilized. These efforts could be coordinated by the Department of Industry, Trade and Commerce, and form part of an overall industry promotional program."

Now I would like to close by reading a passage from a most excellent article on the Future of International Business by Norman Macrae, deputy editor of The Economist:

"As is usual in the early years of extraordinary scientific advances, when producers who do not quite know what they are doing are trying to sell to consumers who do not understand what on earth they are about, a large number of the commercial pioneers of the new technologies have fallen flat on their faces. This has, again as usual, caused delight among the luddite majority of mankind. When many of the early car manufacturers were going bust in Edwardian days, The Economist won considerable plaudits from the then Establishment by publishing a well-reasoned article called 'The Triumph of the Horse'.

We laugh at this in our superior knowledge in retrospect - but how about our knowledge in prospect? Predictions in the first decade of this century about the coming triumph of the horse were no less silly than business projections today which fail to pay central heed to the explosive changes which computer and telecommunicative technolo[illegible] are highly likely to bring about.

(1) Some time in the period 1972-2012 we probably will make the breakthrough into genuinely intelligent use of computers, in place of today's damn silly use of them. The acceleration of both innovation (which is already advancing fast) and teaching capabilities (which for centuries have hardly advanced at all) will then become exponential.

"The speed of technological advance has been so tremendous during the past decade that the useful life of the knowledge of many of those trained to use computers has been about three years. This has meant that in many (perhaps most) of the jobs required to use them there has been nobody with any useful knowledge on hand. Nearly everybody was naturally trained by somebody who was trained by somebody who was trained more than three years ago. If yours is a firm where the computer operation has snarled up, you should not therefore be surprised.

"These failures during 1961-71 have been enormously dispiriting to those who advocated the introduction of computers; and enormously cheering to those who never wanted the introduction of the wretched things. Many of the most advanced people do not now believe that there will be a breakthrough in their lifetimes to adequate use of our extraordinary new power. 'You cannot now get to the information-processing revolution,' says one, 'because there are already too many information-processing pathologies lying about'."

This, gentlemen, is the real challenge that we all face. It will be met and overcome in some hierarchys, let's make sure ours is one of them.

The best definition of the breakthrough tentatively forecast by Norman Macrae is that, by some stage within the period 1972-2012, ordinary intelligent man will have become able to make meaningful use of computers to about the same degree as the ordinary intelligent man can drive a motor car now. From some uncertain date ahead (his guess is after the mid-1980's for offices, only slightly later for homes), computer terminals are liable to start spreading at about the pace that television sets spread after 1947 - and television then went from nought to nearly 90 per cent household coverage in some advanced countries in less than 20 years.

Well, gentlemen, you have a lot of work to do, a major advantage to Canada to exploit. I would like to leave you with only one last word. Knowledge of what a computer will or can do is not enough. You've got to get out and sell it - remember the pathologies I spoke about. I noticed a reference in your report that the CIM should be encouraged to be more active in this area and perhaps hold computer sessions at their conferences. This is an excellent idea but you are the chaps that are going to have to do it. Who else can?

R.D. Hindson
Materials Branch
Department of Industry, Trade and Commerce.

FLOTATION MODELS - A Bibliography

1. An extremely thorough critical review of work up to approximately mid-1969 will be found in 'Mathematical Modelling of Flotation Processes' by E. T. Woodburn, published in Minerals Science and Engineering, 2 , 2 , pp. 3-17 , April 1970. (65 references.)

2. 1969

Eerola, P., and U. Paakinen, 'Introduction of Theoretical Aspects into the Computer Control of a Flotation Process', A Decade of Digital Computing in the Mineral Industry (ed. A. Weiss), A.I.M.E. (New York, 1969), pp. 827-851.

Niemi, A., and U. Paakinen, 'Simulation and Control of Flotation Circuits', Automatica, 5 , 5 , pp. 551-561, September 1969.

Smith, H.W., and A.K. Bjerring, 'A Preliminary Dynamic Model for a Flotation Circuit', A Decade etc. (see above), pp. 867-893.

Woodburn, E.T., et al., 'Integrated Grinding and Flotation Control - Computational Problems in an Optimum Decision Making Model', A Decade etc., pp. 695-728.

3. 1970

Scrimgeour, J.H.C., Hamilton, R.E., and T. Toong, 'The Use of Mathematical Modelling in Developing Advanced Control Systems for Mining Industry Processes', C.I.M. Bulletin, pp. 1181-90, October 1970.

4. 1971

Kelsall, D.F., and P.H.B. Stewart, 'A Critical Review of Application of Models of Grinding and Flotation', Symposium on Automatic Control Systems in Mineral Processing Plants, Aust. I.M.M. (Brisbane, 1971), pp. 213-232.

5. 1972

Fournier, R.D., and H.W. Smith, 'On-Line Estimation of Flotation Rates', A.I.Ch.E. Winter Meeting, November 1972 (to appear)

King, R.P., 'Model for the Design and Contorl of Flotation Plants', Tenth International Symposium on the Application of Computer Methods in the Mineral Industry, Johannesburg, S.A., April 1972 (to appear)

Loveday, B.K., and G.R. Marchant, 'Simulation of Multicomponent Flotation Plants', Tenth etc. (see above) (to appear).

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MINES BRANCH

OTTAWA

MINERAL SCIENCES DIVISION

Division Report MS PP 72-14

ON THE USE OF, AND OPERATING PROBLEMS ENCOUNTERED WITH ON-LINE X-RAY ANALYZERS IN THE MINERAL PROCESSING INDUSTRY

by

A.H. Gillieson

June 26, 1972

MINERAL SCIENCES DIVISION

Division Report MS PP 72-14

"ON THE USE OF, AND OPERATING PROBLEMS ENCOUNTERED WITH ON-LINE X-RAY ANALYZERS IN THE MINERAL PROCESSING INDUSTRY"

by

A.H. Gillieson

- - -

INTRODUCTORY NOTE

This is a version written subsequently, of an extemporaneous invited talk, under the above title, given on Friday, May 12, 1972 to the Workshop Seminar on "The Use of Computers and Automatic Control in the Canadian Mineral Industry" sponsored by the Mines Branch, National Research Council, and the Department of Industry, Trade and Commerce, and held in the Business School, University of Western Ontario, London, Ontario, May 11-13, 1972.

- - -

In the twenty minutes available it is not possible to describe in any great detail the problems encountered in the use of X-ray analyzers in the mineral processing industry. I will therefore try to give a survey, mainly in tabular form, of the important factors in the hope that this summary will assist the discussion in the workshop session on "On-line X-Ray Analyzers" which is to follow this talk.

It is clear from Tables 2 and 3, p. 15 of the previously circulated survey on "Operations Analysis, Process Design, Process Control in the Canadian Mineral Recovery and Metal Production Industries", sponsored by the NRC Associate Committee on Automatic Control, that industry wants better and cheaper sensors and that its greatest interest is in the mineral analysis of ores.

The relevant portions of these two tables are shown on the first slide and reproduced herewith:

SURVEY: (p.15), Table 2

1. Better sensors for continuous accurate real-time output
2. More or better studies on economic justification
3. Better process models
4. Lower-cost sensors

SURVEY: (p.15), Table 3

		Request Frequency
1.	Mineral analysis of ores	8
2.	On-line particle size analysis	7
5.	Slurry mass flow	3

The second slide, reproduced herewith, shows the factors considered to be of major importance in X-ray fluorescence (XRF) on-line analysis.

FACTORS IN XRF ON-STREAM ANALYSIS

1. Sampling of stream
2. Particle size variation
3. Excitation of fluorescent X-rays
4. Absorption effects
5. Matrix effects
6. Inter-element effects
7. Solids content of slurries
8. Separation of X-ray wavelengths or energies
9. Detectors
10. Electronic circuitry
11. Computer calculation of corrections

The first factor is the sampling of the slurry stream, a major, complex, and difficult problem. Time and my lack of detailed knowledge of the problems of sampling slurry streams in the plant do not permit more than this mention of its importance.

Similar considerations apply to the second factor; particle size variation. All of us are aware that particle size affects results in XRF analysis and know the theoretical work of Dr. Fernand Claisse, Laval University, on the subject. Although aware of the problem, I have had no opportunity as yet to investigate experimentally its effects on XRF on-line analysis.

Slides 3 and 4 summarize the two methods of excitation of the characteristic fluorescent X-rays of the elements of interest.

X-RAY EXCITATION

Conventional X-ray tube

(CXT)

ADVANTAGES	DISADVANTAGES
High intensity	Continuous background
Flexibility in X-ray voltage and power	High cost ($10,000 upwards)
	Filtered water cooling
	Electric power (3 to 5 KVA)
	X-radiation hazard
	High-voltage hazard
	Large bulky apparatus

X-RAY EXCITATION

Radioisotope Source (RIS)

ADVANTAGES

* Low cost ($500 to $1,500)
* Simplicity
* Compactness
* No background to X-ray line
* No high-voltage hazard
* No cooling required
* Low radiation hazard

DISADVANTAGES

* Low intensity
* X-ray voltage and power fixed for each source
* Present limited range of sources
* Short useful life of some sources

Absorption of the X-rays is a basic factor and slide 5 summarizes the relevant aspects of this phenomenon.

ABSORPTION

WANTED

* In elements of economic interest to increase yield of fluorescent X-rays and therefore sensitivity;
* In scintillation counter phosphor e.g. NaI (Tl) or in solid-state detector.

UNWANTED

* In other elements e.g. gangue,
* In X-ray tube window,
  Slurry cell window,
  Detector window,
  Water,
  Air.

Associated with X-ray absorption are matrix effects, which are an important factor in XRF on-line analysis. In our own work for example, we have been able to obtain good calibration curves for concentrate streams, on the one hand, and different but equally good curves for heads and tailing streams, on the other hand, but no satisfactory single curve could be derived to cover both. This outcome is due to the considerable differences in the solid matrices in the two kinds of stream.

Inter-element effects are of major importance in the XRF analysis of bulk solids and in powders, but in our experience to date they are of negligible importance in on-line XRF analysis of slurry streams. This is at first sight surprising, but becomes understandable when we recall that X-ray excitation is an atomic phenomenon, and it is not the weight proportions but the atomic concentrations of the elements in a mixture which are of prime importance. Thus in a 50% solids-content slurry of sulphide ore, the atomic concentration of the solids is only about 12%.

Of prime importance is the determination of solids content and the relevant possibilities for measuring this factor are summarised in slide 6.

SOLIDS CONTENT DETERMINATION

EXTRINSIC

* Direct weighing
* Gamma-gauge
* Sonic
* Neutron moderation

INTRINSIC

* By X-ray, making use of ratio:

$$\frac{\text{backscatter from slurry}}{\text{backscatter from water}}$$

The next factor to consider is the separation of the X-rays produced, by wavelength or by energy, and the advantages and disadvantages of the two possible methods of separation are shown in slides 7 and 8.

SEPARATION (RESOLUTION) OF X-RAYS

Conventionally by wavelength spectrometer

ADVANTAGES

* High resolution
* Possible to use first, second or third orders of diffraction from the crystal

DISADVANTAGES

* Expensive diffracting crystals
* Not compact
* Large intensity loss in collimators and crystal

DISADVANTAGES (Cont'd)

* Long path length between sample and detector

SEPARATION (RESOLUTION) OF X-RAYS

Alternately by electronic energy discrimination

ADVANTAGES	DISADVANTAGES
* Compact	* Poor resolution, except with solid-state detectors; which are expensive and require liquid nitrogen cooling
* Short path length between sample and detector	* Solid-state, sealed or flow proportional detectors must be used; scintillation counters not suitable
* Low intensity loss	

The sensors by which the characteristic X-rays are measured and detected are clearly of major importance in XRF on-line analysis and the relevant characteristics of the detectors are detailed in slide 9.

DETECTORS

TYPE	RANGE	ADVANTAGES	DISADVANTAGES
Scintillation	Ti and heavier elements	High sensitivity	Cannot be used with energy discrimination Detector background
Sealed & flow-proportional counters	Sealed: Na upwards	No detector background	
	Flow: Ti down to F	Best for light element X-rays	Flow-proportional type require supply of counter gas

DETECTORS (Cont'd)

TYPE	RANGE	ADVANTAGES	DISADVANTAGES
3. Solid State	Sulphur and heavier elements	High resolution Wide range	Low sensitivity Require liquid nitrogen cooling Expensive

Relevant to some of the comments by the previous speaker, Mr. Leaven on "The Stages in the Development of a Process Sensor", I have some observations on electronic circuitry. It is customary to use the detector signal to charge a capacitor for a suitable time and then to read the accumulated charge by: (a), a vacuum-tube voltmeter, whereby the charge is not dissipated; (b), measure the discharge time down to a preset amount - the charge is lost and the readout is logarithmic; or (c), use the discharge time down to a preset level, to feed an accurate oscillator signal into a digital counter. All these methods require high performance capacitors and relays. It is now possible to use ordinary capacitors coupled to FET operational amplifiers to feed the digital counter much more cheaply and quite as efficiently.

Finally I have a word to say on computer calculation of corrections to the raw X-ray data. The customary empirical correction formulae is a polynomial. This, while mathematically accurate, cannot easily be interpreted physically and it is felt that efforts should be made to produce correction formulae with much greater physical meaning.

ECONOMIC MODELLING

By

N. R. Arden

Canadian Mineral Industry Workshop May, 1972

INTRODUCTION

Ladies and Gentlemen, the title of my talk, as Mr. Grassby indicated, is "Economic Modelling". This can be interpreted in a number of ways. The Session Developer, Leo Nenonen, no doubt intended to refer to the modelling of economic entities such as Stelco. And I will certainly be talking about that. But there is another interpretation that I would like to suggest to you - and that is modelling where the benefits clearly justify the cost. And I will certainly be talking about that, too.

However one interprets the title, there is far too much work being done at Stelco to be covered in any detail in a twenty minute talk. I propose to concentrate on our long-range forecasting process and, in particular, on our Corporate Financial Model. In doing this, I will, I hope, achieve two things. I will share with you our experiences in long-range financial modelling, and the conclusions that we have drawn from them. And I will indicate those areas where we feel Government assistance can be a significant help.

In order that my discussion on the Corporate Financial Model can be put into proper perspective, I will first give a brief description of Stelco - of its operations and its organization. Then I intend to explain the long-range forecasting process and how models are used to make it more effective. Finally, I will describe the development of our Corporate Financial Model, and the uses to which it has been put. If time and our Chairman permit, I will then entertain questions from the floor.

STELCO

For those of you who don't know us, Stelco is Canada's largest steel company. We produce about 40% of this country's steel, and market a greater variety of steel products than any other Canadian steel company. We are fully integrated. We mine coal and iron ore, and we sell nuts and bolts. Although we have eighteen plants in total, our basic steel production is centred at Hilton Works in Hamilton. On the financial side, we are reasonably successful. In 1971, net income was $66 million on sales of $730 million.

SLIDE 1

The Company is organized into seven divisions - Operations; Marketing; Personnel; Accounting; Finance; Corporate Planning and Facilities Planning, Engineering and Research. As you can see from the slide, I am restricting my discussion of the organization to only a few departments - in fact only to those directly involved in the long-range forecasting process, and to the area in which I work - Data Processing. Corporate Planning is a fairly recent addition to the Divisions of the Company.

THE LONG-RANGE FORECASTING PROCESS

Before I discuss in detail the contributions to the long-range forecast that are made by these Departments, I would like to give you an overview of the process. The bi-annual forecast is based on a fifteen year forecast of the economy, prepared by the Economics Department. This is converted by Commercial Research into an estimate of the size of the Canadian Market for each of some thirty product groups. Desirable levels of market participation are imposed on the estimate by Product Sales to obtain a sales forecast for Stelco. This is then supplemented by a forecast of exports. The sales forecast is converted to a demand on our major facilities and a need for raw material by Facilities Planning. By comparing demand with capacity projections supplied by Operations, and new facility costs supplied by Engineering, the capital expenditure required for new facilities is identified, and capital spending and purchased steel programs are developed. When all of this is put together, there is sufficient information for Financial Analysis to prepare a series of financial statements for each year of the forecast. Finally, the Treasury Department checks that any required financing is reasonable. These financial statements are the basis on which Senior Management decide the direction in which Stelco will be moving during the next five to ten years.

Now let us examine the detail of how this is done, where modelling is used, and some of the problems we encounter.

ECONOMICS

The Economics Department starts off the whole process with a forecast of the real Gross National Product for the next fifteen years, which is then broken down into the major sectors of Consumer Spending, Government Spending, and Business Investment. REAL GNP is forecast by estimating the population growth and changes in the participation rate, including unemployment. The product of these two factors is the labour force. REAL GNP is calculated by applying an estimated productivity per person. The breakdown of this forecast is achieved by studying trends in the proportionate contribution of each Major Sector. With the notable exception of construction, a lot of statistics are available from various federal departments for making these forecasts. In fact, some of these statistics have even been extrapolated into the future, with all assumptions clearly delineated. Unfortunately, the future is not that well-ordered, and what real forecasts the Government produce, are of limited value - - as, somewhat understandably, neither explicit nor implicit assumptions are stated. Other than occasional extrapolations, the Economics Department does not use the computer. While a lot of resources at Universities and elsewhere have been expended on developing econometric models, the state-of-the-art has really not progressed beyond producing forecasts which need to be subjectively evaluated in conjunction with those produced less rigorously by economic "experts".

COMMERCIAL RESEARCH

From the forecasts of REAL GNP and population growth supplied to them by the Economics Department, Commercial Research prepare four different projections of the Canadian market demand for each major rolled steel product group. These are prepared on a time-sharing computer by a program using linear regression and other statistical techniques. The projections are reduced to a single forecast within stated confidence limits by a qualitative assessment of the projections and of other subjective factors such as the impact of competitive materials. Product Sales' Senior Management then establish participation levels for each rolled steel product. These levels are imposed onto the forecasts to yield the sales tonnage Stelco plans to achieve.

FACILITIES PLANNING

Facilities Planning's function is to translate the sales forecast into a load on our major manufacturing units and into a demand for raw material. Our Operating Division supplies projected capacity figures for these units, and Engineering supplement this information with an estimate of the cost of building new units with varying capacities. In any industry where additional capacity comes in large steps, semi-finished goods have to be purchased to smooth the increase in production. Consequently, the availability of purchased steel adds another dimension of complexity to the forecast.

Availability of construction workers and of raw material and scrap impose additional constraints. It is not surprising that the development of capital expenditure plans and forecast requirements for raw material and purchased steel, is computerized. Facilities Planning have developed their Corporate Capital Program Model to show the impact of different timings for the introduction of new major manufacturing units.

Forecasting the availability of raw material and scrap by region is particularly difficult. It is an area where Government involvement has been successful in other countries, but not yet in Canada. There is also a definite, and I believe already recognized, weakness in construction industry statistics. The impact of changes in productivity, and the availability of tradesmen are two specific areas where our planning would benefit from improved statistics.

FINANCIAL ANALYSIS

The long-range forecasting process is completed by the consolidation of all the plans we have just discussed into financial statements for each year of the forecast. This is done by our Corporate Financial Model which I will describe to you in a moment. Before I do, though, I would like to complete my description of the process.

Once the financial statements have been prepared, they are examined by our Treasury Department to determine the feasibility of the required financing, and are then presented to the other Division Heads by the Accounting Division, which bears the final responsibility for the production of the forecasts. At this time, new constraints could be introduced and much of the process re-worked.

THE CORPORATE FINANCIAL MODEL

Before discussing the Stelco Corporate Financial Model, I would like to emphasize that it is basically the automation of a manual process. This approach considerably simplified the analysis requirements and also permitted a demonstrable reduction in the cost of producing the financial statements.

The design objectives were to develop a flexible, easy-to-use system which would provide rapid turnaround in a secure environment. In addition, it was particularly important that the users of the system have confidence in the output - or at least confidence that the output is as accurate as the input! With these objectives in mind, let us now turn our attention to the design of the Model.

Time-sharing was chosen as the most effective computing medium. It permits Financial Analysis the control of running the Model themselves, and the many levels of security offered by most time-sharing suppliers. It also allows for conversational data error correction, and provides rapid turnaround. However, a version of the Model was also developed to run on our in-house computer - - in the event that there was any problem accessing the time-sharing system.

SLIDE 2

Most of the data used by the Model has already been indicated - that is Sales, Capital Spending, and Raw Material and Purchased

Steel Supply Plans. The additional information that Financial Analysis uses, falls into three categories:

1. Statistically-derived percentages, - such as, A & S as a proportion of Sales, or Accounts Payable as a proportion of Sales and Captial Spending.
2. Constants - such as tax and depreciation rates.
3. The financial figures for the Base Year of the forecast - which are included in all of the exhibits, and are also needed by the Model for the first forecasted year calculations.

For reasons of security and to improve the accuracy of the data input process, all of this data is given coded identification.

Before I proceed any further, I should mention two important characteristics of the Model. Constant dollars are used throughout, and all calculations are deterministic - - that is to say, the Model itself does not alter the value of any of the variables.

The first of the three modules of the Model handles data input and validation. In order to identify the data to be used in a particular run, a set of parameters need to be supplied to the module by the time-sharing terminal operator. These parameters indicate the base year and the final year of the forecast, and the number of product groups, mines, and types of purchased steel that are to be considered.

SLIDE 3

Data input is kept to a minimum by using three files - the Old Master file, the Update file, and the New Master file. After the parameters have been entered, all relevant information is extracted from the old Master file. For example, it might contain information for a ten-year forecast, but the parameters for this run might only indicate a five-year forecast. Consequently, information for years 6 to 10 would be ignored. The Update file is used to modify or supplement this information. Thus the capital spending plan for years 2 and 3 might be adjusted to show a change in the timing of the purchase of some land, and a whole new set of figures relating to an additional coal mine might be added. The resultant New Master file contains all the information for this run. When a series of runs of the Corporate Financial Model are made, they are usually variations on a single basic forecast. This basic forecast is entered in an Update file - with no Old Master file. The New Master file that is generated by this run is used by the subsequent variations as an Old Master file.

SLIDE 4

The parameters and all the data in the Update file are subjected to extensive validity checks. These fall into four categories:

1. Identification - the coded identification that I mentioned earlier must be both an acceptable code and

consistent with the value of the parameters. For example, if only thirty product classifications are to be considered, use of the code for product classification number 31 would be rejected.

2. Range - acceptable bounds are defined for all data.

3. Volume - the amount of data supplied must also be consistent with the value of the parameters. Thus, if six years of data are supplied for a five-year forecast, all the data will be rejected.

4. Check Totals - the totals of certain key sets of figures, such as sales tonnage per product classification, are entered as data and compared with the computed totals.

Any error that is detected is immediately identified to the terminal operator, with an explanation of the cause of the error and the values of the invalid data. The operator then has two choices. Immediate correction can be made - which is of course subject to the validity checks - or the rest of the Update file can be scanned for other errors, and then the validation module can be started from scratch with a modified Update file. The New Master file is only generated if all the data is acceptable.

The other two modules of the Corporate Financial Model do the required calculations and produce a set of financial statements. I do not believe that there is much for you to gain by my discussing these calculations, which must be fairly obvious from the data used; and I am sure that you have all seen a comparative balance sheet. So I won't elaborate on these two modules, unless they are brought up in the question period.

The fact that time-sharing was the chosen computing medium permitted us to exhaustively check out the Model, before handing it over to Financial Analysis. This ability of time-sharing to make exhaustive checkouts a practical possibility is one that has been rarely exploited in the past, but I believe will be one of its strongest attributes in the future - as business data processing start to use time-sharing in program development. While users will accept, albeit reluctantly, responsibility for the data they supply to the computer, any bug in the program logic that is discovered after development is complete, is certain to reduce the confidence of the user in his system. As I suggested earlier, confidence in the area of economic modelling is particularly important. So I am relieved to say that, in 2-1/2 years of operation, no bug has been discovered. In fact the only complaints we have received involve the inflexibility of the Model - it doesn't allow even minor mistakes to get through!

The model has been used extensively. In the preparation of the long-range forecast immediately prior to the Model's development two variations were evaluated - each taking about two days work. For the next forecast, nearly forty alternatives were examined - at a cost of about $12 each. Our timing was particularly fortunate in that Stelco had recently purchased land at Nanticoke, and careful consideration had to be given to the timing of new facilities to be built at this site. Since then, other series of forecasts have been run as required.

CONCLUSIONS

Before closing, I would like to summarize what we have been discussing.

Stelco's long range forecasting process is a logical progression which converts an economic forecast into a market forecast which in turn is converted into a demand on facilities. From this, capital expenditure, and purchased steel and raw material supply plans are generated, and financial statements are projected. Modelling is not used at the earlier stages where the forecasts are essentially subjective, but is heavily used at the later stages where the complexity of the calculations provides optimum return from the use of computers. Three areas were identified where Government could help improve the forecasting process:

1. The issuing of economic forecasts, with all assumptions stated.

2. Improved construction industry statistics.

3. Better forecasting of the availability of raw material and scrap.

Finally, discussion of Stelco's time-sharing Corporate Financial Model was centred about its extensive input data validation, and the application of other standard data processing techniques in an area where these have been too often ignored.

Thank you.

stelco

- OPERATIONS (Capacities)
- MARKETING
  - PRODUCT SALES (market participation)
  - COMMERCIAL PLANNING AND RESEARCH (market forecast)
- PERSONNEL
- ACCOUNTING
  - ADMINISTRATIVE SERVICES - DATA PROCESSING (economic modelling)
  - ACCOUNTING - FINANCIAL ANALYSIS AND CONTROL (financial statement generation)
- FINANCE
  - TREASURY (financing)
  - ECONOMICS (economic forecast)
- CORPORATE PLANNING
- FAC. PLAN., ENG. & RES.
  - FACILITIES PLANNING (capital expenditure, purchased steel/raw material supply)
  - ENGINEERING (new unit costs)

INPUT DATA

SALES

CAPITAL SPENDING

RAW MATERIAL SUPPLY PLAN

PURCHASED STEEL SUPPLY PLAN

STATISTICALLY - DERIVED PERCENTAGES

CONSTANTS

BASE YEAR FINANCIAL FIGURES

PARAMETERS

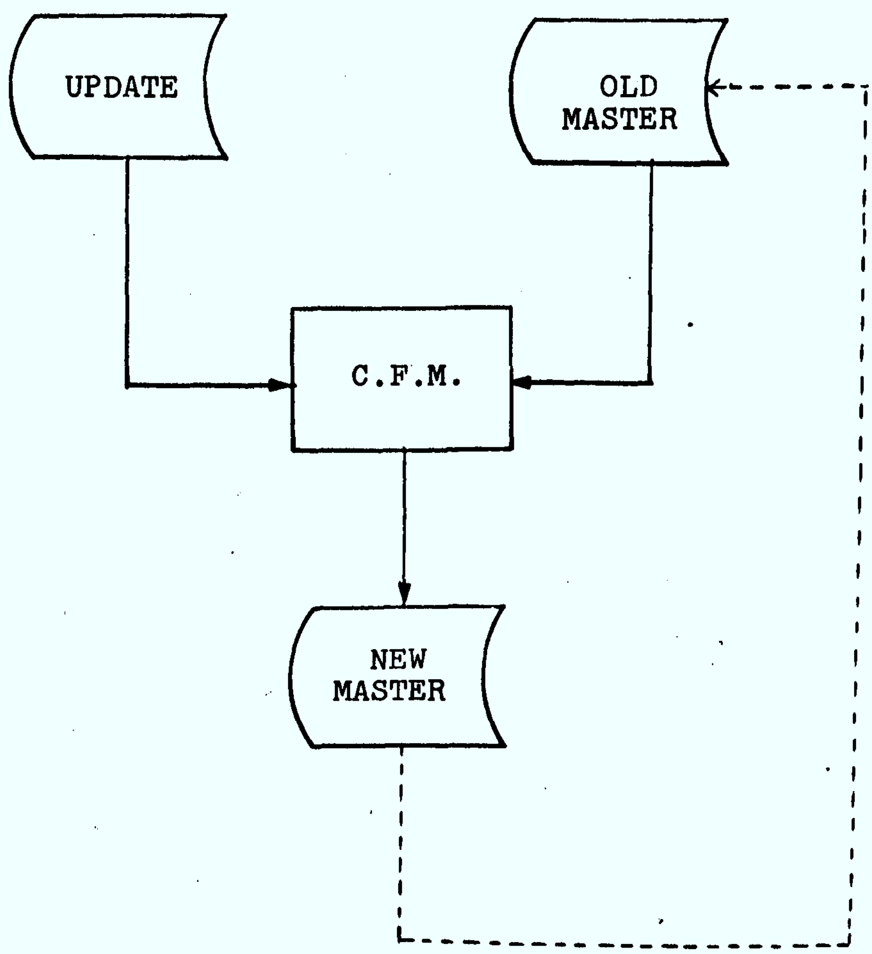
BASE YEAR

FINAL YEAR

NUMBER OF PRODUCT CLASSIFICATIONS

NUMBER OF PURCHASED STEEL TYPES

NUMBER OF MINES


UPDATE
OLD MASTER
C.F.M.
NEW MASTER

VALIDITY CHECKS

1. IDENTIFICATION

2. RANGE

3. VOLUME

4. CHECK TOTALS

THE STAGES IN THE DEVELOPMENT OF A PROCESS SENSOR

1. Introduction
2. Market Demand
3. Market Analysis
4. Product Analysis
5. Product Synthesis
6. Production
7. Marketing
8. Installation and Servicing
9. Criteria of a good Sensor Development

E. W. Leaver
8 May 1972.

THE STAGES IN THE DEVELOPMENT OF A PROCESS SENSOR

INTRODUCTION

The actual development phase in the life of a Process Sensor is a relatively small part of that life. As I believe one can not meaningfully discuss it in isolation, I am taking the liberty of discussing it in relation to the stages in the life of a Process Sensor.

Development of a sensor should not be undertaken lightly. It is an expensive and risky business. Unfortunately, many of the factors involved in that risk are not within the control of the developer. I doubt if our company would engage in it if we weren't in the Systems business where proprietory sensors can and usually are, invaluable.

It is important to keep reminding oneself that a sensor, like everything else in this world, has a limited life span. No matter how clever it's design may be, changing uses, materials and techniques are going to terminate its usefulness in a foreseeable time (not always easy to estimate).

Further, the 'lifetime' of developments seems to be growing alarmingly shorter with each passing year.

Hence, apart from the 'new needs market', the life cycle of a sensor begins with the obsolescence of an old one, and is terminated by its own obsolescence. In between these events lie a long sequence of decisions, nearly all of which have to be <u>right</u> if the whole experience is to be a success.

MARKET DEMAND

The first of these decisions and the first stage in the development of a Process Sensor, the most important, depends on the answer to this simple question. Is there a genuine economic demand? Obviously, the answer can only be yes, if there has been a real demand emerge from associated areas of technology or a search for a new product opportunity results in discovering a gap in the spectrum of sensors available.

Unfortunately, we are not always logical, and there have been many instances where a misplaced love of technology has led to unuseable and/or unsaleable products. A hundred thousand or a million dollars down the ;ike a decision has to be made to write-off the investment and sometimes the developer along with it.

The proposed new sensor must be thought by the prospective user to be valuable enough so that he will be willing to not only pay for the 'nuts and bolts' but also to help pay for the development that brought it into existence.

MARKET ANALYSIS

The decision to proceed with a product is usually only taken after an estimate of the profit to be expected. This estimate is based on the number of units that can be sold over the expected product life, multiplied by the unit price that can be charged, minus the costs of development plus the costs of manufacture.

Sometimes the situation may be different, however. The development of a new type of sensor by a System supplier may give it an edge over the competitor. This could result in a significant increase in systems orders which could yield profits a hundred times greater than that generated by the sensor itself. Knowledge of this situation could trigger a GO decision when ordinary criteria would lead to the abandonment of the project.

Marketing considerations rank high in such decisions. In the case of the sale of the sensors only, rather than the system, a whole gamet of other considerations enter into the picture, including the mechanics and efficiency realizable in marketing the product.

Is the market big enough? Are we in a position to exploit it? Can the product command a satisfactory price?

What about competition? The probable competitive lead time? The patent situation? Royalties?

Would Government support under IRAP or PAIT be available for the development? Would the manufacturing restrictions of such support make the support uneconomic?

When you contemplate a list like this, you wonder how any sensors get developed at all! Many don't!!

These questions, and others, because we haven't exhausted the list by any means, are important. Ignoring any of them is often a shortcut to disaster.

PRODUCT ANALYSIS

On deciding that a market exists for a sensor to carry out a given function, the next decision is as to the method to be used.

If we want a sensor to detect moisture, one might use a-c conductivity, d-c conductivity, capacitance, microwave absorption, infra-red absorption etc.

If we want to measure the uranium content of ores we might use gamma or beta radiation, x-ray fluorescence or a number of other techniques.

Light scatter has been used to detect copper and gold ores.

Which method is chosen usually comes down to signal to noise, in a generalized sense. Invariably a sensor detects a whole group of variables in addition to detective and/or measuring the one you want. The trick is to accentuate the sensitivity to the desired variable and reduce the sensitivity to the undesired ones.

With the advent of the digital computer to the Process Control System scene, the sensor requirements can be somewhat less stringent. A suitable program together with sensors responsive to related variables can provide compensation not otherwise available, or available only at an expense of great time, effort and cost. This configurat-ion can markedly reduce the complexity of the sensor and/ /or improve its accuracy and repeatability. In turn, the development time and costs may be significantly reduced.

Software, in general, is less costly, more flexible and more easily and economically upgraded than hardware. Unlike hardware it's cost of reproduction is negligible.

In addition to the above considerations, one must take into account not only the state of the art of the various methods but the knowledge of it of the developer, and the compatibility with present hardware and software in use by him.

In case a number of methods seempractical, rough development budgets for each can be prepared for comp-arison purposes.

The development budget for the method chosen should then be finalized, and a Development Summary showing times, people, materials, facilities, tools required is prepared. A Pert Chart is extremely useful.

TABLE I
Development Summary

1. # of units that can be sold:

(See Table on Next Page)

Year 1	at $	each or	$ Total
Year 2			
Year 3			
Year 4			
Year 5			
Total Units			Total $

2. Estimated manufacturing costs at above rate: Total $________

3. Estimated Product Development cost: $____________
   " Market " " $____________
   " Total Development cost: $____________

4. Estimated after tax profit is: $\frac{1 - (2 + 3)}{2}$ = ________

In this table a five year amortization period is chosen, but obviously this will vary with the product and the industry it is to serve.

Note that in general, the units estimated to be sold will vary from year to year, being small during the introductory period, rising to full market potential and then tapering off as new competitive products appear.

Also the price will have to take market strategy into account, rising from an initial introductory price, reaching full profit potential and then falling as the market becomes more competitive. When the product can no longer command a price at which profit can be made, the product is obsolete as far as its supplier is concerned.

The acceptable after-tax net profit will also vary with the risk associated with this particular investment and the financial environment of the company doing it. It would be difficult to justify a figure of less than 10% on sales. System selling may, of course, change these criteria.

PRODUCT SYNTHESIS

The decision is taken to go ahead and research and/or development commences according to plan. This plan, like all plans, should be subject to 'audit' from time to time to disclose 'snarls' or projected 'snarls' in the program.

A bench model is generated from this work which is then exhaustively tested in the laboratory. Often complex environmental models have to be set up to perform these tests in a meaningful manner. Field testing, if feasible at this stage, is invaluable. If it is not feasible at this stage it is imperative after the next model, the production prototype is constructed.

This brings up the importance of a high degree of co-operation between the developer and the ultimate user. The latter must be willing to permit the installation of a new untried device on his operating system. Not by any means are all users likely to agree to this.

The usual user stance is 'We don't even want to be #3!' I can understand this. But thank God for these few progressive souls who are willing to be #1.

Field testing involves putting the sensor on line and comparing its readings against such things as hand samples, metallurgical analysis etc. Correlating the new sensor measurements with other variables is often helpful.

Ease of calibration, repeatability and reliability under field conditions are essential criteria of performance.

When the sensor returns from its field trials, the necessary engineering modifications are made. In designing the product on prototype, which is the next stage, additional factors such as ease and economy of production, and ease and economy of field servicing must be taken into account. In some products, the latter consideration is often lamentably neglected. This is like building a time bomb of user discontent and an inhibitor of future sales into the product.

Production planning, purchasing followed by production and stocking are set in motion.

MARKETING

Marketing now enters the picture again. The whole sequence started with the market and to the market it must return.

Marketing plans start at the time the decision is taken to go ahead with the project. A number of important decisions have to be made in this area as well. If the sensor is to be part of a system, the means of carrying it to the market is already available. If this should not be the case, then the old question of the use of agents or in-house salesmen will come up.

The production of information must commence, literature, advertising, instruction manuals, application information, talks, sales presentations etc.

All these things are essential parts of the program, just as important as the development itself.

The program must be a marketing success or even the most brilliant technological achievement will turn out to be a business disaster.

INSTALLATION AND SERVICING

People buy things to perform desired and/or needed functions for them. In Industry they buy things that they believe will make money for them.

It is not sufficient that a product should be well designed and be capable of doing a good job. It must be properly applied and maintained. If it is not, the customers will become disenchanted with the supplier even if 90% of the problem is due to their own reasons.

If then a supplier expects to get this development money back, he must anticipate the problems of installation, calibration and maintenance that will be encountered by the user and do everything he can to minimize them.

Some of these can be reduced by adequate information as mentioned above, some by proper selection and access to spare parts, and last but probably most important, operator training, instrument engineer training and adequate field service support.

If the sensor is part of a turnkey installation, most of these problems are greatly reduced. The supplier takes care of them while the user gets on with his business. I think this accounts for the great increase in this way of doing business in the Paper Industry in the last few years.

CRITERIA OF A GOOD SENSOR DEVELOPMENT

There are many criteria of a 'good' sensor development but in a business sense, two are;- both the user and the developer must make money, and both are sufficiently happy with the program that they are looking eagerly toward the next one.

OBSOLESCENCE AND RE-ASSESSMENT

In due course, the development will run its market course. Even with updating, re-engineering, application modification and the whole gamet of life-stretching exercises that can be devised, time will run out.

Other sensors may appear which will nibble at the edges of its field of application and diminish its market. Perhaps newer and better sensors will appear which will totally supplant it. Those who love it, because they grew it, may still hang on. But sooner or later it must be buried.

If the developer is on his toes, it will be he who has already brought out its successor. But often it isn't, because you can't win them all!!

Then the real soul searching reassessment begins.

AN EXAMPLE OF SENSOR DEVELOPMENTS

During the hey-days of uranium prospecting, we developed a low voltage geiger tube and incorporated it in a new light weight geiger counter that reduced the size and weight of this instrument by 75%. Sales soared.

Within a few years much of the market disappeared when scintillation counters with a much higher gamma sensitivity appeared on the market.

Then air borne scintillation counters came in when large scintillation crystals became available.

Three developments in ten years, but then they all vanished. The U.S. stopped buying uranium and most of the World stopped looking for it. The market for all practical purposes disappeared and with it the ability to amortize the last development. (The previous ones had paid for themselves many times over).

TABLE II

LIST OF SOME OF THE SENSORS DEVELOPED AT EA

1. Low voltage Geiger tube for radioactive ore detection, density and level detection and measurement.

2. Scintillation sensors for α, β and γ radiation for exploration and possible geological survey purposes.

3. Ion chambers for special purposes including Beta gauges.

4. On-line caliper gauges for paper measurement

5. On-line opacity gauges for paper measurement

6. Ore detectors and measurement devices for uranium, iron, copper and gold using gamma radiation, neutrons, lasers etc.

7. a-c Conduction sensors for low moisture measurement in paper. (redevelopment)

8. Microwave sensors for high moisture content of paper and pulp.

9. Microwave sensors for low moisture content of paper board etc.

10. First digital differential speed measurement system.

Cominco Ltd./1385 Cedar Ave./Trail, British Columbia, Canada/Tel. (604) 364-2581

Services.

Mine Evaluation and Production Scheduling (MEPS)

MEPS is a computer system developed for the Mines and Exploration departments of Cominco Ltd. It is an evaluative planning tool for surface mining proposals and projects.

Contributions from Geologists and Mining Engineers were instrumental to the successful development of MEPS. The result of this collaboration between mining professionals and computer specialists is a product that will aid in mine evaluation and production scheduling.

MEPS is easy to use, readily understood and reacts to a vocabulary that is familiar to the mining industry. Extensive error editing procedures significantly reduce the time required to proceed from problem recognition to solution.

Some highlights of MEPS are:

1. Geological data storage and retrieval.
2. Statistical analysis and variograms.
3. Contour maps of assays and geological horizons.
4. Trend surface analysis with residual evaluation.
5. Ore reserve calculations.
6. Open pit design.
7. Marginal profitability calculations on pit walls.
8. Production scheduling.
9. Vertical cross section plots indicating pit outlines, ore grade contours and selected geological horizons.

Cominco Applications of MEPS

1. Valley Copper

   Valley Copper is a large low grade porphyry copper deposit located in south central B.C. MEPS was used extensively to complete the feasibility study of a 40,000 ton/day mining operation. A sequence of pit limits were designed to maximize profit over the life of the mine.

3. Pine Point

The Pine Point property, in the Northwest Territories, contains several high grade lead-zinc deposits. MEPS is used for plotting lead-zinc contours, ore reserve calculations and pit designs.

4. Sullivan Mine

The Sullivan Mine at Kimberley B.C. is the largest lead-zinc mine in the world. MEPS will be used to store and retrieve geological information obtained from several thousand holes drilled over the past 50 years. MEPS will also be used for plotting ore grade contours and ore reserve calculations.

General Philosophy of MEPS

Since Mining and Geology are not exact sciences, it would be futile to attempt the development of a completely automated mine planning system. MEPS is designed to compensate for this limitation. When basic theory falls short of practical know-how, MEPS allows mining engineers and geologists to interact with the computer and guide it to desired solutions. For example, the computer's geological interpretation may be modified in areas where it appears unreasonable. Likewise, computer pit designs may be altered by introducing ramps, moving walls and/or changing wall slopes in any section of the pit. These modifications are quickly and easily specified by using familiar terminology and data.

MEPS is organized into three distinct areas. These are:

1. Data Managing
2. Contouring
3. Mining

Data Managing

Geological data is edited, stored, retrieved and maintained by this portion of MEPS. A major contributing factor to its flexibility is a generalized geological data file definition. Since no two applications are the same, data definitions may be tailored to reflect the characteristics of the ore body and the objectives of the study.

Contouring

Contouring may be considered the heart of MEPS. All methods for developing numeric surfaces from randomly spaced data have a pronounced influence on the results of ore reserve calculations and pit designs. Once an accurate numeric representation of an ore body is developed, volume and grade calculations are comparatively simple. Any discrepancy between actual and expected grades may only be contributed to poor contours.

MEPS provides four contouring methods:

1. trend surface
2. polygonal
3. moving weighted average (kriging)
4. close trend

The last method is unique to MEPS. One of its distinguishing features is its ability to handle directional bias and localized trends. When detailed contour maps are required, as in ore reserve calculations, the close trend method is believed superior to all known methods.

To complete the contouring capabilities of MEPS, there are a number of generalized routines. Some of the major topics covered by these are:

1. contour plotting
2. logical and arithmetic operations on numeric surfaces
3. surface integration to calculate volumes and areas
4. creation and storage of geological files for use in subsequent mine design and simulation studies
5. reliability estimates on numeric surfaces
6. claims and geological zone boundary definition

Since a geologist is ultimately responsible for all ore reserve estimates, he may exercise an override option to modify computer generated contours. To eliminate this option would be reckless and out of line with the general philosophy of MEPS.

Mining

The mining portion of MEPS is used to formulate and evaluate open pit mining plans. Its main organization is along two lines, automatic and manual pit designs.

Once an ore body has been mapped and stored in geological inventory files, ultimate or most profitable pit limits may be calculated automatically. These designs are based on current or expected economic factors such as metal values, mining and milling costs. Proven techniques are included to determine the sequence of pit limits to maximize profit over the life of the mine.

The manual side concentrates on the ability to evaluate specified pit designs or incremental pit expansions. A simple coding technique was developed to specify any type of pit topography. MEPS will calculate all pertinent tonnages, grades and profits for each pit design or expansion. To aid mining engineers in determining optimum pit expansions, marginal profitability calculations may be requested for any section of pit wall. An additional feature of MEPS is its ability to determine tonnages and grades on each claim in a multi-claim pit. Appropriate royalty calculations are also made for each claim.

June 12, 1972

Discussion & Plenary Group Summaries

COMPUTER APPLICATION AND AUTOMATIC CONTROL WORKSHOP
FOR THE MINERAL PROCESSING AND METAL PRODUCTION INDUSTRIES

Motions and Resolutions
Thursday, May 10th, 1972 PM Session

MOTIONS CARRIED

1. That, if possible, this group be established as an affiliate of the Canadian Institute of Mining and Metallurgy (CIMM) for continued information transfer related to computer applications and automatic control.

2. That the NRC Associate Committee on Automatic Control (ACAC) or the new CIMM body conduct a survey, similar to the one just made, approximately every two years.

RESOLUTIONS AND RECOMMENDATIONS (generally agreed but not formally voted and carried)

1. That the present NRC-ACAC, or the sub-committee of the present study accept the responsibility for action on the above motions.

2. That an index, data bank or repository of all known process models be established.

3. That the catalogue of process models indicate which have been tested and found valid; those which have been untested; and also, those which are known to have been tested and failed.

4. That a special workshop be held to determine the types of models available and their specific areas of applications (eg. to select minerals).

5. That a catalogue of individuals and their personal skills and knowledge be developed, to facilitate technology transfer between individuals and mutual assistance in problem solving.

6. That an index be established of companies willing to provide an opportunity for a university professor to obtain industrial problem solving or system implementation experience such as under the terms and conditions of the NRC Senior Industrial Research Fellowships.

7. That a counterpart to the NRC Senior Industrial Research Fellowship be established with funding to permit senior industrial personnel to spend a year in university.

8. That more opportunities be provided wherein appropriate industry personnel are used to teach courses in universities.

9. That in view of the interest shown in the government assistance programs for indutrial research and development, that a summary of all such programs be included and distributed in the workshop minutes.

:pm

COMPUTER APPLICATION AND AUTOMATIC CONTROL WORKSHOP
FOR THE MINERAL PROCESSING AND
METAL PRODUCTION INDUSTRIES

Motions and Resolutions
Friday, May 12th, 1972, A.M. Session

MOTIONS CARRIED

1. Moved by Arden that a sub-committee investigate the possibility of establishing an economic modelling centre by the government which would establish a data source.

2. Moved by Madge that interaction between government and industry be at the technical working level.

3. Moved by Ferguson that Operations Scheduling be carried out in an independent area such as administration rather than accounting.

4. Moved by Ferguson that a manual be developed to define terms and list statistics available be established in industrial usable terms, such as was developed by the steel industry.

5. Moved by Ferguson that students enrolled in mineral courses be encouraged to take management science options and industrial personnel be encouraged to attend managerial seminars.

6. Moved by Arden that universities be encouraged to combine computer science with applications.

RECOMMENDATIONS (not formally voted on)

1. Control and planning by industrial management should be developed at a higher level than what is being carried out now.

2. Development of concept/interchange of ideas should be carried out by small users.

3. An over-emphasis of the dollar value is made in management information system reports.

4. Educators should respond to the needs of industrial requirements by modifying the curriculum when necessary.

5. Continue to learn more about ourselves and to be aware of the environmental implications.

/hh

COMPUTER APPLICATION AND AUTOMATIC CONTROL WORKSHOP FOR THE MINERAL PROCESSING AND METAL PRODUCTION INDUSTRIES

Motions and Resolutions
Friday, May 12th, 1972, P.M. Session

MOTIONS CARRIED

1. Moved by Littlewood that the new group which is to be formed should have a special group devoted to sensors and measurement.

2. Moved by Brailey that universities become more involved in the problem of measurement in industry.

RECOMMENDATIONS (not formally voted on)

1. Prime requirement is that instrument manufacturers supply X-Ray Analyzers which are flexible enough to allow the user to buy either an entire system or components.

2. The Department of Energy, Mines and Resources should carry out a critical study of sampling and produce a handbook.

3. Directive to the Department of Energy, Mines and Resources to establish a definite calibration procedure for on-stream analyzers. Range of samples made should be taken from the process stream etc.

4. Since the flow rate measurement is inaccurate, methods must be found to encourage developments. Possibly NRC could contract development in universities through IRAP's but industry should be prepared to make test facilities available to prove new methods.

5. A government agency should develop sensors for molten metal baths. Industry should make test facilities available.

6. Measurement of high temperature gases should be studied by a government agency.

7. The priorities of this group be set: (a) involvement with problems of a practical nature within a short period of time (b) model development (c) better ways of justification.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry."

University of Western Ontario

May 12 - 13, 1972

Discussion Group Name: Modelling Simulation & Control of Flotation

"	"	Chairman:	H.W. Smith	Date 11/5/72	
"	"	Secretary:	A.H. Gillieson	No. Present:	10

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

---

1. X-ray analyzing: adequate for control but better calibration required, more closely allied to ore composition and physical nature of slurry.

2. pH: accuracy in plant $<$ 0.2 pH (McCullen) glass electrode no trouble with abrasion, maintenance difficulties.

3. Models: required to match variations in feed with collector control. Practical experiments to ascertain parameters.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry."

University of Western Ontario

May 12 - 13, 1972

Discussion Group Name: Modelling Techniques for Process Control and Plant Design

" " Chairman:	P. Wood	Date:11/5/72	
" " Secretary:	Peter Browne	No Present:	12

SUMMARY, CONCLUSIONS & RECOMMENDATIONS:

Why Model?

For continuous processes dynamic models are useful to:

- Predict output
- Compare prediction with reality and deduce disturbances you did not measure
- simulate and tune control strategies.

How to Model?

Pulse testing and pseudo-random binary sequence tests have been used.

Shortage of modelling skills

NRC hybrid installation can help.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry".

University of Western Ontario

May 12 - 13, 1972

Discussion Group Name: Modelling, Simulation & Control

" " Chairman: F.J. Kelly Date; 11/5/72

" " Secretary: S. Vezina No Present: 5

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

---

1. Design models for grinding mills are well established.
2. Grinding models have minimal use in simulation. They must be modified for on line data.
3. For a given grinding circuit configuration, a survey of established control systems should be conducted to determine which is the best system.
4. Existing cyclone models must be verified by plant data.
5. An "Instrument and Control Committee of C.I.M. should be formed.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry."

University of Western Ontario

May 12 - 13, 1972

Discussion Group Name: A Review of Smelting Models and Control

" " Chairman: L. Nenonen Date: 11/5/72

" " Secretary:

SUMMARY, CONCLUSIONS & RECOMMENDATIONS:

---

1. Models are being developed for process design (analytical models) and statistical models for process optimization. The main problems are measurement. Sometimes good models are developed but their potential applications are not fully exploited.

2. Some companies work on aspects of modelling, i.e., they have ideas of individual process features but have not unified them in an overall process model.

3. There is a basic conflict between practical people and more highly trained people re development of models, i.e.,practical people do not believe in them.

4. Aside from the value of such models in individual process control, they are also valuable in overall plant control.

5. Universities should base their models on plant flow sheets and tackle real processes.

6. Models tell us what we need to measure and often eliminate the need for difficult to get measurements.

7. Return on the investment, length of time required to develop models are important factors.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing and Metal Production Industry"

University of Western Ontario
May 12-13, 1972

Discussion Group Name: Economic Justification
Discussion Group Chairman: J. Scrimgeour — Date: May 11th, 1972
Discussion Group Secretary: R.A. Ferguson — No present: 16

SUMMARY, CONCLUSIONS & RECOMMENDATIONS:

1. (a) Approve project by just going ahead (on an R & D basis)
   (b) Do a full economic study - variables to control, disturbances, estimate improvement possible, estimate economic benefit; outputs desired, causes of upsets, how they can be controlled; full cost/benefit.
   (c) Do (b) so often that everyone knows all about it - no one would dream of building a new plant without computer control.

   (a) is mostly used; few at (b); none at (c)

2. Examples of fast pay-backs:
   (a) Computer ensures contracted amount of Natural gas is always taken.
   (b) At Lake Ontario Steel cement kiln furnace temperature critical, up and down; computer controls better and closer.

3. Polymer examples, where discipline of developing model led to better understanding fundamentally (3 years) so computer no longer needed.

4. Cannot ever recover 100% ore. Many people can get 95% without computer equipment. Therefore last portion of saving is hard to prove and get.

5. PAIT grant and tax incentives for justification study would help. Knowledge about PEP needed.

6. Mining should be treated as a non-renewable resource and you must get the best recovery on first time through, not in hoping to reprocess the tailings fifty years later.

7. Should use "total systems approach" evaluating exploration through tailings recovery - seek global optimum, not suboptimization.

8. Standard packages like paper industry.

9. A body for technology transfer (CIMM).

10. University professors should spend minimum six to twelve months in industry working on A SPECIFIC PROBLEM THROUGH TO SOLUTION, e.g. NRC Senior Industrial Fellowships.

11. Devise more package-turnkey packages.

12. CIM - should have sub-committees to act as clearing house.

13. This type of gathering meets a communications need; should meet about once per year.

14. ACA list of publications should be more widely distributed.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry."

University of Western Ontario
May 12 - 13, 1972

Discussion Group Name: Computer Problems
" " Chairman: F. Oswin Date: 12/5/72
" " Secretary: G. Samuel No. Present: 11

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

Hardware breakdowns and software errors cause down time. Total maintenance vs. contract maintenance: depends on location (remoteness) and number of similar installations.

Data transmission over telephone lines not reliable enough for control. Cost of air conditioning and maintenance. Cost of computer room. Most hardware problems encountered with sensor interface. CPU generally reliable. Sensor back up involves high wiring and capital cost. In poor environment discs, tape readers and punches wear out.

How to decide which vendor to buy from requires knowledgeable people, both in hardware and software. Standard software for process control would assist in this problem. Being developed by Purdue.

One source must take responsibility for complete system. Diagnostic checks must be designed into system to identify faults. In general these are not provided by vendor and have to be written by user. Note may have problems with skilled bodies, e.g. instrument and electronic maintenance.

Multi-mini vs. maxi. Multi-mini requires more programming for intercommunication. However, this is standard package. This also allows for mini stand-alone for limited period.

Operator acceptance. Problems with online testing - protection of running programs - online tuning of new programs.

Hardware problems are largely overtime. Most computer problems in the software.

Required to be developed - On line diagnostics-should be provided by supplier. More reliable peripherals.

Changing technology - problem of spares. CPU speed is not a problem.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry."

University of Western Ontario

May 12 - 13, 1972

Discussion Group Name: Economic Modelling

" " Chairman: R.W. Stahlberg. Date: 12/5/72

" " Secretary P.J. Ripley No. Present: 8

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

Several Modelling Levels:

1. Project evaluation, capital investment, (DCF, etc).
2. Continuing systems to evaluate current processes (econometric models).
3. Forecasting short and long term production and cash flows.

Conclusions:

1. Economic modelling can only be performed when accounting and production data is available.
2. The state of the art of economic modelling in Canadian industry is encouraging.

Recommendations:

1. Economic models should continue to be developed as an interdisciplinary tool.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry"

The University of Western Ontario
May 12 - 13, 1972

Discussion Group Name: Mine Planning
Discussion Group Chairman: D. Madge — Date: 12th May 1972
Discussion Group Secretary: J. Scrimgeour — No. Present: 7

SUMMARY CONCLUSIONS & RECOMMENDATIONS:

A. Three most important topics: (1) Mine evaluation (2) Mine planning/Hewlitt Metal (3) Haulage and simulation. Best work by Canadian Geological Service in Ottawa. Interpretation of what is in the ground, item (1) is most important. Also Lefkowitz of Placer Mines. Computer time for some mine planning programs was excessive. Mine managers and mining engineers are quicker to accept O.R. technique than geologists.

B. Where used, the best accepted O.R. technique is Monte Carlo Simulation e.g. see CORS Journal on sizing the fleet at Pine Point. Models of shovel speeds etc. will give loading time data etc.

C. Simulation shows that a truck dispatcher could save 2 trucks in 30 but it is hard to sell present (and future) managers.

D. O.R. is starting to be used for underground mines - e.g., trackless mines. Also can use E.D.P. for maintaining inventory of reserves but very hard to estimate weights and grade of material pulled from slopes. Same data indicates head grade at concentrator about 30 hours later.

E. To develop better predictors you must use them. Then evaluate and improve.

F. There may be an opportunity to apply truck tracking or automatic vehicle identification (AVI) systems for head grade estimating but the real opportunity for better control is in the concentrator.

G. Operating rules for distinguishing waste from ore are very empirical and open to question.

H. The use of computer graphic displays, light pen inputs etc., will be useful in mine planning when they become lower in cost.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry."

University of Western Ontario
May 12 - 13, 1972

Discussion Group Name: Management Information for Control
" " Chairman: R.A. Ferguson Date: 12/5/72
" " Secretary: A. Molinari No. Present: 16

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

INDUSTRY

1. Industry should get together to set up guidelines and reference manuals for "information for control" similar to the organization in the steel industry "Steel Industry Systems Association."
2. Organizationally the MIS should report to Operation Department not accounting since MIS is an operating function.

GOVERNMENT

1. Statistics are not reliable in the eyes of industry.
2. Statistics should be defined in more "industry usable terms."

UNIVERSITY

1. Students taking mineral courses should be encouraged to take optional "management science" courses.
2. Managerial seminar for personnel with some years of industry exposure after graduation.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry."

University of Western Ontario
May 12 - 13, 1972

Discussion Group Name: Operations Scheduling
" " Chairman: Manfred Kretzschmann Date:12/5/72
" : Secretary: A.H. Gillieson No. Present: 8

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

Discussion Group: Operations Scheduling

1) While there appears to be an encouraging progress in the scheduling and optimizing of unit operations, integration towards scheduling the overall production process and tie-in with long range planning is still lacking.

2) Control and planning operations should be integrated at a higher level in the organization, although the development of practical applications has to start from the bottom up.

3) Where scheduling on a larger scale has been applied successfully, improvements were usually observable. However, we still don't seem to be able to effectively measure the economics so as to determine whether and how far away we are from the optimum. Thus there has to be some concurrent development in the accounting systems along with the economic models.

4) The mathematical tools available today are generally found adequate, although some special adaptations, such as a variant of linear programming for especially mining operations, might be considered.

5) Education, development and dissemination of ideas and concepts through people is still a most important factor. Surveys of applications in use, their successes and failures would be very useful.

Footnote: In view of the range of applications from corporate planning models to day-to-day job schedules the time allowed for the discussion of this subject was not nearly enough.

(Revised May 15/72, M.K.)

WORKSHOP

"THE USE OF COMPUTERS AND AUTOMATIC CONTROLS
IN THE CANADIAN MINERAL PROCESSING INDUSTRY"

University of Western Ontario, May 11-13, 1972

Discussion Session: "Operations Scheduling"

M. H. Kretzschmann, Falconbridge Nickel Mines Limited

Where Do We Go From Here?

The Canadian Mineral Industry shows continuing and growing interest in computer applications. Wider acceptance, however, will increasingly depend on proven returns, as management and users are taking a critical look at the profitability of their computer investment and its overall contribution.

Operations scheduling is likely to gain more ground in applications related to practical problems that serve immediate or easily definable phases in the operation. The application of complex mathematical models, particularly on a large scale, will depend largely on the development of personnel who are able to relate and adapt the models to the real life situation.

Mini computers and small business systems are likely to influence the demand for technical personnel, experienced in programming in small machines.

There were some 30 scheduling schemes described between 1965 and 1970 in the proceedings of the Annual Symposia* alone, covering applications in mining, milling, smelting and transportation. Their aims were generally to:

- attain fixed, set objectives such as a given production rate and/or smooth grade, finishing a project in a given time, etc.,

- make the best possible use of the resources available,

- maintain the best possible operating conditions in the production process or the technological process.

They cover a wide range in short and long term production scheduling from the most immediate such as on-line blending and scheduling over daily routine work schedules to long range planning.

Technically, scheduling applications may make use of one or more concepts or techniques:

- analytical (differential-calculus)
- mathematical-iterative (linear programming, dynamic programming)
- heuristic (successive trial optimum seeking)
- logical-algorithmic (CPM, Pert)
- simulation (any envisioned model of the operation)

Most of the applications in the mineral industry use mathematical programming (largely L.P) and simulation.

*Annual Symposia of Computers, OR Techniques, etc.in the Mineral Industry.

As scheduling is an integral part of the management decision-planning-control complex, the scheduling objectives derive from and are subject to currently prevailing corporate and operating management's decisions, policies, philosophies and opinions. We may, therefore, have different objectives in applications that appear technically similar or are the same.

As scheduling in most cases involves evaluating large numbers of combinations or alternatives, complex mathematics or scanning of large data sets, computer scheduling techniques evolved quickly along with the proliferation of computer installations in the industry.

How much has really been accomplished?

In 1969, M. T. Pana commented upon the wealth of papers published at that time, "although a lot of good work has been described in the literature, it appears that very few of these techniques relating to production scheduling and planning are actually being routinely applied in the industry".

We should establish if what was said about the largely American scene, at the time, is applicable to the Canadian industry today.

There are, on occasions, differences in viewpoints regarding the existence and usage of computerized procedures, depending on whether one talks to the computer people or the users, even in the same organization. Sometimes the computer techniques are only played by a few dedicated computer types while the rest of the organization continues to use the old methods.

If the above statement is still true, perhaps we should look at it as a businessman faced with a large pile of unsold goods. Granted, some of these papers may have been educational and some of you may remember conventions heavy with theses optimizing hypothetical ore bodies, mining and milling operations, but the major share of the contributions came actually from industry. Thus, our immediate efforts should be directed at finding out what is inhibiting broader acceptance and use of computer techniques in practice.

Communication and Human Relations

Just as a chain is only as strong as its weakest link, a computer procedure intended to steer a production process has to reach through all levels of management, supervision and technical staff in order to be effective.

One problem that confronts managers and operators alike is the complexity of the techniques being proposed, or rather their unintelligibility, and what-if any - the expected improvements in real terms might be; that is: throughput, recovery, cost, etc. Frequently used terms such as: "greater efficiency", "improved performance", "better control", etc, are not only rather vague, but also too much of a cliché to be convincing.

We should consider an old pedagogic axiom and ask ourselves: "If we can't make our proposed methods and objectives clear to others, how well do we really understand them ourselves?" If nothing else, this will encourage us to dig deeper and learn more about the processes that we want to schedule and control. This approach will put us into a better position to come up with procedures that are more applicable.

In complex optimizing models, decision makers frequently find it difficult to understand their role in defining the model parameters. On the other hand, it was found in one case that there was much greater acceptance and understanding, when the basic relationships were shown in simple graphs from which they could determine the desired operating conditions as points.

Among the areas, where other major hang-ups could occur, are the relations with the technical personnel at the user end who may suddenly see their positions threatened. Whether or not it is management's intention to offset some of the computer procedure's cost by savings in labour, such fears may be very real and may threaten the successful implementation and application of an otherwise sound and well designed computer procedure. It is not only essential that we dispell and eradicate those fears, but we must also enlist the active cooperation of the planners, schedulers and operators who have probably the greatest contribution to make in the actual implementation, refinement and ultimate perfection of the models.

We can, of course, not escape or brush over the general dilemma of automation, if labour saving is meant to be an objective. It is unfortunate that the jobs to be affected are not the most menial and mundane (in fact computerization may create more of those) but are instead functions that require some education, technical know-how and perception of the operations that provide the company with a training ground and pool of manpower, from which jobs people can build up experience and advance to greater responsibilities.

On the national level, we have to consider the broader effects of automation which means largely imported technology vs Canadian jobs.

Economic Factors:

However, the interfacing of computer techniques with human relations and communication may be considered quite manageable problems compared with the challenges that will face computer applications in the seventies.

The diminishing proportion of variable cost vs fixed cost tends to restrict the operating range and thereby the decision interval and optima may become self evident by simple contemplation.

Shrinking profit margins tend to reduce the application of computers and the user's willingness to invest in application developments. Present trends suggest that organizations (and periods!) with abundant resources and wide profit margins show the largest expenditures for computers and related resources. Thus, it appears that developments are governed largely not by technical needs but by the availability of funds. In other words, they are still considered luxuries.

Such views will have to change drastically if the application of computers is to continue at an appreciable rate. This does not mean that management is likely to turn increasingly against computers, in fact their interest in them appears to continue unmitigated if not more intense, but they are going to demand increasingly hard proof of the expected returns and possibly their verification.

Facilities and Other Applications:

The lack of suitable facilities turned up in the survey and was also the main contributing factor in the failure of at least one other known case (Alcan Jamaica, 1970). What is not known here, is the number of applications that were never developed or tried because of this lack.

Access to a facility is no problem for the larger users who have no trouble justifying computers for several applications, but it is a deciding factor for small operations, especially in remote locations, where they usually also cannot afford full time personnel to administer and support any computer applications. Part time attention by user personnel normally engaged in other activities may be one answer, and suitable user education and information may help to provide a solution.

Integration of computer scheduling with related applications, i.e., as part of a larger system design, can be quite important with regards to cost as well as general utility. Preparation and entry of data is costly and the ability to make use of the same information in more than one way generally enhances the acceptance of the individual applications. At LKAB, the production scheduling files also produce Fe grade maps, Phosphorous maps, drift plan data and other information. In the steel and metal working industries, production control systems are usually closely tied in with other business procedures: order entry, inventory control of raw materials and semi-finished goods, timekeeping, shipping. billing and accounts receivable.

Integration of otherwise unrelated procedures that are able to follow a common source data path, entry records, files, etc., greatly reduces both data preparation cost and demand on machine resources and provides an effective means to turn a modest batch computer into the small man's multi-job stream processor.

Teleprocessing is said to provide an effective solution to users in remote locations. However, slow speed (teletype) time sharing is inexpensive only at a very low usage, and its cost increases rapidly with higher print volumes that some scheduling applications require and for which its capabilities are too limited. RJE batch processing provides more capability for volume output at a lower incremental cost but starts at a higher fixed cost. Whether teleprocessing will be able to provide computer access at a cost lower than today and by how much is not too certain. Recent developments in small data processing computers have produced systems of capable configurations at a cost comparable to the fixed cost portion of RJE terminals.

The diversity of applications and methods would seem to make it difficult for the computer service industry to develop and maintain system support at a low enough cost to make it attractive to the small, remote user. If any noticeable headway is to be made, some form of assistance would be required, but how?

If present events are an indication, the public may have to foot the bill for systems and/or application development, as for example, in the case of Queen's QUIC/LAW legal information retrieval system. The moral question is: "Should the taxpayer be expected to pay for a facility that apparently benefits only very few?" In this case, the legal profession does not happen to be exactly a needy group! Must we show that the general public may derive real benefits from such developments, that is: is it really in the national interest? Recently a telephone company executive was asking essentially the same question while referring to the huge outlays that the carriers have to make to provide better data communication services. Since the users are not that numerous and are already clamoring for lower rates, should the ordinary telephone subscriber have to pay to provide for a return on those investments?

As mentioned before, small business type computers may provide an attractive alternative to TP in many scheduling applications except maybe those that are based on mathematical programming. Their justification, of course, would usually depend on other applications.

Process Control computers operating under a disk executive system and with a modest amount of disk storage in excess of the process requirements can conveniently supply computer access at remote mine-mill sites. Formerly, non-process or free-time sharing was only available with medium to large Process Control systems. However, in certain configurations, and with closely tailored software, minicomputers can now match or even outdo larger machines in this capacity.

What is Really Essential?

Currently there seems to be far too much emphasis on the means rather than the ends. It appears that in all these discussions about problems with computer facilities, hardware, software, telecommunications, manpower and even human relations, we miss (or possibly - cover up?) the basic point before going to work on solutions. How much do we really know about the operation and/or the process?

The outputs of the production process are the collective result of men and machines, human endeavor, motivation and concern, supervisory skills, forethought and vision, reliability of equipment, availability of resources when needed and much more. Many of these cannot be quantified at all, others only with difficulty, and even those that are quantifiable may be difficult to interpret or are apt to lead us astray.

Frequently when excellent results are being achieved, the momentum and the perfect meshing of the various functions in the operation may be readily apparent, but maybe only quite intuitively. Sometimes even the experienced observer might not be able to assess the situation any closer than perhaps "we had a good day".

If disturbances occur, it is not always possible to relate what caused what, even if quantified data is available.

In metallurgical processes, empirical approaches using correlation-regression or other variance analysis based techniques are greatly hampered by the interdependencies in the data. These and other "root problems" may help to explain why views and opinions among the decision makers often vary, and this is also what makes the introduction of computer procedures difficult.

There has to be considerably more fundamental research and a deeper understanding of the problems at hand. Personnel development seems to be a starting point but isn't easy to accomplish. The particular qualities that we are looking for: experience, human relations, perception, vision and imagination besides technical know-how are not necessarily related to extensive formal education and high academic qualifications. Also, if talent in these areas is discovered, it is usually quickly absorbed by the operation. Certainly the lack of effective communication between industry and academics doesn't help, neither does complaining about industry's "apathy", which could, by the way, be disputed. Perhaps if industry is apathetic about trying new theories, it is because it has been oversold with something that didn't produce what it promised.

Where are We Really Going?

While we are back at the human problems we may devote some final thought to our present values and goals and the quality of life that is mentioned so often now even though it may be somewhat beyond the scope of this discussion. We hear increasing public criticism of poorly performing systems. But what about the other side of "optimization", i.e., the "good" systems? Economies in computerized designs of equipment so as to cut down on latent excess performance (in excess of the ratings), may produce savings to the manufacturer as well as enhanced sales due to limited operating range, i.e. with effects akin to planned obsolescence, or: minimizing one's working capital tie-up by lower inventories and more frequent computerized purchasing of small quantities, produces savings for the user by tieing up the suppliers capital (by invoice lag).

Thus, many so called "optimizations" are at the expense of somebody else. Since those affected will likely counteract by pricing their products accordingly, the question is what are we really achieving and how does it affect the economy as a whole?

Then, could it be that computer operations inflated beyond justification have added to the cost of the product and thereby contributed to inflation?

It has been said that people's views and ideas are, to a very large extent, shaped by the events of their time. Could it therefore also be that the selling (and overselling) of concepts like Cash Flow and Present Value vs. Return on Investment has wetted the business appetite for the "fast buck" and thus contributed to the rising tide of expectations and social unrest? Although these thoughts may not seem to worry us now, perhaps they should.

COMPUTER APPLICATION AND AUTOMATIC CONTROL WORKSHOP
FOR THE MINERAL PROCESSING AND METAL PRODUCTION INDUSTRIES

Motions and Resolutions
Friday, May 12th, 1972, P.M. Session

Discussion Group Name: Sensors for Process Measurement

Chairman: Dr. H.W. Smith

Session Developer: F.J. Kelly

RECOMMENDATIONS

On-Line X-Ray Analysis

1. It was recommended that the Department of Energy, Mines and Resources (EMR) carry out a critical study of solids sampling, possibly leading to a handbook for the design of samplers.

2. It was recommended that equipment manufacturers adopt a more flexible approach, that is they should be prepared to provide either a whole system or components.

3. It was recommended that EMR define and establish a calibration procedure for on-line X-Ray analysis; it should include the variables included in the talk by Dr. A. Gillieson.

Slurry Flow Measurement

This discussion group felt that present methods were not satisfactory. Suppliers should undertake improvements in existing electromagnetic methods. It was recommended that NRC and EMR should encourage slurry flow measurement development in the universities, possibly through a contractual arrangement; for such developments industry should be prepared to undertake the evaluations.

Temperature Measurement

1. It was recommended that the new group or committee,whose formation was recommended earlier in this workshop,have a sub-committee on sensor development.

2. It was recommended that NRC or EMR,either in-house or through contract arrangements, should encourage the development of improved or new temperature sensors for molten metal baths; again industry should provide test facilities. High temperature gas sensing methods could also be improved.

Particle Size Measurement

No recommendations were made by this group.

On-Line Gas Analysis

This group did not convene.

Motions

It was moved that the universities be encouraged to become more involved with the development of new and improved instrumentation. There was also a possible role for community colleges in this area. Such developments should proceed with close co-operation of industry, particularly for in-plant evaluation of sensors.

It was recommended that an information and evaluation centre for instrumentation and sensor development be formed, possibly as a co-operative venture with equipment suppliers.

Final Discussion

The following were the overall needs of the industry with priorities shown:

1. Improved sensing and better observations.
2. Improved control and regulation.
3. Model development.

A need for a study of improved maintenance of instrumentation and plant was expressed in the last few minutes of discussion.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry."

University of Western Ontario
May 12 - 13, 1972

Discussion Group Name: Slurry Flow Measurement
" " Chairman: R.J. Brailey Date: 12/5/72
" " Secretary: H.W. Smith No. Present: 4

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

---

1. Separate consideration of volume flow and percent solids measurement.

2. EM flowmeters marginally adequate for varying flows - lack of activity by suppliers in undertaking product improvement in cooperation with users.

3. Alternatives; acoustic (in initial development at U. of T)? thermal? segmental orifice with sealed DP system? open weir? Difficulty of tests indicate industry should provide test facility for developmental testing.

4. Density - % solids; standard method gamma gauge (requires knowledge of composition).

5. Alternative; neutron determination of water (EM & R); inertial method (very satisfactory on small streams).

Recommendation

Flow rate measurement is among the most inaccurate in mineral processing plants. Methods must be found to encourage development. Possible mechanisms are: NRC, contract development in universities (possibly IRI's). Industry should be prepared to make test facilities available.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry"

University of Western Ontario
May 12 - 13, 1972

Discussion Group Name: Temperature Measurement
Discussion Group Chairman: R. Littlewood — Date: May 12, 1972
Discussion Group Secretary: N. Daneliak — No. Present: 13

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

The group defined its range of interest as temperature at ambient to 3000° F.

Some of the problem areas are:

(1) There is no "standard" method of temperature measurement, in fact, no absolute measurement. This problem (in steel industry) is being overcome to some extent by using temperature models (e.g. reheating, hot rolling, etc.)

(2) It is difficult to measure "bulk" temperature by stand-off methods (emissivity, scale build-up, ore complications).

(3) Combination of high temperatures and agressive environments (hot metal, molten slug cause difficulties).

(4) It is difficult to obtain accurate measurements of temperature of hot gases.

Recommendations:

(1) The new group which is to be formed should have a sub-group devoted to sensors and measurement.

(2) A specific area which should be directed to a government agency for study is that of sensor development for molten metal baths.

(3) A second area is that of measurement of high temperatures of gases which also should be studied by a government agency.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry"

University of Western Ontario
May 12 - 13, 1972

Discussion Group Name: Particle Size Measurement
Discussion Group Chairman: B. Osborne — Date: May 12th, 1972
Discussion Group Secretary: F.J. Kelly — No. Present: 13

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

---

1. Range of sizes required - one would feel that two points may be required at some time.
2. Accuracy appears to be sufficient.
3. Types of sizing analysis methods in labs.
4. Sampling techniques should be improved.

Conclusions:

1. There are two instruments available which require industrial testing.
2. One point on the size analysis curve appears to be sufficient at the moment.
3. An accuracy of 1 to 2% appear to be good enough from the user point of view.
4. There is a smaller need for a continuous instrument to measure large dry material.

DISCUSSION GROUP SUMMARY

"Computer & Automatic Control Workshop for Mineral Processing & Metal Production Industry."

University of Western Ontario

May 12 - 13, 1972

Discussion Group Name: On-Line X-Ray Analyzers

" " Chairman: A. Molinari Date: 12/5/72

" " Secretary: L.A. Cragg No. Present 12

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

---

1. Primary sampling systems were discussed - question whether or not samples are valid - consensus appears to be that present sampling systems are satisfactory and that this judgement is based on experience rather than less subjective criteria.

2. Secondary sampling - two methods of offering the sample to the analyser were discussed - (a) where the samples are switched to a common cell and (b) where the sample cells are mechanically positioned to the analyzer. No significant preferences were expressed.

3. It is recognized that sampling is expensive and that the techniques that have been employed have been locally developed without adequate discrimination. ∴ we request Department of Energy, Mines and Resources to evaluate existing systems to publish a collection of "do's and don'ts".

4. It is recommended that X-Ray equipment manufacturers be encouraged to provide basic instruments rather than supplying "systems" which may contain extraneous components.

5. Strong feelings were expressed to the effect that an X-Ray analyzer without a computer is useless.

Calibration

Use of computers for X-Ray conversion to assay is essential.

Recommendation

Need for development of a standard calibration procedure and a mathematical calibration model.

Attendance List

MINERAL PROCESSING WORKSHOP

Companies Represented:

National Research Council of Canada - Ottawa

Mines Branch (EMR) - Ottawa

Mill Office, Hudson Bay Mining & Smelting Co. - Flin Flon Manitoba

Laval University, Quebec

Sherritt Gordon Mines, Lynn Lake Manitoba

Algoma Steel Corporation, Wawa and Sault Ste. Marie

Sala Machine Works Ltd., Mississauga

U. of Toronto

Noranda Research Centre, Point Claire Quebec

The International Nickel of Canada Ltd., Toronto

University of Alberta

University of Windsor

Queens University

Polymer Corporation Ltd., Sarnia

Dept. of Industry, Trade and Commerce, Ottawa

Dept. of Mines & Resources, Ottawa

Steel Co. of Canada, Hamilton

Dominion Foundries & Steel, Hamilton

Milltronics, Peterborough

Westinghouse, Hamilton

Electronics Associates of Canada Ltd., Willowdale

Falconbridge Nickel Mines Limited - Falconbridge

Iron Ore Co. of Canada - Montreal

Ecstall Mining Ltd.

Quebec Iron Titanium Corporation - Sorel

Teklogix Ltd. Mississauga

Alcan

Data Processing Services, Cominco

IBM. Don Mills

MINERAL PROCESSING WORKSHOP

May 10, 11, 12, 13

COMPANIES	REPRESENTATIVES
Alcan Aluminium Co. of Canada	Ted Arceszewski Peter Browne John Braams
Algoma Steel	Fred Oswin Alan Comfort William Gardian Dave Corkill Derek Brisland
Cominco Ltd.	D.N. Madge
Dept. of Energy Mines & Resources	Fred Kelly William Gow
Dept. of Industry Trade & Commerce	Jack Scrimgeour W. Stapleton Ralph Hindson
Dominion Foundries & Steel Co.	Dennis Webber
Dow Chemical	J. M. Hay
Ecstall Mining Ltd.	M. P. Amsden Roger Harris
Electronic Assoc. of Canada Ltd.	Eric Leaver
Falconbridge Nickel Mines Ltd.	M. H. Kretzschmann Robert Brailey Clyde Lewis
Hudson Bay Mining & Smelting	James Hillier

COMPANIES	REPRESENTATIVES
International Nickel Co. of Canada	Dr. Stahlberg
	R. E. Butler James Grassby Iqbal Jaswal P. J. Ripley
Iron Ore Company of Canada	Donald Shalanski
Laval University	Leone Cloutier Serge Vézina
Milltronics Ltd.	Brian Osborne
Mines Branch (EMR)	Archibald Gillieson Jiri Soukup
National Research Council of Canada	Roger Fielding Leo Nenonen Alan Tanner Dr. Davies Tom West G. W. Donaldson John Carter
Noranda Research Centre	Walter Dutton
Noranda Mines, Norcomp Div.	George Robbins
Polymer Corporation	Walter Petryschuk
Queens University	Andrew Mular
Quebec Iron and Titanium	Walter Marik George Hamilton
Sala Machine Works	Adrian Molinari
Sherritt Gordon Mines Ltd.	J. A. MacLellan Robert Ferguson

COMPANIES	REPRESENTATIVES
Steel Co. of Canada	Roy Littlewood Nick Arden Nicholas Daneliak
Teklogix Ltd.	Lawrie Cragg
University of Alberta	Reg Wood
University of Toronto	H. W. Smith
University of Western Ontario	A. I. Johnson Jim Brown Bill Svrcek
University of Windsor	Jorma Braks
Westinghouse Canada Ltd.	George Samuel

pl
May 12, 1972

To encourage and facilitate cooperation between industry and universities, this list of Deans of Engineering is included.

ACADIA UNIVERSITY

Dean F.C. Turner, (Fred)
Faculty of Engineering,
Acadia University,
Wolfville, Nova Scotia.

UNIVERSITY OF ALBERTA

Dean George Ford
Faculty of Engineering,
University of Alberta,
Edmonton, Alberta.

UNIVERSITY OF BRITISH COLUMBIA

Dean W.D. Liam Finn,
Faculty of Applied Science,
University of British Columbia,
Vancouver, B.D.

UNIVERSITY OF CALGARY

Dean R.A. Ritter,
Faculty of Engineering,
The University of Calgary,
Calgary, Alberta.

CARLETON UNIVERSITY

Dean Donald A. George,
Faculty of Engineering,
Carleton University,
Ottawa, Ontario.

COLLEGE MILITAIRE ROYALE DE ST.JEAN

Dr. M. Benoit,
College Militaire Royale de St-Jean,
St. Jean,
(Québec)

DALHOUSIE UNIVERSITY

Professor K.F. Marginson,
Head of Department of Engineering,
& Engineering Physics,
Dalhousie University,
Halifax, N.S.

UNIVERSITY OF GUELPH

Professor H.D. Ayers, (Hugh)
Director, School of Engineering,
University of Guelph,
Guelph, Ontario.

LAKEHEAD UNIVERSITY

Dr. George K. Flemming,
Acting Chairman, Engineering,
Lakehead University,
Thunder Bay, Ontario.

LAURENTIAN UNIVERSITY

Dr. A.S. Tombalakian,
Director of the School of Engineering,
Laurentian University,
Sudbury, Ontario.

UNIVERSITE LAVAL

M. Pierre Grenier, Doyen,
Faculté des Sciences,
Université Laval,
Québec 10, (Québec)

LOYOLA

Dean George W. Joly,
Faculty of Engineering,
Loyola College,
Montreal, Quebec.

UNIVERSITY OF MANITOBA

Dean J. Hoogstraten, (Jack)
Faculty of Engineering,
University of Manitoba,
Winnipeg,
Manitoba.

McGILL UNIVERSITY

Dean G.L. d'Ombrain, (John)
Faculty of Engineering,
McGill University,
Montreal,
(Quebec).

McMASTER UNIVERSITY

Dean L.W. Shemilt, (Les)
Faculty of Engineering,
McMaster University,
Hamilton,
Ontario.

MEMORIAL UNIVERSITY OF NEWFOUNDLAND

Dean A.A. Bruneau, (Angus)
Faculty of Applied Science,
Memorial University of Newfoundland,
St. John's Newfoundland.

UNIVERSITE DE MONCTON

Dean Victor Ross,
Faculty of Science,
Université de Moncton,
Moncton, New Brunswick.

MOUNT ALLISON UNIVERSITY

Professor R.A. Boorne,
Director of Engineering,
Mount Allison University,
Sackville, N.B.

UNIVERSITY OF NEW BRUNSWICK

Dean Leslie G. Jaeger,
Faculty of Engineering,
University of New Brunswick,
Fredericton, New Brunswick.

NOVA SCOTIA TECHNICAL COLLEGE

Dean Orest Cochkanoff,
Faculty of Engineering,
Nova Scotia Technical College,
P.O. Box 1000,
Halifax, N.S.

UNIVERSITY OF OTTAWA

Dr. B. Lu, (Ben)
Vice-Dean,
Faculty of Science & Applied Science,
University of Ottawa,
Ottawa 2, Ontario.

ECOLE POLYTECHNIQUE

Mr. Roger P. Langlois,
Directeur,
Ecole Polytechnique,
1500 Marie Guyard, Montreal.

QUEEN'S UNIVERSITY

Dean R.J. Uffen, (Bob)
Faculty of Applied Science,
Queen's University,
Kingston, Ontario.

ROYAL MILITARY COLLEGE OF CANADA

Dean J.W. Dolphin, (Bill)
Department of Civil Engineering,
Royal Military College of Canada,
Kingston, Ontario.

UNIVERSITY OF SASKATCHEWAN

Dean J.B. Mantle, (John)
Faculty of Engineering,
University of Saskatchewan,
Regina, Saskatchewan.

Dean W.R. Staples (Bill)
Faculty of Engineering,
University of Saskatchewan,
Saskatoon, Saskatchewan.

UNIVERSITE DE SHERBROOKE

M. Pierre Bourgault, Doyen,
Faculté de Science Appliquée,
Université de Sherbrooke,
Sherbrooke, P.Q.

SIR GEORGE WILLIAMS UNIVERSITY

Dean J. Clair Callaghan,
Faculty of Engineering,
Sir George Williams University,
1435 Drummond Street,
Montreal 25, Quebec.

ST.FRANCIS XAVIER UNIVERSITY

Professor J.H. MacDougall,
St. Francis Xavier University,
Antigonish, Nova Scotia.

ST MARY'S UNIVERSITY

Dean J.L. Ryan, (Jim)
St. Mary's University,
Halifax, Nova Scotia

UNIVERSITY OF TORONTO

Dean J.M. Ham, (Jim)
Faculty of Applied Science & Engineering,
University of Toronto,
Toronto, Ontario.

UNIVERSITY OF WATERLOO

Dean A.N. Sherbourne, (Archie)
Faculty of Engineering,
University of Waterloo,
Waterloo, Ontario.

UNIVERSITY OF WESTERN ONTARIO

Dean A.I. Johnson,
Faculty of Engineering Science,
University of Western Ontario,
London, Ontario.

UNIVERSITY OF WINDSOR

Dean J.G. Parr, (Jim)
Faculty of Applied Science,
University of Windsor,
Windsor, Ontario.

Montreal,
December 14th, 1971.