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SOME COMMENTS ON WATER JET AND LASER CUTTING OF PEACHES

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1.0 Introduction

At the request of Mr. John Kitson of the Agriculture Canada Research Station in Summerland, B.C., Engineering Research Service became involved in a brief study on the use of hydraulic jets for the cutting of peaches. The work was undertaken by the Gas Dynamics Lab. at N.R.C. with the laboratory testing carried out by Mr. Bill Brierly of N.R.C. and Mr. R.P. Hocking of E.R.S. The work extended a brief study conducted by Mr. C.A.M. Smith of N.R.C. in 1966, the results of which were never published.

The gas dynamics laboratory at N.R.C. has been actively involved in the design and develppment of special hydraulic jets for a variety of cutting applications ranging from rock boring to high speed paper cutting. Cutting operations are common in the food and agriculture industry and constitute a possible application of hydraulic jet cutting. Cutting of lettuce for harvesting has been one application (Schield, 1973). The suggestion of using lasers to cut peaches was made by one cannery in the Okanagan valley of B.C. (Milnes Foods Ltd.) and a trial on this possibility was undertaken at Lumonics Research Ltd. of Ottawa, a leading Canadian manufacturer of industrial and research lasers. The test was conducted by the Lumonics staff through the co-operation of Mr. A. Buchanan, President of the company.

2.0 Tests on water jet cutting at N.R.C.

The tests conducted at N.R.C. considered the parameters of pressure and jet size and to a lesser extent the number of passes required for a complete cut under the various pressures and jet sizes. The tests conducted and the results observed by Messrs. Brierly and Hocking are adequately outlined in the internal N.R.C. report prepared by Mr. Brierly. (Brierly, 1974). Briefly, the tests covered pressures from 5,000 to 15,000 psi and jet orifice sizes from 0.003 to 0.008 inches.

3.0 Laser cutting

The cutting tests conducted used the Lumonics Model 750 transversely excited CO_2 laser. This laser produces 200 watts continuous power with a maximum output of 600 watts for 15 seconds.

4.0 Results of cutting trials

The test results from the N.R.C. arc reproduced in Table 1. Water useage and hydraulic horsepower requirements are reported in Table 1. The degree of cut and cut quality are governed by the nozzle diameter, pressure and the cutting speed. The cutting speed was controlled by rotational and traverse speeds of the peach as it passed under the jet.

A $\frac{1}{4}$ sec cutting time gave complete cuts for the .003 in. nozzle at 10,000 psi and at 8,000 psi or above for the .004 in. nozzle. A 1/6 sec exposure was adequate for the .004 in. nozzle at 15,000 psi or for the .008 in. nozzle at 5,000 psi and higher. The water flow rate, hydraulic horsepower and water useage per peach all increase with pressure and nozzle diameter. Nozzle selection is based on the quality of cut as well as power and water useage. The smaller diameter nozzles gave cleaner cuts (Fig. 1-3) but required higher pressures and longer cutting time. The finer kerf of the smaller nozzles would be advantageous as less material is removed during cutting.

The CO_2 laser was unsuitable for cutting peaches. The kerf was wide, (Fig. 4) the cutting slow and energy consumption high. With the wide kerf, material loss was excessive and a great deal of energy used to vaporize water and peach solids during cutting. At a power of 200 watts about 15 sec would be needed to cut a single peach. While improved optics could reduce the cut width, the high latent heat of evaporation of water would still demand a large energy input in relation to cutting a dry material.

5.0 Problems in the application of hydraulic jet cutting to peach operations.

While fast, effective cutting of peaches can be performed with water jets, several problems are apparent for commercial application. Automatic equipment is available for peach processing and can serve as a standard for other hypothetical equipment. In the preparation of peach halves, it is necessary to orient the fruit prior to the two operations of cutting and pit removal. Both the Filper and FMC automatic peach machines use mechanical orientation devices to align the suture or crease of the peach correctly in relation to the cutter. With the Filper the orientation is performed as the peach travels on a vertical cup conveyor while the FMC performs a two stage orientation on a horizontal plane.

Cutting and pit removal operations are performed differently on the two machines. In the Filper unit the oriented peach is held firmly between two rubber "cups" or holding devices and cut using knife blades. While the pit is held by the cutter the two halves of the peach are rotated in opposite directions to separate the peach halves from the pit. A problem arises with split pits in some areas (it is is not a major problem in Ontario) as a special machine must be used to remove the pits from this fruit. In the pit remover a semi-circular knife scoops out the broken pit as well as a bit of flesh. The approach taken by FMC was to cut the pit in half using a circular saw blade and then scooping out the two pit halves using a pair of semi-circular knives. With the FMC system, split pits are not a problem and a clean concave depression is left in the peach half. Some fruit is removed with the pit.

Satisfactory operation of these two automatic machines has been achieved by the plants using them and consequently there is no great pressure for the development of a new system. Cutter blade performance and longevity do not appear to be a problem.

It is apparent that in a peach line, as in the apple peeling and coring process, orientation of the fruit is critical. While water jets would work very satisfactorily in the cutting, they would have to be considered in relation to the total operation. Orientation could be performed with existing equipment but special adaptations would be necessary for pit removal.

6.0 Summary

Clean fast cutting of peaches can be attained with high pressure water jets, however, there are problems in the application of such methods. Extensive modification of existing equipment would be required if water jets were to replace conventional blade cutting. The major difficulty is to spearate the flesh from the pit after cutting.

Laser cutting of peaches is not practical, as the energy consumption is high and the kerf is wide. The wide kerf wastes excessive amounts of material and all the problems of orientaiton and pit removal that apply to the jet cutting would apply to laser cutting as well.

Application of jet cutting in the food industry will have to be undertaken by equipment manufacturers and not by the food processor as totally new lines or at least extensive modification of existing lines would be necessary. At the present time, with the availability of effective, automatic peach equipment, there is no real incentive for the development of a complete new line.

While the application of jet cutting to peaches would be difficult, there are many less complicated cutting operations where application would be much simpler. Of particular interest would be any operations where knife maintainance is a problem, where for example the cutting blade is exposed to

abrasive conditions. Applications where the physical size of the cutting blade limit effectiveness might also be considered, for example in boning meat. The very fine jet could be very useful for cutting in small, hard to reach areas.

7.0 Acknowledgements

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8.0 References

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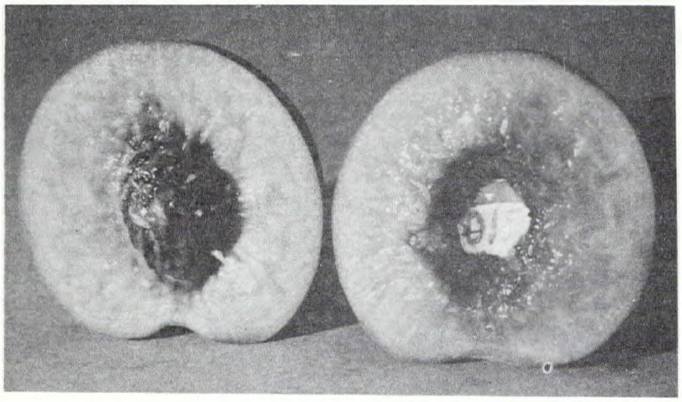

Fig. 1. Test No. 015

Nozzle Dia.	.003 in.
Pressure	10,000 psif/in^2
Cutting Time	$\frac{1}{4}$ sec
Hyd. H.P.	.116

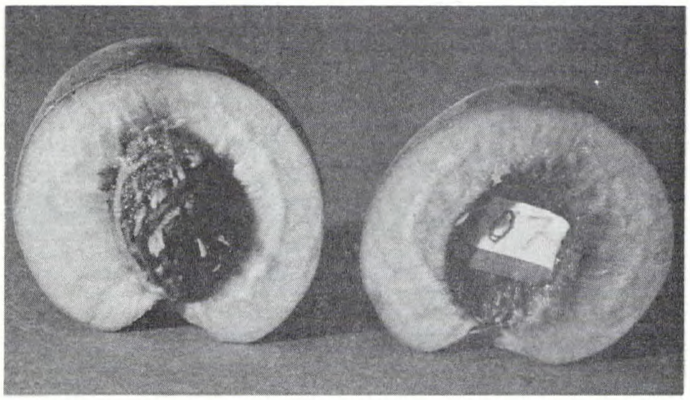

Fig. 2. Test No. 07

Nozzle Dia.	.004 in.
Pressure	8,000 psif/in^2
Cutting Time	$\frac{1}{4}$ sec
Hyd. H.P.	.2

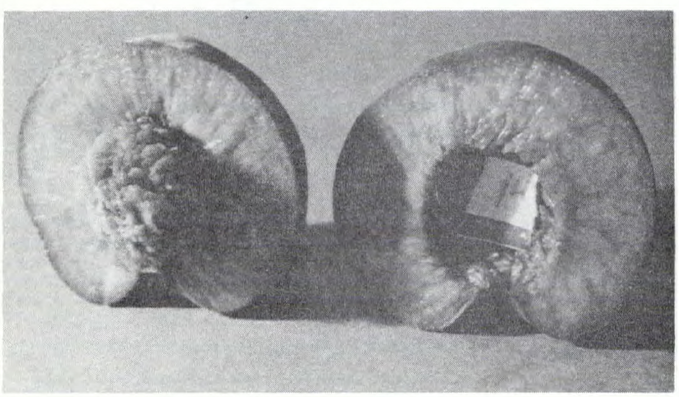

Fig. 3. Test No. 14

Nozzle Dia.	.008
Pressure	5,000 psif/in^2
Cutting Time	1/6 sec
Hyd. H.P	.393

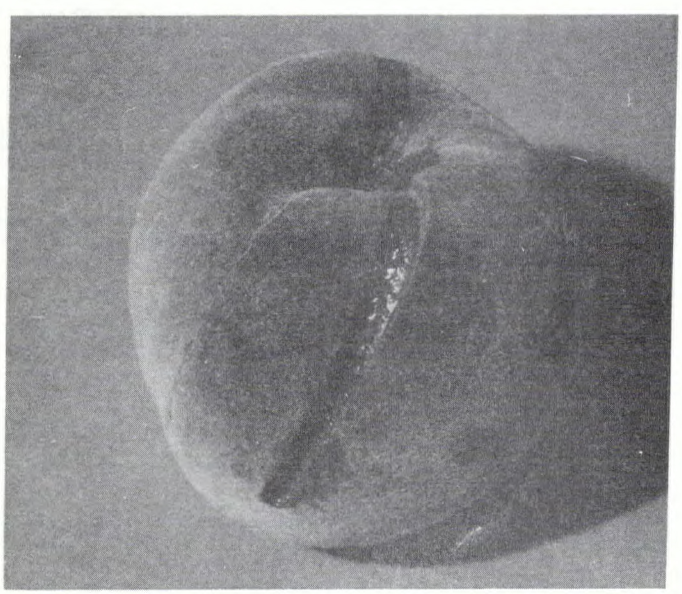

Fig. 4. Laser Beam

Average power	200W
Cutting time	y sec

TABLE I

TEST RESULTS

Test No.	Nozzle Dia. ins.	Pressure psi	Cutting Time secs.	Percent of Full Cut	Hydraulic Horse Power	Q Flow Rate US gals/ min.	Amount of Water Per Peach US gals.
1	.004	5,000	1/6	60	.098	.034	$.9 \times 10^{-4}$
2	.004	5,000	1/6	60	.098	.034	$.9 \times 10^{-4}$
3	.004	5,000	1/6	60	.098	.034	$.9 \times 10^{-4}$
4	.004	5,000	1/6	60	.098	.034	$.9 \times 10^{-4}$
5	.004	5,000	1/6	60	.098	.034	$.9 \times 10^{-4}$
6	.004	10,000	1/6	90	.278	.048	1.3×10^{-4}
7	.004	10,000	1/6	90	.278	.048	1.3×10^{-4}
8	.004	10,000	1/6	90	.278	.048	1.3×10^{-4}
9	.004	15,000	1/6	100	.511	.058	1.6×10^{-4}
10	.004	15,000	1/6	100	.511	.058	1.6×10^{-4}
11	.004	15,000	1/6	100	.511	.058	1.6×10^{-4}
12	.008	5,000	1/6	100	.393	.135	3.7×10^{-4}
13	.008	5,000	1/6	100	.393	.135	3.7×10^{-4}
14	.008	5,000	1/6	100	.393	.135	3.7×10^{-4}
15	.008	5,000	1/6	100	.393	.135	3.7×10^{-4}
16	.008	10,000	1/6	100	1.11	.191	5.3×10^{-4}
17	.008	10,000	1/6	100	1.11	.191	5.3×10^{-4}
18	.008	10,000	1/6	100	1.11	.191	5.3×10^{-4}
01	.004	5,000	1/3	40	.099	.034	1.9×10^{-4}
02	.004	6,500	1/4	50	.146	.038	1.5×10^{-4}
03	.004	6,500	1/4	50	.146	.038	1.5×10^{-4}
04	.004	6,500	1/4	50	.146	.038	1.5×10^{-4}
05	.004	8,000	1/4	100	.200	.043	1.8×10^{-4}
06	.004	8,000	1/4	100	.200	.043	1.8×10^{-4}
07	.004	8,000	1/4	100	.200	.043	1.8×10^{-4}

TABLE I (Continued)

Test No.	Nozzle Dia. ins.	Pressure psi/in^2	Cutting Time secs.	Percent of Full Cut	Hydraulic Horse Power	Q Flow Rate US gals/ min.	Amount of Water Per Peach US gals.
08	.003	6,500	1/4	50	.082	.022	$.9 \times 10^{-4}$
09	.003	6,500	1/4	50	.082	.022	$.9 \times 10^{-4}$
010	.003	6,500	1/4	50	.082	.022	$.9 \times 10^{-4}$
011	.003	8,000	1/4	90	.112	.024	1×10^{-4}
012	.003	8,000	1/4	90	.112	.024	1×10^{-4}
013	.003	8,000	1/4	90	.112	.024	1×10^{-4}
014	.003	10,000	1/4	100	.156	.027	1.1×10^{-4}
015	.003	10,000	1/4	100	.156	.027	1.1×10^{-4}
016	.003	10,000	1/4	100	.156	.027	1.1×10^{-4}