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Concentration and Recovery of Second Press Apple Juice

G. E. Timbers

CONTENTS

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1.0 INTRODUCTION

During the pressing of apples for the production of apple juice considerable quantities of sugar and other soluble solids are lost as waste in the pomace. One procedure to recover at least a portion of these soluble solids is to second press the pomace. Water is added to the pomace and soluble solids are recovered in the second press juice. This second press juice has several possible uses, for example, as a base material for fruit drinks.

One of the problems with the second press juice is its low concentration. The juice obtained in this manner is about 6% soluble solids compared with about 12% soluble solids found in first press apple juice.

The use of reverse osmosis provides one possible means for concentration of the 6% second press juice up to the single strength concentration level of first run juice.

In this report, the use of reverse osmosis for concentration of dilute juice is studied.

2.0 REVIEW OF LITERATURE

Flow through semi-permeable membranes due to osmotic pressure differences forms the basis of osmosis. If a hydrostatic load is applied to the high osmotic pressure side of the membrane, solvent can be induced to flow from a region of high osmotic pressure to a region of lower pressure. This phenomena is the basis of reverse osmosis. The first synthetic membranes were made in 1867 by Traube, however, the major advances have been made since 1960 when Loeb and Sourirajan perfected a technique for preparing a very thin dense membrane on a porous substrate, thereby obtaining high permeation rates.

Research on reverse osmosis and commercialization of the process has been carried out in several areas. Among these are desalinization, purification of brackish water and pollution control (Lacey, 1972). Application has been found in the pulp and paper industry and in food processing. Among the food processes are maple sap concentration, (Willits, 1967 and Alwin, 1969) whey processing (Horton, 1972), egg white concentration (Lowe, 1969), and juice concentration (Morgan, 1965; Merson, 1968; Matsuura, 1973).

Pollution control requirements have given impetus to reverse osmosis studies, as it is well suited to many waste water treatment and pollutant recovery systems.

3.0 MATERIALS, EQUIPMENT AND METHODS

3.1 Reverse osmosis apparatus

The reverse osmosis unit used in this study was an Osmo 3319-SS manufactured by Osmonics Inc.[a]. The membranes in this unit are of the spiral type with approximately 33 ft.^{2} (3.06 m^2) of membrane surface. The membranes used in this study were of the cellulose acetate type. High rejection membranes which reject about 97% sodium cloride were used. The high rejection membranes have a molecular weight cut-off for organics of 200.

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[a] Osmonics Inc., 2641 Louisiana Ave. South, Minneapolis, Minnesota 55426, U.S.A.

3.2 Pumps

The Osmo 3319-SS is equipped with a built in 3/4 HP centrifugal pump capable of delivering 170 psi above line pressure. To supplement this pump and extend the pressure range up to 1000 psi a Mantin-Gaulin [(b)], 3 cylinder homogenizer pump was utilized. At all times the output pressure of this pump was restricted to 850 psi to prevent over pressuring the reverse osmosis module.

3.3 Second Press Apple Juice

Second press apple juice was shipped from Sun-Rype Products Ltd.,[(c)] in 45 gal polyethylene lined drums. The juice contained 250 ppm added SO_2 to prevent fermentation during shipment.

The juice used had a 6% soluble solids content, and a pH of 3.5.

3.4 Test Procedures

Second press juice was recirculated through the reverse osmosis system until the concentration was raised from the initial 6% soluble solids up to the desired 12% concentration. When the 12% level was reached, concentrate removal was started at a rate to match the permeate flow and feed input was started at a rate to balance the over-all quantity of liquid in the system and maintain the concentrate level at 12% soluble solids.

During the operation samples were taken at intervals for refractometer readings, and volumes of feed, concentrate removal and permeate were recorded. Pressures of operation and product temperatures were also recorded.

Samples of the input product, concentrate and permeate were analysed for free SO_2 content following the procedure of Ruck (1).

[(b)] Gaulin Corp., 44 Garden St., Everett, Mass. 02149, U.S.A.

[(c)] Sun-Rype Products Ltd., 1165 Ethel St., Kelowna, B.C.

4.0 RESULTS AND DISCUSSION

4.1 Test Results

Trials on the recovery of second press juice consisted of starting the equipment on the 6% soluble solids juice and recycling until the concentrate reached the desired 12% soluble solids. For steady state operation at the concentrate level of 12% feed material at 6% was added and concentrate removed at a rate to balance the permeate removal.

Table 1

Summary of trial results for steady state operation

Run No.	Time (min)	Permeate Collected (l)	Permeation Rate l/hr	Permeation Rate gal/ft^2 day	Pressure (psi)	Concent. (% soluble solids)	Energy watt hr/ kg H_2O
5	111	13.1	7.1	1.38	900	13	341
6	130	13.75	6.4	1.24	850	12	378
7	180	21.05	7.0	1.36	900	12.8	346
8	129	10.85	5.05	0.98	550	12	480
9	136	33.75	15.6	3.02	550	12	155
10	167	45.0	16.7	3.24	600	12	146
11	61	24.0	23.6	4.57	625	11	103

A very marked improvement is observed between runs 5 - 8 and 9 - 11 in permeation rate. This improvement was due to a modification in the equipment whereby two "O" rings were added to prevent juice from being forced past the membrane module. Later trials conducted with cranberry juice (Timbers, 1973) gave somewhat higher permeation rates at similar concentration levels when the "O" ring placement was changed (Fig. 3). The prevention of bypass around the membrane appears to be quite important when operating at pressures in excess of 500 psi. The actual seal supplied with the module was in the form of a flat band rather than the form shown in the company literature which necessitated the use of additional "O" rings.

Permeation rates of 3 to 4.5 gal/ft^2 day at pressures of 550 to 625 psi (37 to 42 atm) would be increased by higher operating pressures. These rates fall within the processing capacities of membranes for fruit juice concentration given by Matsuura (1973). Matsuura's values were obtained using 1000 psi (68 atm) with a membrane area of 9.6 cm^2. The processing capacity as used by Matsuura is the volume of feed solution that 1 ft^2 of membrane can handle per day.

During these trials energy inputs to the two pumps were measured. Because of the excess capacity of the Manton-Gaulin high pressure pump, at least 2/3 of the liquid passing through the pump was recycled or bypassed (Fig. 1). For this reason only 1/3 of the measured input energy to this pump was considered as necessary work in the energy calculations. The maximum average energy inputs to the two pumps were 12A at 110V for the RO pump and 2.0A at 550V for each of the three phases of the Gaulin pump.

A radical difference in energy requirements is found between runs 5 - 8 and 9 - 11. Of these runs 9 - 11 seem realistic as in the first four runs a large portion of the juice must have been bypassing the membrane. The values of 100 - 150 watt hr per Kg of water removed are considerably lower than the 645 watt hr/Kg required for evaporation. This figure for evaporation does not include any efficiencies which could be achieved through regeneration or multiple effect evaporation.

One important factor which cannot be assessed in short term trials is the required rate of membrane replacement. Cost estimates for membrane replacement vary widely. Values from $0.10 to $1.00 per ft^2 yr have been given (p. 181, Lacey, 1972).

During the concentration of the apple juice a concentration of the SO_2 in the juice also occurred, some of the SO_2 was lost in the permeate although average SO_2 concentrations as determined using Ruck's method (1969) were:

Feed juice	250 ppm
Concentrate	390 ppm
Permeate liquid	95 ppm

If SO_2 is being used as a preservative prior to reverse osmosis, the degree of concentration of this material must be taken into consideration to keep SO_2 levels within the proper limits.

5.0 CONCLUSIONS

Reverse osmosis seems to offer a viable means for the recovery and concentration of second press apple juice. Concentration of the material from 6% soluble solids to 12% soluble solids is readily accomplished at reasonable pressures and flow rates. The quality of the juice is maintained during concentration with only a relatively small amount of darkening occurring. Energy requirements to remove water are lower than those expected for an evaporative process. Estimation of the membrane life and replacement cost would require a longer term pilot plant study as this factor is a key for assessing the economics of the process.

Reverse osmosis with a high rejection cellulose acetate membrane provides complete recovery of sugars. Some acids may be lost in the permeate liquid. SO_2 is also concentrated during the process which could be a factor if SO_2 was used to preserve the feed juice.

6.0 ACKNOWLEDGEMENT

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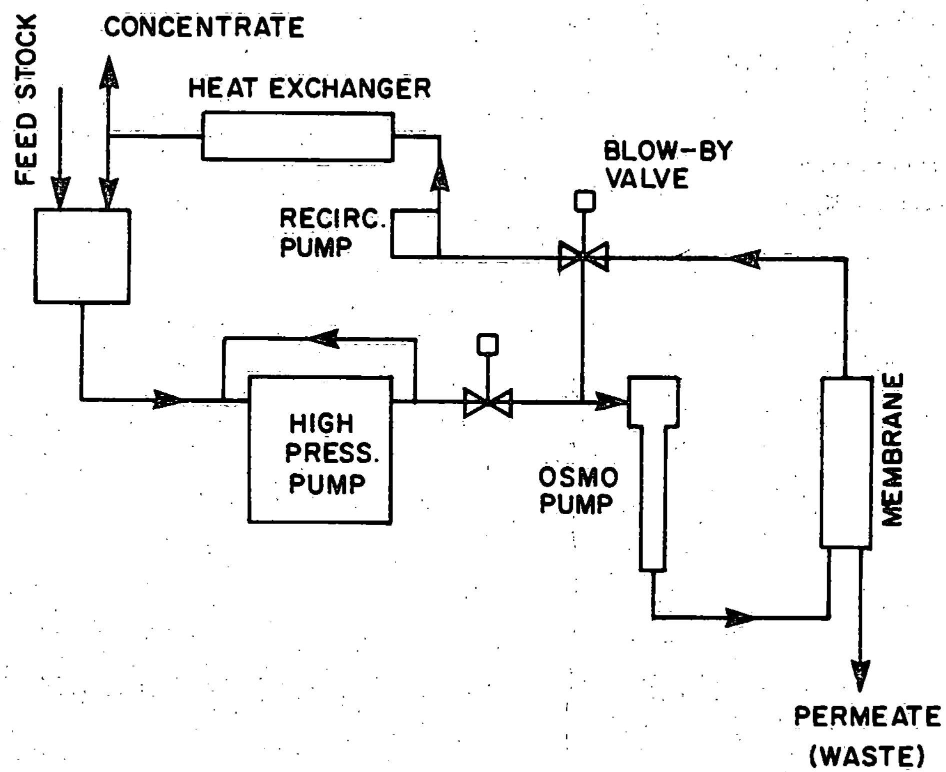

Fig. 1. Product flow in reverse osmosis test system.

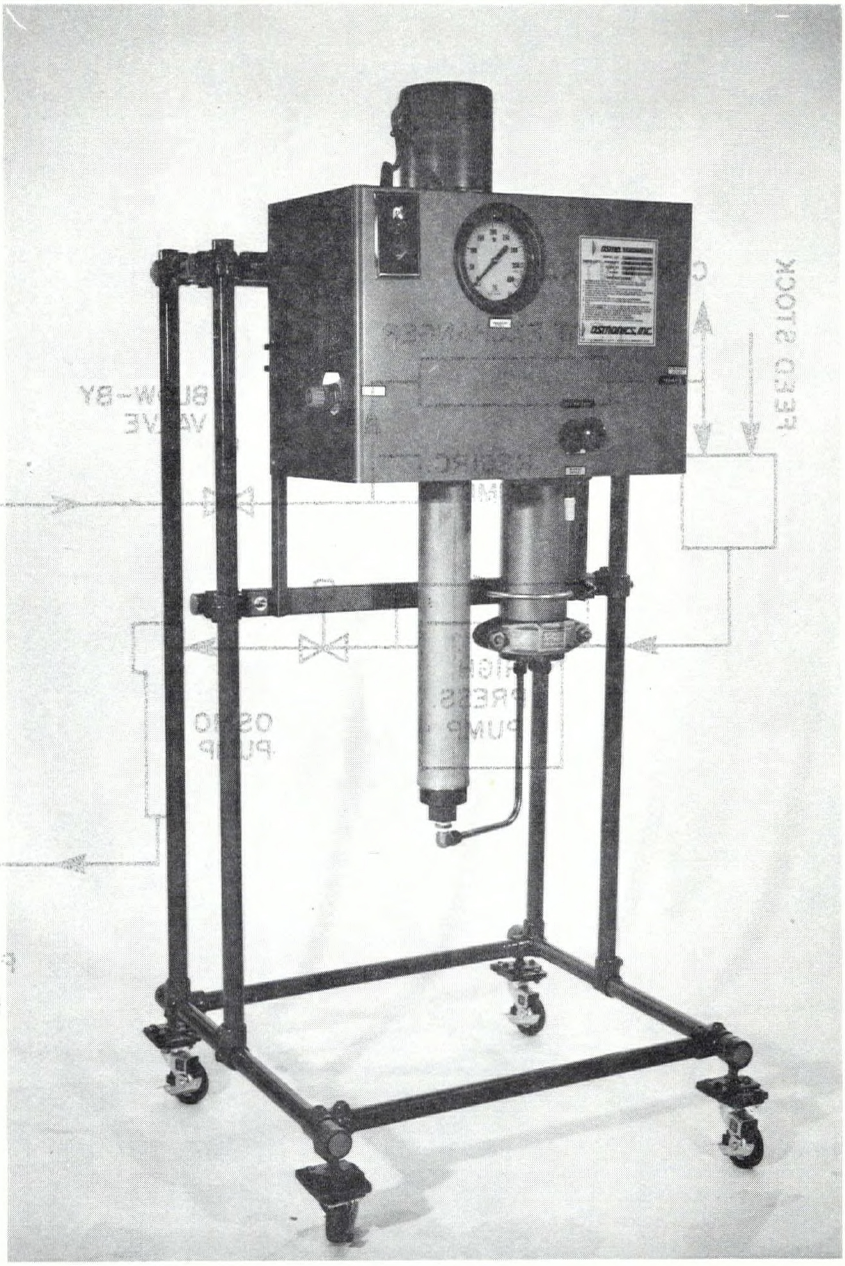

Fig. 2. Osmo 3319-SS reverse osmosis unit used for the study.

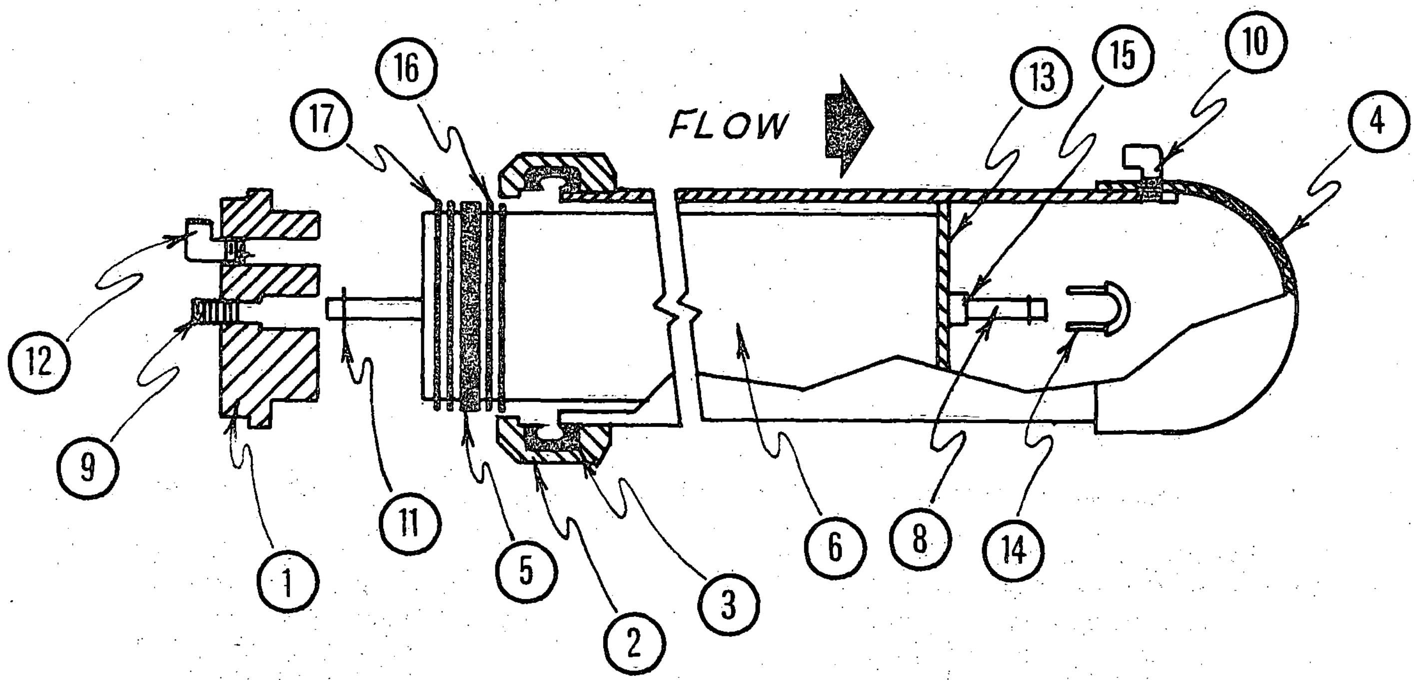

Fig. 3. Osmo reverse osmosis pressure vessel and module arrangement.

1. End Plug
2. Victualic Coupling #75
3. Victaulic Rubber Gasket
4. Pressure Vessel
5. No-bypass Seal
6. Module OSMO-504
8. Center Tube of Module
9. Permeate
10. Outlet from Pressure Vessel
11. "O" Ring for Module Center Tube
12. Inlet for Pressure Vessel
13. Anti-telescoping Stop
14. Pure Water Socket Cap
15. Down Stream Spacer
16. Additional "O" Rings (initial placement)
17. Additional "O" Rings (placement for later project)