HAYES DANA ULTRAFILTRATION SYSTEM. Ralph Davies[1], Robert E. Curtis [2], R.V. Laughton [3].

[1] Dana Canada Inc., St. Catharines, Ontario, Canada

[2] DELCAN, London, Ontario, Canada (retired)

[3] Pollutech Environmental Limited, Oakville, Ontario, Canada

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PROJECT SUMMARY

In 1983 Hayes Dana Inc. (now Dana Canada Inc.) Chassis Division in Thorold, Ontario retained the services of DELCAN (Consulting Engineers and Planners) and Pollutech (Environmental Consultants) to outline a procedure by which they could discharge the contents of the oil washing system into the Regional Municipality of Niagara sanitary sewer system. Hayes Dana had previously discontinued sanitary sewer discharge and was currently paying substantial amounts for off-site haulage of this waste oil and alkaline cleaner. They wished to resume sewer' discharge to reduce overall trucking costs.

The waste product arises as a result of spreading of forming compounds on chassis frames which are stamped in large presses. This forming compound is then washed off in a hot alkaline bath prior to final production. Preliminary treatability studies indicated that physical or chemical treatment to attain Regional Guidelines for an effluent oil concentration of 15 mg/L would be technically difficult and economically unfeasible. These early studies did suggest, however, that the process of ultrafiltration could feasiblely separate the two main components of the waste stream with the potential to recover one or both of the waste components for reuse within the chassis plant.

Once the feasibility of utilizing product recovery rather than sewer discharge had been discussed in detail with Hayes Dana Inc., a search was made for an ultrafiltration system or membrane in Canada that could tolerate the high temperatures and high pH necessary for this process. A Canadian manufacturer could not be found, however, two suppliers in the United States were identified as suitable. Preliminary discussions resulted in the selection of a Romicon ultrafiltration pilot plant for evaluation of the process.

A six week pilot test program was carried out in late 1983 at the Hayes Dana Plant in Thorold, Ontario. Results collected over a four-week detailed period clearly indicated that the process functioned in the manner previously shown by laboratory screening trials and that a permeate could be produced which closely resembled the existing alkaline cleaner. The project became economically feasible as a result of a significant reduction in of f-site haulage cost of the waste oil and cost savings by way of a major reduction in alkaline cleaner requirements.

During 1984 DELCAN carried out preliminary engineering studies sufficient for tendering to two American and one Canadian ultrafiltration manufacturers. This was followed by preselection of the ultrafiltration equipment and detailed engineering of the retrofit installation at the Hay es Dana plant. The plant construction was completed in April 1985 and is now operating successfully, producing a recoverable permeate and reusable forming compound solution.

PROJECT BACKGROUND

Hayes Dana Inc., Chassis Division, of Thorold Ontario produces die cut and stamped metal components for the automotive industry. The plant employs a work force of 600, operating 3 shifts per day, 5 days per week. Production in 1984 was 470,000 automotive frames, 90,000 axle housings and 250.000 van extensions. Prior to stamping each metal component, the part is coated with an oil based forming compound. Once the stamping is complete the parts must be washed in a hot (70^{o}C) alkaline cleaner (pH 12+).

Prior to painting of the metal components all oil must be removed from the parts. Under current operations three batch wash tanks (each approximately 28 m3), are used for this purpose. Prior to installation of the new recovery system these tanks were dumped every two weeks, as the tanks cleaning efficiency deteriorated due to oil contamination. This waste was hauled off-site, at a cost of $250,000 to $300,000 per year.

An initial laboratory scale treatability study was conducted on the Hayes Dana wash water wastes to investigate alternatives to handling the oily wastes. These tests included both chemical and physical treatment methods. Conventional chemical coagulation and flocculation could not produce an effluent suitable for sanitary sewer discharge. The use of ultrafiltration (UF) at 175 kPa and a 50,000 molecular weight cutoff membrane, appeared to be the best alternative.

The wash water waste is composed of oil, caustic cleaner, emulsifiers, water and product debris. The purpose of the UF system is to separate the oil and debris from the water, cleaner and emulsifiers. The oily waste is concentrated, and the permeate (cleaner, emulsifier, and water) is recycled to the wash tank. The loop, therefore, is essentially closed on the system and product recovery is maximized.

Existing industrial applications are installed that use the UF system on a batch basis for waste oil treatment. We believe, however, this application is a unique treatment process in that it is a continuous closed loop. Most other applications do not recover the permeate forming compound or the associated heat energy, but instead neutralize the caustic with, discharge to the sewer.

Ultrafiltration, as defined by ROMICON (now supplied by KOCH), is a pressure activated physical separation process in which a porous membrane is used to restrict the passage of emulsified oils, while allowing water and other smaller dissolved fluid additives to readily pass. Ultrafiltration units are cross-flow filters which means that the feed stream flows tangential to the membrane surface. The pressure used to pump the fluid also serves as a driving force for transfer of water through the membrane where it is collected and either stored for further use or discharged. Figure 1 illustrates the basic processes of ultrafiltration and back flushing for this type of system. The recycle around the membrane system ranges 90-130 L/min. while the actual flow through the membrane is only 4.5 L/min. This creates the cross-flow effect.

In the ROMICON ultrafiltration system separation of the emulsified oil from water is achieved by means of a hollow fiber cartridge. This cartridge, similar in configuration to a shell and tube heat exchanger, consists of a bundle of hollow polymeric fibers encased in a plastic shell and held in place by an epoxy potting compound at each end of the cartridge. In operation the soluble oil emulsion flows through the inside of the hollow fibers while filtered water is collected in the shell and discharged through a separate outlet port as shown in Figure 1. Built in membrane cleaning, in addition to that provided by back flushing, also occurs in the recycle mode as outlined in Figure 2.

PILOT PLANT TEST PROGRAM

A pilot scale ultrafiltration system (UF) was installed on one of three existing oil wash tanks in the Hayes Dana chassis plant in December 1983. The pilot plant system as shown schematically in the attached Figure 3, withdrew wash water (70^o-75^oC) from the 28 m^3 Wash Tank through a cooling tank to the process tank and then through two (2) ROMICON ultrafiltration modules to separate the oily waste from the cleaner solution. The permeate (water, cleaner, surfactant, emulsifier) was returned to the Wash Tank anc' the waste oil solution was delivered to the Process Tank.

The input to the UF system was always drawn from the Process Tank, and therefore the concentration of the oil in this tank continually increased. Once the concentration of the oil in the Process Tank had reached approximately 2 percent, or when the permeate flow rate had decreased to less than 4.5 L/min. (2.5 m^3/m^2/day) the influent to the treatment process was temporarily halted. At this point, the UF system can be operated to concentrate the oil in the Process Tank, with the permeate returned to the Wash Tank. This operation results in the concentration of the oil in the Process Tank, prior to wasting.

Once the waste oil in the Process Tank reached a maximum concentration of 15 percent, the contents of this tank was pumped out, and the waste oil was sent for recycling or disposal. When necessary, the UF system was back flushed or washed, and then the process was reactivated.

As this process results in the recovery of waste cleaner, it is only necessary to add cleaner to the Wash Tanks, when analytical tests show the cleaner concentration is falling below 1.5 percent and parts are not being washed properly. During the test period, the two small Wash Tanks were operated comparatively, to show the savings in chemical cleaner, and wash water dumping, achievable using the UF system. Considerably less cleaner was required in the wash tank receiving recycled permeate.

A summary of the pilot plant test results is given in Table 1. This table provides information on oil and Grease content (Freon extractable),Total Solids and Dissolved Solids. Oil and Grease analysis is used to determine how concentrated the Process Tank contents are, and how clean the permeate recycle has become. The level of dissolved solids is monitored to determine whether there is a build up of inorganics in the system, which is used to determine what "bleed-of f" is required to maintain suitable wash water conditions. The dissolved solids would include low molecular weight solutes (i.e. salts, surfactant, emulsifier, cleaner), and the difference between the Total and Dissolved Solids would be Oil and Grease.

TABLE 1: Pilot Plant Test Results

Source	% Oil & Grease	% Total Solids	% Dissolved Solids
Wash Water	0.35	2.3	2.2
Recovered Cleaner	0.02	1.8	1.8
UF Stage 1	5	-	2.5
UF Stage 2	15	47	12.4

The preliminary test results suggested that the permeate could be held at an average Dissolved Solids level of 1.8 percent, with an average Oil and Grease content of 230 mg/L. The concentrate averaged 15 percent Oil and Grease, with Total Solids averaging 50 percent.. This results in the Wash Tank maintaining an average Oil and Grease content of 0.3 percent with Dissolved Solids at 2.1 percent. The pilot system (unlike the full-scale unit) collected a lot of debris, as shown in the concentrate Total Solids.

Data collected f rom plant operating. staff f during the pilot plant program showed that the test Wash Tank averaged 3,500 mg/L Oil and Grease as compared to 6,700 mg/L oil and grease in the normally operated (non-UF) Wash Tank after one week of washing. The average permeate flow from the UF system to achieve these results was 3.5 L/min. at 50 OC. The feed pressure to the membranes averaged 175 kPa with a 140 kPa pressure drop across the membranes. The weekly consumption of stock cleaner was reduced in the UF Wash Tank. Additionally, the non-UF Wash Tank was dumped when needed, in comparison to continuous use of the Wash Tank content connected to the UF process.

The total permeate volume which was returned to Wash Tank during the pilot plant study was approximately 100 m3. The average daily permeate return was 5 m^3/day representing a flux rate of 1.75 m^3/m^2/day. Wash Tanks #l and #2 and Side Rail Tank are the same size having a volume of 28 m3. Therefore, the permeate recycle rate during our study was averaged at 17.5%. This permeate return rate was keeping the oil concentrations in the Wash Tank between 1500 mg/L and 4600 mg/L and Total Solids concentrations between 1.9 and 3.7%. Under these conditions the washing process was performing satisfactory.

Total concentrate wasted during the study period from one wash tank was 3.5 m3. Average concentrate wasted was 2.25 m3 every two weeks as compared to previous off-site hauling of 28 m3 every two weeks, or a reduction of 92 percent.

The pilot plant testing confirmed the suitability of the ultrafiltration process to provide a viable alternative to off-site hauling for the disposal of contaminated wash water. In addition the process demonstrated the additional advantages of having zero discharge requirements to the Regional sewer system, significant reductions in cleaner requirements, the potential for increased efficiency of the washer operation, and the

SELECTION AND INSTALLATION OF FULL-SCALE SYSTEM

On the basis of the test results from the pilot plant program, and the needs of the wash water system, four (4) possible alternatives for an installed UF "system" were developed. These alternatives were as follows:

- Install three UF units of equal size, using one UF unit to treat the wash water from each tank.
- Install two UF units, such that one unit (double size) treats the contents of Wash Tank # I and Wash Tank #2, and a second smaller unit treats the contents of the Siderail Tank.
- The use of Alternative 2, in conjunction with a third UF system to further concentrate the recovered oil from the two main UF units. This would allow for a reduction in size of the two main UF units, w they would not be required to complete the oil concentration step.
- Install only 2 UF units, where one large main unit would provide primary separation of the oil and cleaner from all three wash tanks, and a second smaller unit would provide for further concentration of the oil by a batch process.

In comparing the advantages and disadvantages of these four alternatives, the following additional points were considered:

- The use of Alternative I meant that one unit could be out-of-service, but two thirds cleaning could still be maintained. This alternative however dictated increased maintenance needs.
- Selection of Alternative 2 would still provide for some redundancy as in Alternative 4, but all parts (I.e. pumps) may not be interchangeable due to process unit sizes.
- Alternative 3 and 4 both provide for a better chance of producing a reusable oil product. Cleaning of the main units would also be reduced, due to less fouling.

A detailed review of the four alternatives, from a technical and economic viewpoint, revealed that Alternative 4 was the best alternative. This proposed system is depicted in the attached Figure 4. An additional item that was evaluated in the final detailed review included the impact of the heat exchanger to protect the UF system and allow for preheating the makeup water used into the wash water system.

Upon completion of the pilot plant program, DELCAN undertook to prepare a detailed engineering review of the proposed system. Associated equipment preselection tender documents were forwarded to the selected bidders in August 1984. The one Canadian and two American suppliers were selected as the only manufacturers currently reporting to have UF systems that would meet the needs of this process.

Upon receipt of the equipment preselection bids a detailed review was made by Hayes Dana, DELCAN and Pollutech. Each UF supplier's equipment was ranked according to technical merits, proven experience, Canadian content and cost. Unfortunately the Canadian supplier manufacturers could not demonstrate suitability of the UF membranes for this purpose.

Final site engineering was completed in December 1984 with preselection of the Romicon UF system. Contractor tenders were let in February 1985 and based on bids received the contract was given to Canal EIectric to begin site work scheduled for March 1985. The installation was completed, and the process commissioned, in early April 1985. No major difficulties were experienced in the start-up of the process.

The final plant layout, as illustrated in the attached Figure 5, consists of the following major components:

- two Romicon UF units, one having 20 cartridges (15 m^2 area total) and the second having 10 cartridges (7.5 m^2 total),
- three Goulds 15 kW, 1800 L/min feed pumps, two of which are on active duty, one standby,
- one Tranter 1.9 m^2 plate and frame heat exchanger handling feed from all three hot wash tanks,
- four Goulds 0.75 kW, 110 L/min. transfer pumps, three to deliver the wash water form the wash tanks, and one to transfer processed waste oil between the process tanks,
- two 8.5 m^3 process tanks to hold the recovered concentrate,
- two 1.5 m^3 cleaner tanks to store permeate for UF membrane cleaning,
- automatic level controls and associated equipment to control the process

PLANT OPERATING RESULTS

The full-scale facility has now been in operation for 2-112 months with only minor debugging problems experienced. To date approximately 30 m3 of permeate are being recovered daily, with some 4.5 m3 of forming compound per day available for reuse. Typical operating data for the system during the period to date is as outlined in Table 2.

TABLE 2: Full-Scale Test Results

Process Stream	Test Results (% Oil and Grease)
Wash Water	1.1
Recovered Cleaner	0.02
UF Stage 1	6.5
UF Stage 2	5.5

Ultrafiltration membrane flux rates have averaged 1.75 m^3/m^2/day for the main process unit and 1.25 m^3/m^2/day for the concentration unit. Membrane cleaning, using only recovered permeate is required on a weekly basis for the concentration unit and monthly on the main process unit.

There have been no operating difficulties experienced to date with the ultrafiltration modules. Minor adjustments were required to the bag filters, which pre-screened out metal fragments, to limit premature filter bag rupture. The extent of waste paper products in the wash tank contents has also resulted in minor plugging problems with the heat exchanger.

Full-scale plant operation has exceeded the results projected from the pilot plant studies. Work is continuing on a long-term reuse of the recovered permeate and the suitability of recycled forming compound.

PROCESS ECONOMICS

Prior to installation of the UF wash water treatment system the following annual costs were directly attributed to the wash water process:

Alkaline Cleaner	$ 100,000
Waste Oil Hauling	$ 293,000
Total Costs	$ 393,000

The total cost of the facility to date to handle the wash water and provide for the two recovered streams was as follows:

Treatability Studies	$ 24,000
Detailed Engineering	$ 36,000
Romicon UF System	$ 126,000
Support Equipment & Installation	$ 96,000
Total Installed Cost	$ 282,000

Conservative cost savings to be realized on an annual basis as a result of the material and energy recovery associated with the treatment system are as follows:

Alkaline Cleaner	$ 50,000
Waste Oil Hauling	$ 260,000
Recovered Product	$ 70,000
Total Savings	$ 380,000

Based on these installed costs and recovered costs, the payback period is less than one year. This is based on annual costs as follows:

Equipment	$ 282,000
Interest	$ 34,000
Operation & Maintenance	$ 30,000
Total Annual Costs	$ 346,000

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