Dryer section rebuild and expansions, with new concepts for lubrication purification and oil reservoir sizing

STEPHEN FUSCO AND RIC SELBIE

ABSTRACT

Recently several mills made the decision to increase capacity by installing modern high-pressure dryer cans and new antifriction bearings. The expansion required an upgrade to the lubrication system. The challenge was to rebuild the lubrication system within the tight spaces available and improve the contamination control for the entire system. Using an innovative idea of incorporating an integral vacuum distillation and an exhaust demister system for water control, the mills were able to not only downsize the oil reservoir to fit within the small space allocated but also to substantially improve oil quality.

Application:

Theses dryer section rebuilds have shown that older paper machines can be upgraded to achieve higher production levels and improved runnability. The same process detailed here can be considered feasible on any machine with limited dryer and antiquated bearing and lubrication systems.

RECENTLY TWO OLDER PAPER MAchines were rebuilt with an emphasis on improving the existing dryer sections. Both machines were limited by the pressure rating of the existing dryers. The speed and reliability were also limited because of the older babbitt journal bearing on the dryer cans. The rebuild of each machine's dryer section was tailored to the requirements needed to increase production. Antifriction bearings would be required. An additional constraint was the limited space that was available for a new circulating oil system and its components. The use of antifriction bearings put an increased demand on the new oil system. This increased load on the lube system was due to the relatively low machine speed of less than 300 m/min (1000 ft/min). The old lubrication system was contaminated with babbitt and years of particles left from improper filtration. It required replacement.

DRYER SECTION FOR MILL A

The existing paper machine dryer section consisted of 38 dryers, each 1220 mm (48 in.) in diameter. The dryers were pressure rated at 517 kPa (75 psi). Each bearing had babbitted assemblies, and all components were in poor condition. Oil flow rate to the bearings was 76 L/min (20 gal/min). Replacing the existing dryers in the constant-rate or high-evaporation zone required new 1034-kPa (150-psi) dryers to meet the new production rates. The new dryers would be fitted with antifriction bearings, new gears, and siphons for higher operating speed and better runnability. The new bearing assemblies required 212 L/min (56 gal/min) of oil flow.

THE EXISTING FRAMES WERE ACCEPTABLE

An important key to the rebuild was using the existing dryer section framing; the frames were in good condition. The new dryer cans and bearing assemblies were designed to fit in the existing frames. The lubrication system was replaced and installed in the basement. **Figure 1** shows the dryer section and a schematic of the oil system.

Production goals are being met

The mill has experienced about an 8% increase in production. A secondary success of this rebuild was the contribution of less unscheduled downtime on the machine due to bearing replacements.

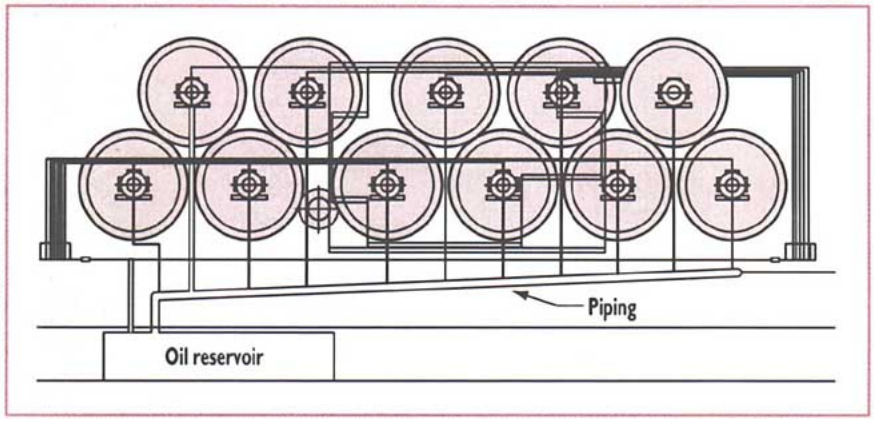
DRYER SECTION REBUILD AT MILL B

In this expansion, the mill had previously rebuilt the wet end of its board machine; the sheet entering the dryer section was now wider. The existing dryers in the first section could not carry and dry the wider sheet.

The first dryer section consists of twenty-three 1066-mm (42-in.)-diam. dryers in a three-high configuration, as shown in **Fig. 2**. These dryers were fitted with plain babbitted journal bearings. However, the bearings presented maintenance and run-ability problems. Lubrication was provided by an oil mist system, which could not be used with new antifriction-type bearings. The new lube system had to fit in the basement area and had to be small enough to fit through exiting doors and column spacings. Space was at a premium.

The existing foundation and frames were sound

In this case, the mill wanted to reuse the existing dryer frames without any changes to the machine foundation, if possible. After review of the machine frames and existing sole plates, a plan was devised to remove the existing dryers and move the



1. Schematic of dryer section and typical oil piping lines—Mill A

frames outward on the sole plates. The existing sole plates were wide enough to accommodate the new dryers. These dryers have a 254-mm (10-in.)-wider face. They were fitted with new antifriction bearings within the existing frames. New dryer cans were installed to replace the old non-ASME-coded dryers.

The lubrication system was installed in the basement. Its flow rate was sized at 87.5 L/min (23.0 gal/min) to handle the new bearing requirements. The general arrangement of these changes is shown in Fig. 2.

LUBRICATION ISSUES

Lubrication changes were required

Lubrication changes were key to both of these rebuild successes. There was not enough space in either case to install a conventional-size lube oil reservoir. But was this necessary?

Should reservoirs use the old standards for sizing?

As the mills expand, the lubrication systems become obsolete or undersized. There may not be enough floor space to increase the size of oil storage consistent with old philosophies. Engineering may think that an expansion is not possible, because there is insufficient room to increase the oil reservoir size. This limitation is based on old theories of filtration and water-separation techniques. Perhaps the reservoir doesn't need to be expanded.

There is an informal sizing standard within the engineering centers of the pulp and paper industry. This standard recommends oil reservoir volume for dryer sections, press sections, and wet-end equipment to be 30 times the rated pumping capacity. The driving force behind this standard was to allow about 30 min of settling time for water, air, and particles to separate by gravity from the oil returning from the bearings. Some conservative requirements push this capacity to 60 times the flow rate, especially for dryer sections. For example, a small dryer section with a lubrication requirement of 284 L/min (75 gal/min) is typically specified with an 8516-L (2250-gal) reservoir. This will allow the oil to reside in the reservoir for 30 min before the pump suction returns the oil to the bearing. During this time, the water and air were expected to separate.

Oils in use today do not separate in 30 min

Over the years, papermakers have demanded more of their machines in terms of speed and throughput. Oil formulations were developed to handle the increase in lubrication demands. The oils were formulated with a variety of detergents and oxidation and rust inhibitors. These formulations allowed the mills to run at a higher throughput but eliminated the natural separation of water from the oil. Because of the additives, the water would now form strong emulsions within the oil. These emulsions are extremely stable—so stable that the water would not separate from the oil in 30-60 min. In fact, the emulsions are so stable that we are now experiencing settling times of several *months* in laboratory containers. Obviously a 30-60-min reservoir is not effective, nor is it practical to build a reservoir to hold several months of oil.

Better oil formulas don't always solve the problem

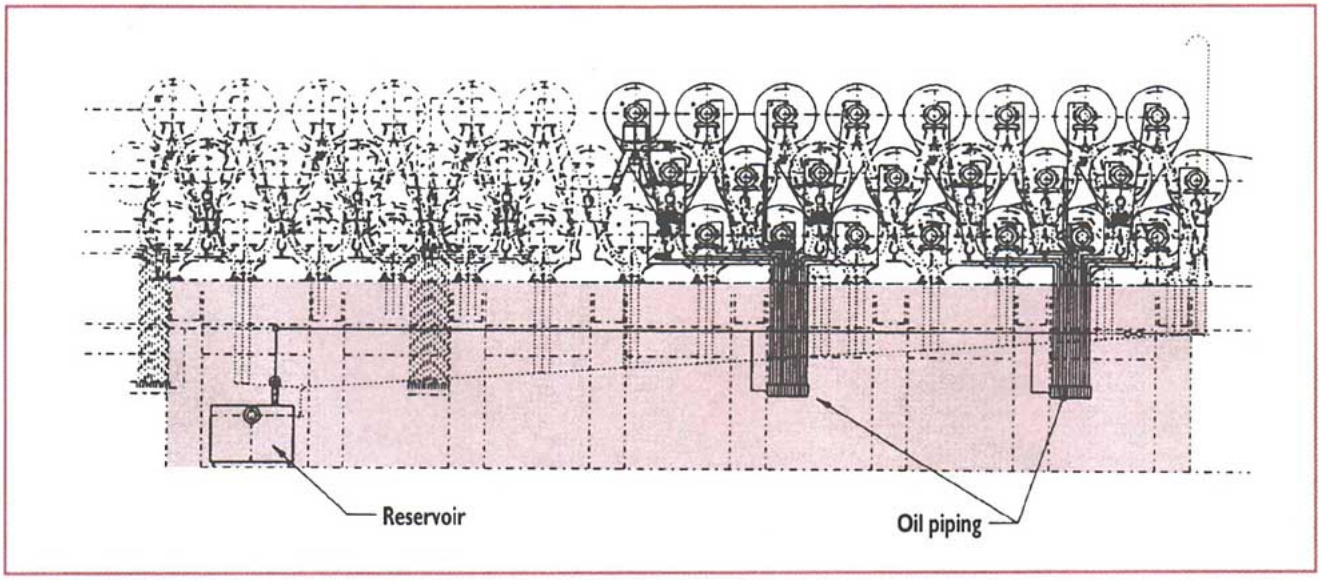
Oil companies have begun developing reformulations that will allow water to separate more quickly. While these formulations do separate water in a laboratory environment, the real world has had a different experience. Contamination from within the paper mill works its way into the oil system. In a recent paper, the authors pointed out that water separation can be severely compromised by very small amounts of organic contaminants. Materials such as pipe sealant, cleaners, and solvents can and do alter the water-separation characteristics of virgin oil.

Positive water–separtion equipment is required

The solution is not to build larger reservoirs and hope that most of the water will separate. Rather, a mill should install water-separation devices that are effective regardless of the emulsions that are formed.

Decide cleanliness levels first

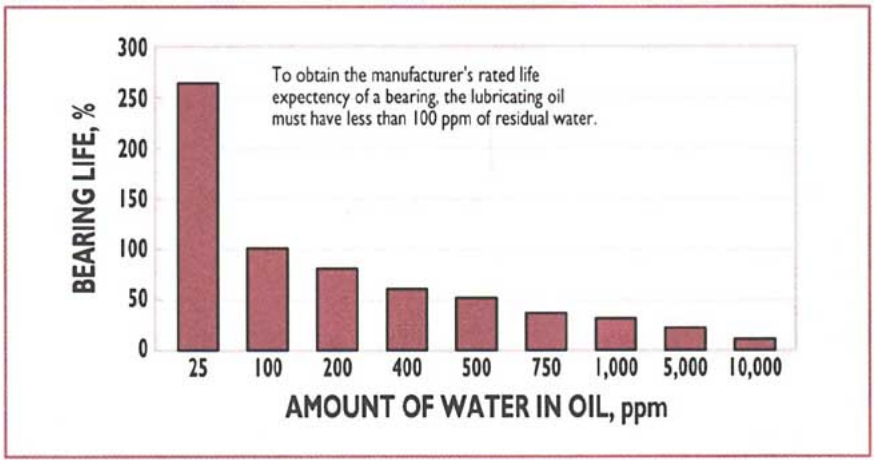
In developing the proper device for these reservoirs, one must decide how dry the oil needs to be. **Figure 3** shows the results of a test run by SKF Bearings. The bearing manufacturer expects its bearings to operate under loaded conditions or for a specified time without failure; this is called the B10 or L10 life of the bearing. It is the operating time usually reported in millions of revolutions or hours before 10% of a group of bearings fail. To operate, the bearing must be lubricated with a known oil of



2. Typical dryer and piping schematic—Mill B

specified cleanliness.

SKF ran the test using lubrication doped with known amounts of water. The results showed that, to reach the published B10 life, the bearing must be lubricated with oil containing only 100 ppm water. Notice that this is a quick opportunity to court bearing disaster. At water concentrations of only 500 ppm, the bearing life is reduced by half. Similar improvements can be argued for increasing bearing life by using very dry oil. Reducing the water content to 25 ppm increases the life 2.5 times.



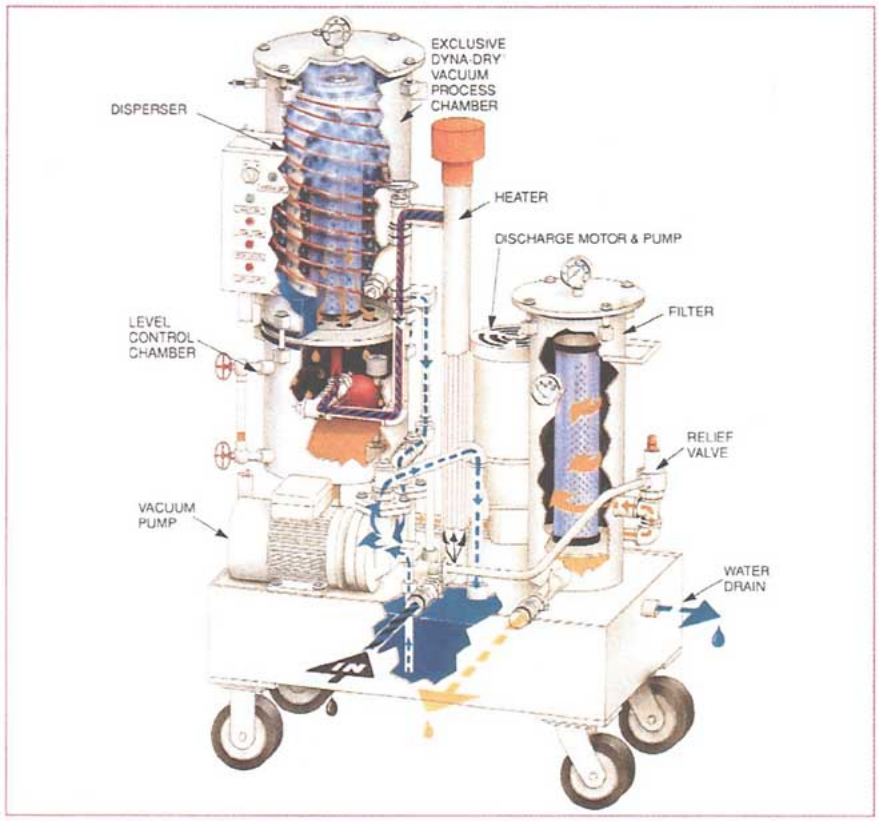
3. Effect of water on bearing life

Similar tests provide insight into why water causes bearing failure. **Table I** shows the effect of water in oil when catalyzed by copper or iron. It points to the reasons why copper should be minimized in oil systems and supports some reasons to use stainless steel piping instead of iron piping and tanks. It does not quantify the exact amount of water or concentration, but it points out that water in combination with iron and copper is detrimental to the life of the oil.

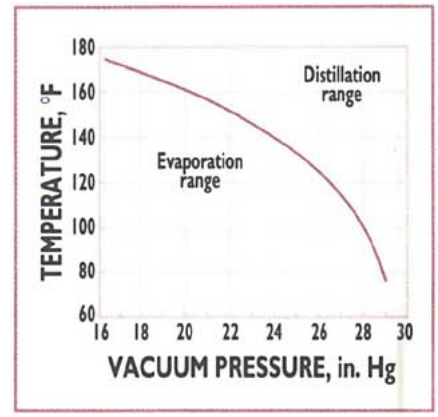
Water present	Catalyst present	Hours to failure	Tan
No	None	3500+	0.17
Yes	None	3500+	0.90
No	Iron	3500+	0.65
Yes	Iron	400	8.10
No	Copper	3000	0.89
Yes	Copper	100	11.20

I. Effect of water on the oxidation of oil

Similar articles and studies show that water is detrimental to oil performance. However, only the SKF paper addresses the relationship between life of bearings and water concentration. From these articles and using common sense, it seems logical to assume that drier oil is better. If equipment is expected to remove water, it should dry oil to less than 100 ppm of residual water. One technique used to remove water and air is vacuum distillation. From experience, we have found that vacuum dehydration, as a water removal technique, can easily maintain oil at or below 100 ppm water. We therefore



4. Cutaway of typical vacuum distillation system



5. Vapor pressure curve for water

have selected vacuum distillation as the technology to remove water from paper machine oils and to break or eliminate any emulsions formed.

Vacuum distillation

Figure 4 shows the major principle behind vacuum drying. If oil is allowed to enter a vacuum chamber, the water will either evaporate or boil from the oil. The vapor pressure curve for water shown in **Fig. 5** indicates the effect of temperature on water removal from oil. Water will evaporate from oil if the temperature/pressure combination is below the vapor pressure curve. If the combination of temperature and pressure is above the line, the water is distilled from the oil. Water removal rate is much greater if the distillation range is reached and maintained. To maintain the vacuum, a vacuum pump must remove the water as it is generated. **Figure 6** shows the typical piping arrangement used to accomplish this function.

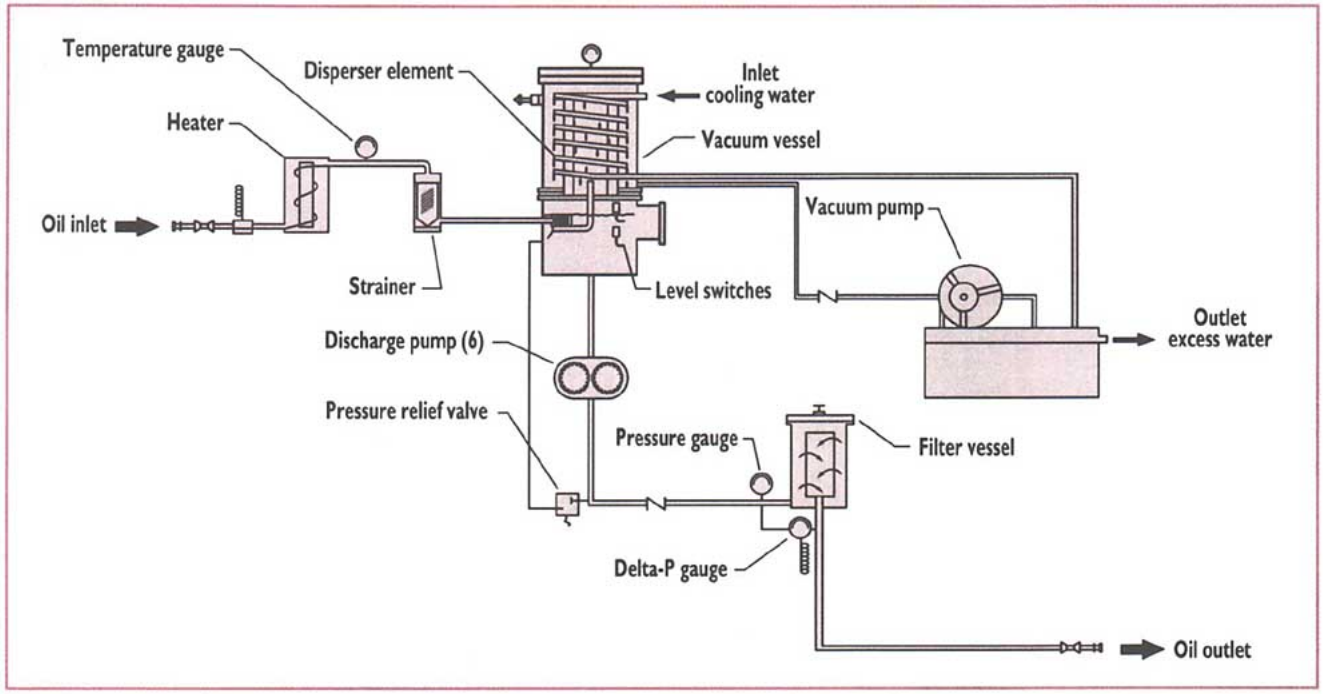
If a vacuum pump alone were used to perform this water removal, the rate of removal would be strictly a function of the vacuum pump size. The term used is *pumping speed*, which is measured in liters per second (cubic feet per min). However, the water-removal rate of a vacuum dryer can be significantly increased by using a vapor condenser in the piping before the vacuum pump.

The condenser can reduce the volume of vapor that a vacuum pump must move by converting it to a liquid. Most systems use an air- or water-cooled condenser. **Figure 7** shows a unique arrangement, where the condenser is an integral part of the vacuum chamber. This reduces the size of the purifier and increases its overall efficiency. Not only is water vapor condensed by the cooling coils, but the jacket of the vacuum chamber is in contact with vapor. This increases the surface area of the condenser, but more importantly, it creates an inner chamber for the water to collect and be removed. Otherwise, the water would be free to condense and fall back into the oil sump.

The final dryness level is a function of the time at a given pressure. The dryness of oil must eventually be in equilibrium with the moisture in the vacuum space above the oil. If the vacuum pump constantly removes the moisture, the oil will give up the water to rebalance the vacuum environment. **Figure 8** shows the effect of increasing or decreasing the temperature at various vacuum levels and the effect it has on oil dryness. The graph's heavy line indicates that a 100-ppm dryness level can be achieved if the oil is distilled at 71°C (160°F) and 26 in. Hg.

Water contamination control is the key to downsizing oil reservoirs

Figure 4 is a cutaway view of a complete vacuum distillation system. In addition to the main pumps, there are other devices common to many different vacuum dryers to control flow rates and oil temperature. The model shown can remove about 3 gal of water per hour. Water-removal rates in this range have been used successfully on reservoirs containing more than 4500 gal of oil. The significance of this water-removing capacity is that it allows the engineer to reduce the oil reservoir size. The pulp and paper industry can design



6. Piping schematic of a typical vacuum distillation system used to remove water and air from lube oils

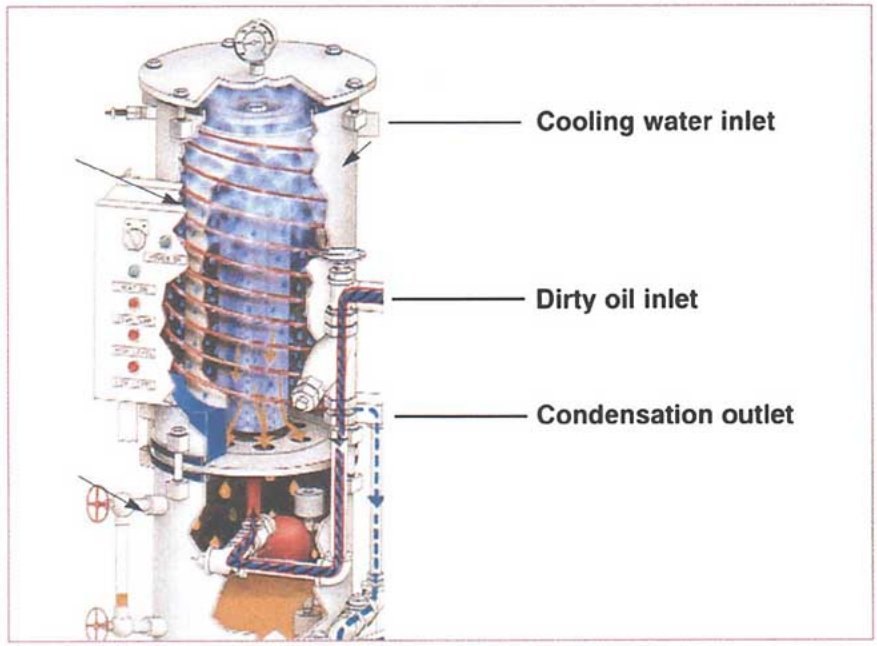
and use these distillation systems on small reservoirs where high oil flow rate to the bearings is required. Several units are in service throughout the United States where space and water contamination is a problem.

Mill A's installation is typical of a space problem being solved

Figure 9 is a general arrangement of the lube oil equipment at an installation in Mill A's plant. As discussed earlier, the mill underwent a significant rebuild and expansion. The mill was severely limited in floor space and access to the basement area, where the lubrication system could be installed. If the classical thinking of providing oil reservoirs of 30–60 times the flow rate were used, the installation would not be economical. However, a reservoir was constructed with the capacity of only a 15-min residence time, but a vacuum dryer was installed using the distillation process described plus one other feature.

Vapor extraction is now an addition to vacuum distillation

The additional feature was to incorporate a vapor and mist extractor in the freeboard area of an oil reservoir.



7. Cutaway of the Dyna-Dry vacuum distillation chamber with integral condensing section

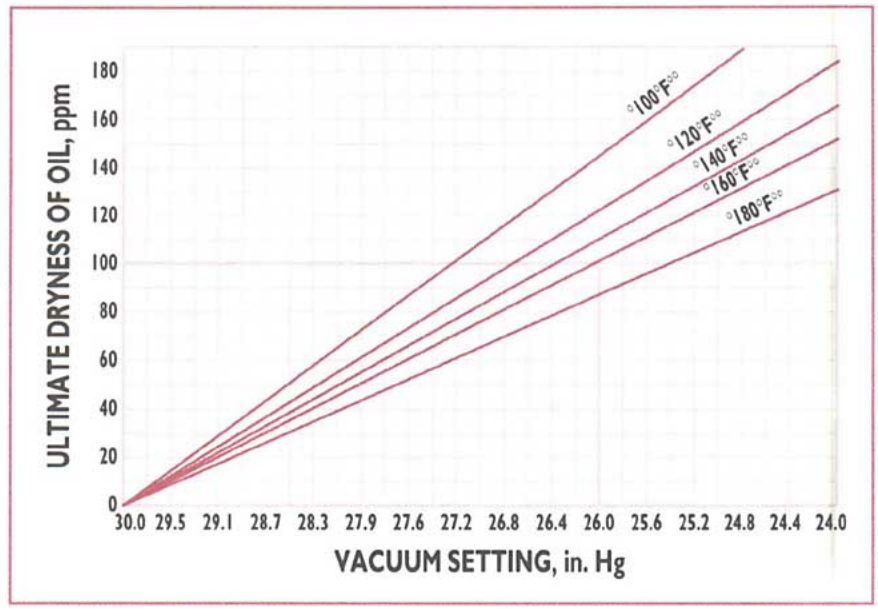
A purifier was mounted on the top of the oil reservoir, and a 152-mm (6-in.) port was aligned to the inlet of a demisting filter system. On top of the filter was an exhaust blower. The blower is used to pull air, oil, and water vapor from the freeboard area of the reservoir. As these vapors are pulled through the demisting element, the water and oil coalesce into droplets. The water and oil will then settle to the sump of the demisting vessel, and the air is exhausted through the blower fan. Oil and

KEYWORDS
Distillation, drier sections, impurities, lubrication, maintenance, oil, rebuilding, separation, space saving design, vacuum distillation, water.

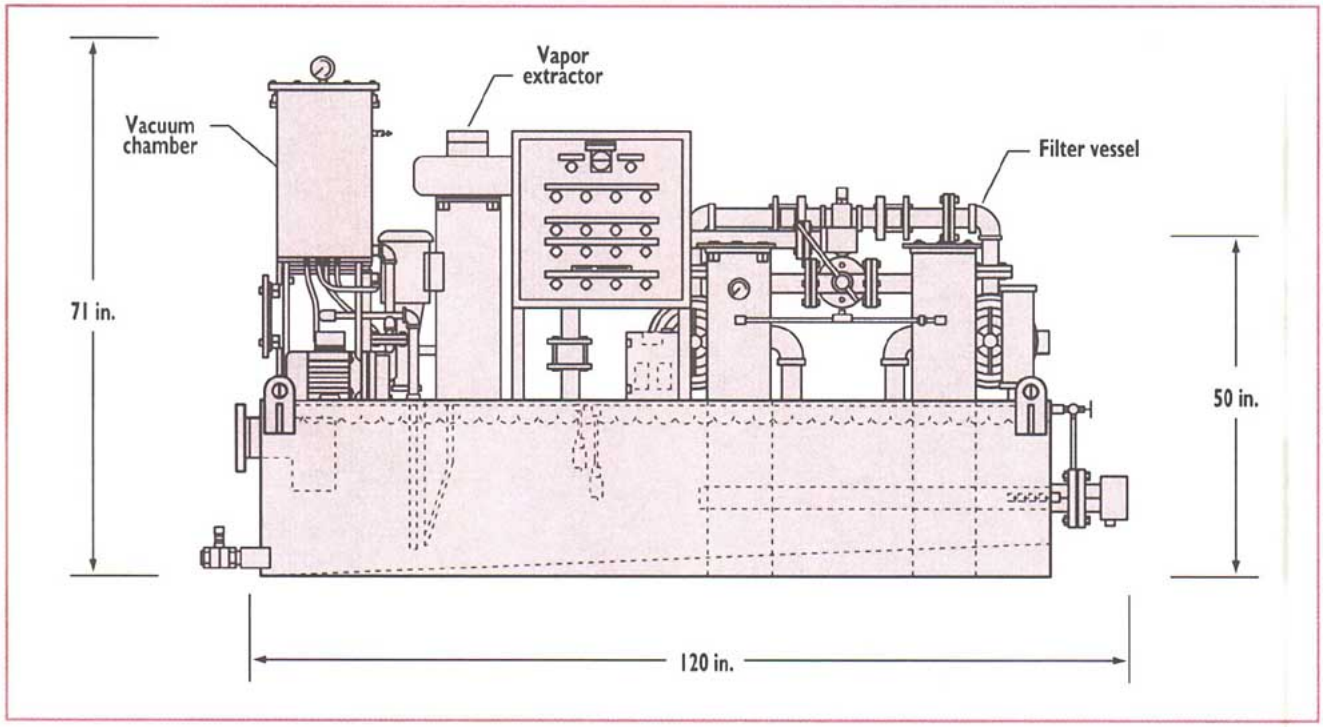
water are diverted to the vacuum chamber, where the water is distilled from the oil. **Figure 10** shows the vapor extractor mounted in conjunction with a vacuum distillation system.

Residual water contamination is below 100 ppm

This combination of vapor extraction, vacuum distillation, and air or gas removal has resulted in a significantly improved oil lubrication system, with moisture levels below 100 ppm. Mills A and B were able to install an effective filtration and lubrication system for their expansion. This was done without the cost and floor space premium of conventional or the classical large, ineffective oil reservoirs.



8. Effect of temperature and pressure on oil dryness



9. General arrangement of the 190-L/min (50-gal/min) lubrication system complete with the vacuum distillation system and vapor extractor. This package contains particulate filtration to 6-μm Beta$_{200}$, with temperature control and regulation. Oil retention time in the reservoir is 15 min. The oil quality is maintained at or below 100 ppm$_{wt}$ residual water.

This new technique is now in use in several mills

This idea has now been applied to other installations in Texas, Wisconsin, Kentucky, Minnesota, and Mon-

tana. We are continuing to monitor these installations and hope to report in a future paper the long-term effectiveness of small reservoirs and truly effective vacuum distillation dryers. **TJ**

Fusco is group leader, Drying, at Valmet/Sandy Hill, Hudson Falls Division, 27 Allen St., Hudson Falls, NY 12839. Selbie is president of Filterdyne Filtration Systems, 1334 Greenville Rd., LaGrange, GA 30240.

Received for review June 28, 1995.
Accepted Aug. 11, 1996.
Presented at the TAPPI 1996 Engineering Conference.



10. Vapor extractor used to remove water and air from the freeboard area in the lube oil reservoir