COOLANT WASTE MINIMIZATION USING A COALESCING PLATE SEPARATOR

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A paper presented at the WEF Industrial Wastes Technical Conference in St. Louis, Missouri, 2000

ABSTRACT

In 1998, a project was initiated at Wolverine Tube in Shawnee, Oklahoma to increase machine tool coolant life and also to increase the life of the tooling used to manufacture copper tubing from copper billets.

The coolant was becoming contaminated with tramp oil that provided a substrate for bacterial growth and tended to upset the operations of the tube reducer machine. The tramp oil also caused undue wear on the tooling and reduced tooling life.

An initial test was conducted using a small, relatively low flow rate coalescing plate separator. This test was very successful, but the flow rate from the test separator was not adequate for the requirements of the tube reducing operations. A larger separator was subsequently constructed and installed. The separator has been in service for more than a year.

The following paper presents the results of the initial testing, as well as the longer-term reduction in waste coolant production and tooling/operating cost reduction. Coolant waste is reduced to approximately 1/3 of previous quantities and costs are substantially reduced. The tramp oil removed by the separator is also being recycled and information on this recycling will be presented.

INTRODUCTION

The Wolverine Tube, Inc. plant at Shawnee, Oklahoma, USA, is a world-class facility for manufacturing copper tubing for all uses. It is capable of manufacturing smooth tubing, as well as externally finned and/or internally finned copper tubing. The plant processes include all stages of manufacture from melting raw cathode, ingots, and scrap copper into billets with a continuous casting machine through production of finished tubing.

An intermediate stage in the manufacture is the processing of the copper through a "tube reducing" machine to make the tubing from a heavy wall copper base tube. This machine pulls and compresses the copper at the same time, thus reducing the size of the tubing and increasing its length.

The copper in this machine is cooled and lubricated by a recirculating machine tool coolant system. Figure 1 shown below is a schematic of the overall coolant recirculation system.

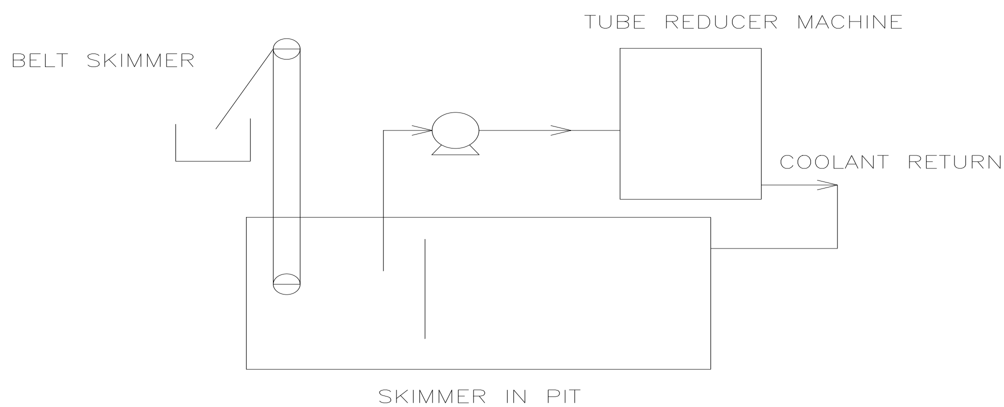

FIGURE 1
ORIGINAL COOLANT SYSTEM SCHEMATIC

Because the tube reducing machine utilizes many relatively slow moving parts, there are lubricating oil leaks from the machinery. The lubricating oil (hereafter referred to as "tramp oil" because it is not wanted in the coolant) must be removed to retain the correct operating properties in the coolant. If the operating properties are not retained within narrow limits, the copper may slip in the tooling, causing tooling damage.

The tramp oil in the coolant is also a substrate for unwanted biological growth that can cause odors and allergic reactions in operators, and causes foaming in the coolant sump.

For these reasons, it was necessary to frequently change the coolant, increasing both waste and expense. Substantial labor was also required to keep the coolant pit clean and relatively free of bacterial growth. It was often necessary to add biocide to help control the growth or anti-foam to control the foaming problem. Unfortunately, the addition of biocide and/or anti-foam could be used to solve these problems, but caused degradation of solution properties and subsequent shortened tooling life.

PREVIOUS ATTEMPTS AT SOLVING THE PROBLEM

Previous attempts at a solution included combination of a centrifuge/sterilization system and the use of two belt-type skimmers for hydrocarbon removal. The centrifuge/sterilization system was not successful because the system was undersized, experienced maintenance problems, and had problems maintaining suitable coolant operating properties after the heat-type sterilization. The belt skimmers were not successful because they were not sufficiently efficient and because they could not treat the majority of the flow stream.

COOLANT TREATMENT USING A COALESCING PLATE SEPARATOR

In 1998, a project was initiated to increase the life of the tooling used to manufacture the copper tubing, increase machine tool coolant life, and reduce biocide and defoaming agent costs by removing the tramp oil.

One of the methods of removing the tramp oil was the use of a coalescing plate separator. In a coolant stream, the majority of the tramp oil will be present as either free oil or mechanical dispersions of oil. The oil in the coolant is present in a spectrum of droplet sizes from large to very small, with the absolute sizes depending on the design of the system. Coalescing plate separator systems depend on gravity for droplet removal, taking advantage of the buoyancy of the droplets.

The rising of hydrocarbon droplets in a separator is governed by Stokes's Law (Perry). This function, simply stated, is shown in the following equation:

$$Vp = \frac{G}{(18 x \mu)} x (d_p - d_c) x D^2$$

Where:

V_p = droplet settling velocity, cm/sec
G = gravitational constant, 980 cm/sec^2
μ = absolute viscosity of continuous fluid (water), poise
d_p = density of particle (droplet), gm/cm^3
d_c = density of continuous fluid, gm/cm^3
D = diameter of particle, cm

From the above equation, it may be seen that the important variables are the viscosity of the water, the difference in specific gravity of the water and hydrocarbons, and the hydrocarbon droplet size. After these are known, the droplet rise velocity, and therefore, the size of separator that is required, may be calculated. Stokes's Law is only valid for spherical particles or droplets, and only in a laminar flow range.

Alternatively, a field test may be made to determine the separation efficiency. This is sometimes useful in separation of tramp oil from coolant in situations like the Wolverine system, where excellent separation is required and a test is relatively convenient.

INITIAL TEST WITH A MULTIPLE ANGLE COALESCING SYSTEM UNIT

It was determined that the best way to ensure that a system was properly functioning was to perform a combination demonstration of the operating principle and field test of performance. A small multiple angle coalescing plate type unit was chosen for this purpose. This unit was equipped with a small diaphragm pump and four cubic feet (0.11 cubic meters) of multiple angle coalescing media. The unit flow capacity was approximately 1.6 US GPM.

The unit was connected to an existing skimmer in the coolant pit and circulation started. A few minutes after the start of circulation, inspection of the effluent from the separator showed visual indications of significant tramp oil removal. The upstream coolant was a light brown color, resembling coffee with milk and dappled with brown droplets of oil, while the downstream coolant was a uniform creamy white color with no droplets of oil visible.

The test continued for several weeks, and it was determined that the separator was adequately removing the tramp oil from the processed coolant, but that the capacity was not sufficient for the amount of tramp oil entering the system.

The required capacity was estimated to be 9 US GPM (34 L/min), based on a belief that the previous centrifuge system (capacity 3 US GPM) had only a third of the required capacity.

DESIGN CONSIDERATIONS IN FINAL SEPARATOR SPECIFICATION

The main circulating flow rate to the tube reducer machine was about 20 US GPM (76 L/min), so the design capacity of the new separator was nearly half of the overall flow. This high percentage of fluid processed was chosen to provide very clean coolant.

Quality of separation was the foremost requirement in the design of the new separation system, but ease of use and maintenance were also concerns. The larger system was provided with 21.5 cubic feet (0.61 cubic meters) of coalescing media. Most of this media was below the surface of the water, but some extended above the surface to process the foam experienced in previous operations. The system was provided with two air diaphragm type inlet pumps, an operating pump and an installed spare. Connections to the pumps were made by hoses with quick-connect fittings on both the fluid and air connections to allow for ease of changing pumps, in the event this becomes necessary. Quick-connect fittings of the no-loss type were utilized to avoid spills and safety hazards. Equipment was chosen similar to existing equipment in the plant to minimize spare parts and maintenance personnel training requirements.

The separator was provided with a 52 gallon (197 L) oil holding tank with the connection at an elevation convenient for emptying into a 55 gallon (208 L) drum. This design was adopted so that when the separator holding tank was emptied into a drum for recycling, it would conveniently fill the drum.

A control scheme was provided with both remote and local “on-off” capabilities, an alarm showing the oil tank full, and a no-flow alarm to alert the operator of system failure.

A schematic of the new separator system is provided in Figure 2 and a separator schematic drawing is seen in Figure 3.

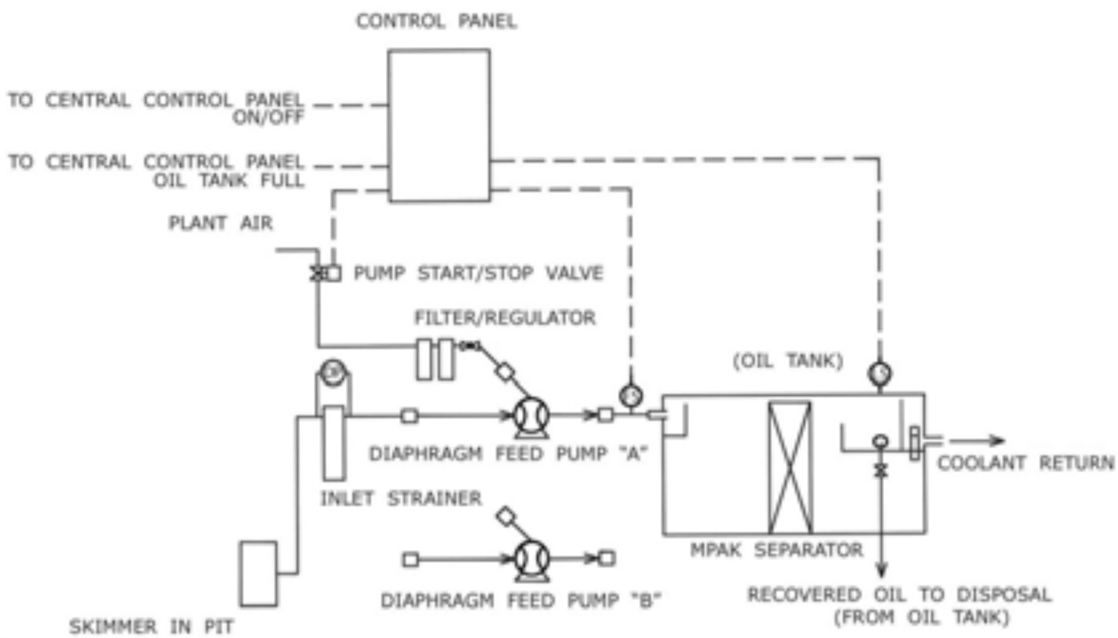

FIGURE 2
SEPARATOR SYSTEM SCHEMATIC

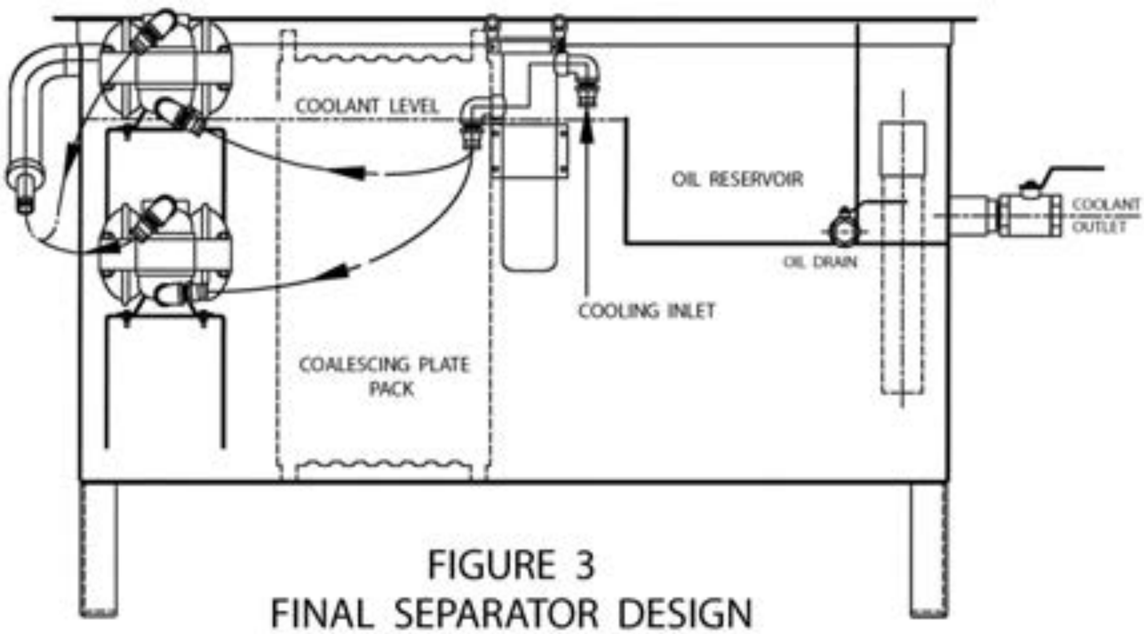

FIGURE 3
FINAL SEPARATOR DESIGN

OPERATING EXPERIENCE

The new separator system has been in operation for several years with good success. Used coolant is processed through an ultrafiltration system for separation of the coolant oil. The water is routed to a DAF unit and the used coolant oil is shipped out to be recycled or used for fuel blend.

The coolant inventory is about 900 gallons at a 10% coolant oil concentration. Coolant oil used in this application is $8.21 per gallon. This makes the cost of a coolant system change approximately $740. The coolant change frequency has been reduced from every two weeks to every eight weeks. The coolant oil savings is approximately $14,500 per year (and 16,000 gallons of water). Not included in these figures are the cost saved by reducing the amount of coolant through the disposal cycle.

The former excessive equipment downtime due to tooling breakage and repairs has been reduced substantially. Uptime at equipment has been increased by 10% to 15%. This equates to approximately 8,000,000 pounds of additional copper processed per year. Tooling cost is estimated to be reduced by approximately $50,000 to $75,000 per year.

SUMMARY AND CONCLUSIONS

Operations of the unit have been very satisfactory to date. Oil has been successfully removed from the recirculating coolant circuit and bacterial growth has been nearly eliminated (because the substrate oil has been removed). Biocide and anti-foam usage have been eliminated, reducing costs as well as avoiding solution quality problems.

The addition of the new separation system has improved operations, avoided equipment down-time, allowed for recycling of more lubricating oil, and cut the amount of discarded coolant dramatically.

Some of the improvements in the plant operation are due to other operating and equipment improvements. However, the new separator system was the key to determining the magnitude of the other improvements required because the tramp oil problem was so overwhelming that it masked the other issues. When the tramp oil was removed from the system it became possible to find and eliminate other hindrances to optimum operation.

REFERENCES

Perry, J. H.; Perry, R. H.; Chilton, C. H.; Kirkpatrick, S. D. *Chemical Engineers' Handbook;* 4 ed. McGraw-Hill Book Company: New York, NY, 1963.