A New Approach to Heat Treating Parts Washing

Rick Terrien

New innovations in the management of heat treating parts washers are yielding powerful, unexpected benefits. Simple, cost effective shop floor practices are being combined in new ways to deliver big quality improvements and significant help to the bottom line. Employing these steps early in the process can dramatically cut waste hauling expenses and greatly reduce environmental liabilities while continuously producing cleaner parts.

Typical heat treatment includes heating to some austenitizing temperature, then quenching in an oil bath to harden the steel. After quenching, the parts are washed and tempered to reduce residual stresses. The management of the parts washing step—after quenching and before tempering—is the subject of this article.

How Parts Washing Impacts Manufacturing

Poorly managed parts washing operations can affect manufacturing in many ways. Quality is perhaps the single biggest issue facing manufacturers using heat treating. Tim Hoefft, a heat treating engineer with Caterpillar, describes the problem: "Caterpillar continuously strives to increase quality throughout its operations. An ongoing evaluation showed that parts washing fluids used in heat treating operations could introduce quality problems when not managed properly. Parts washers covered with oil can cause poor quality washes and create other manufacturing problems downstream. Clean parts are particularly important in our gear manufacturing operations."

Fig. 1 — Treat-All Metals deployed a gravity separator above the parts washer conveyor line. Oily surface solution is pumped up from the wash tank by direct suction skimming. Oil and grit are removed in the separator (center, top). Clean, oil-free wash solution is continuously recycled back to the wash tank.

Parts washers heavily contaminated with oil contribute to quality problems. In poorly managed washers, clean parts are often sprayed with oily wash solution or pulled through a layer of surface oil and grit prior to tempering. Gears and other parts that are improperly cleaned carry oil out of the parts washer. These oils become baked-on contaminants during the tempering step. Removing baked-on oil residues typically requires shot blasting or other labor intensive reworking steps.

Oil dragged from the parts washers into the draw furnaces also raises significant environmental issues. Oil heated inside the furnaces creates a smoky environment for the workers in the plant as well as potentially prohibited levels of hydrocarbon emissions out of the stacks.

Oily parts washers also create significant long-term maintenance problems for furnace operators. Oil burning inside a tempering furnace degrades the fire brick lining. This leads to more frequent relining, an expensive step that keeps the furnace off line and unproductive.

In years past, quench oil was removed by solvent degreasing. However, environmental and safety concerns about solvents have recently led to a change to aqueous cleaners.

Early formulations of aqueous cleaners were aggressive, high pH surfactants designed to emulsify as much oil as possible. Oil that would normally rise to the surface was changed into an oil/water hybrid that was held in solution. This slowed the accumulation of oil on the surface of the washer, but it hid the problem in an ever dirtier bath. When the capacity of the bath to hold emulsified oils was used up, the bath lost its effectiveness. Spent baths must be hauled

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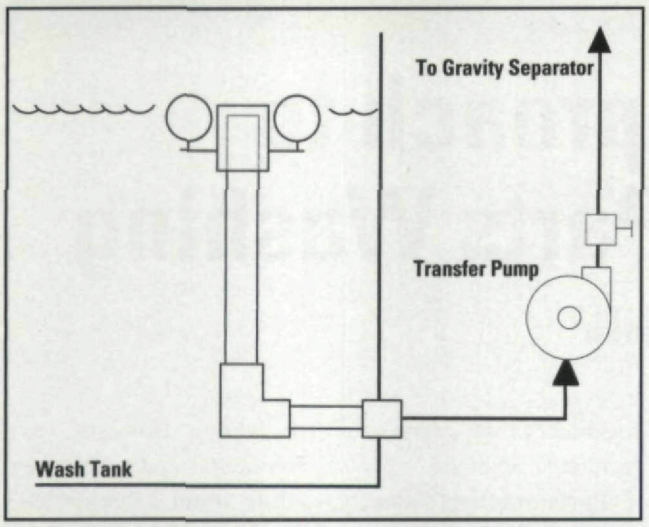

Fig. 2 — The SmartSkim™ direct suction skim head (patent pending) removes floating oil and other contaminants from the wash tank. A transfer pump sends the skimmed solution to a gravity separator, where oil and grit are removed.

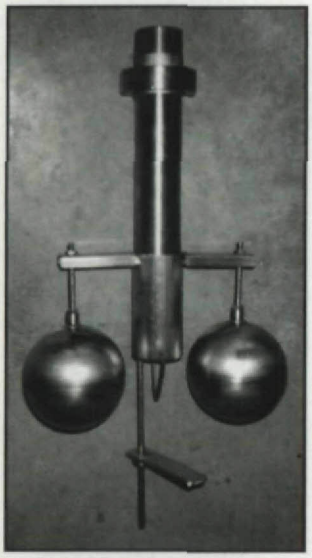

Fig. 3 — The all stainless steel SmartSkim™ skim head (patent pending) from Universal Separators.

away by licensed special waste haulers due to their high pH and high FOG (fats, oils and greases) count. The costs for these hauling services vary by region of the country. However, all add significant costs to the manufacturing process. Frequent hauling cycles also result in the need for expensive replacement cleaners.

Current Treatment Methods

Typical treatment methods for keeping parts washers clean have failed to take a comprehensive approach to the problem. Most employ tools borrowed from unrelated areas of fluid treatment. These typical treatments also rely on old assumptions about cleaners, resulting in an oily wastewater stream that is expensive and labor intensive to eliminate.

Typical methods currently in use include:

• **Drag-Out Systems.** These include oil belts, discs, drums and mops and have been the most common method in recent years. These devices have a component that rotates in and out of the parts washer. Many use an oil-attracting (oleophilic) material to attract oils from the surface. As these components rotate out of the washer, materials clinging to them are scraped off into a waste collection barrel. These devices typically drag out a waste stream that is about 50% oil and 50% wash solution, which is expensive to haul away and requires the continuous replacement of new wash solution and cleaners.

• **Coalescers.** These devices come in a wide variety of configurations, but most employ tightly packed beds of coalescing media. Oily washwater is pumped through the media, causing oil molecules to coalesce and grow larger, making them easier to remove. Coalescers were designed to work in pure oil-water solutions. Heat treating parts washers often contain a much wider variety of contaminants, such as grit, scale and soils. When operators attempt to pump these solids through the tight passageways of a coalescer, the coalescing media blinds over and becomes blocked. In heat treating applications, coalescers must be frequently taken off line and cleaned.

• **Off-Line Gravity Separation.** This method requires operators to pump out their washers into holding tanks for further separation over time. The large holding tanks take up otherwise productive floor space and frequent labor input is required to manage these fluid transfers. Emulsified oil is still held in suspension by emulsifying cleaners as there is no mechanism for readily separating the layers of oil from the aqueous cleaner. Because of this, an oily waste stream is still produced.

• **Barrier Filtration.** Bag and cartridge filters have been tested to solve the problem of oil and solids in the wash solution. These typically blind over quickly, and the cost of consumables becomes prohibitive.

• **Membrane Filters.** Membrane filters are devices that filter fluids down to a very tight micron rating (typically 1 micron and under). In washwater applications, they are designed to remove emulsified oil from the cleaners. Membrane filters quickly blind over with contaminants, particularly free oil. On the shop floor, membrane filters can become expensive maintenance headaches. Membrane filters also damage most cleaners by filtering out valuable cleaner components such as rust inhibitors and defoamers. Membrane filters can be avoided, however, with a simple change from emulsifying cleaners to oil-splitting cleaners.

Emerging Best Practices for Heat Treating Parts Washers

At Treat-All Metals, a commercial heat treating facility in Milwaukee, WI, a large batch washer equipped with a drag-out separation system was not able to keep up with the large volume of oil. It required frequent hauling of oily wastewater and replacement of the wash bath, according to maintenance director Ron Barnhart.

Treat-All tried several new methods before settling on a combination of oil-splitting cleaners, direct surface skimming of the oily wash solution from the wash tank, and separation of the oil from the wash using an in-line, open-channel gravity separator (Fig. 1).

The emergence of oil-splitting cleaners has been a great addition to the toolbox of heat treating managers. Oil splitters emulsify very little oil. Oils in these cleaners rapidly separate and rise to the surface, where they can be easily removed via direct surface suction (Figs. 2–3). Newer versions of oil splitting cleaners are moving toward pH neutral formulations, which contribute to improvements in worker safety.

Gravity separators exploit the difference in specific

gravity between the oil and the wash solution. Oil separates from a fluid at a rate determined by Stokes Law. This formula predicts how fast an object will rise or fall through a heavier fluid based on the density and size of the object and the distance it must travel. Open-channel gravity separators exploit both variables of Stokes Law. Oil must rise only a very short distance before it is captured on the bottom side of closely spaced inclined plates inside the separator (Fig. 4).

Once separated from the flow, captured oil with very low water content can be removed from the gravity separator. This oil, which contains less than 5% water, is referred to as "dry" oil. While oily wastewater produced by other arrangements must be hauled away at the producer's expense, dry oil can typically be sold for a profit. Gravity separators discharge dry oil to a collection barrel without any moving parts. The clean wash water is returned to the wash tank.

Gravity separators also remove solids from heat treating parts washers. Difficult to remove, lightweight solids can easily contaminate the wash bath, causing significant quality problems. Those solids are typically made up of small particles of scale, grit, and stop-off paint, as well as a variety of other contaminants. Solids can be sprayed back onto the part from dirty wash solutions. Parts can

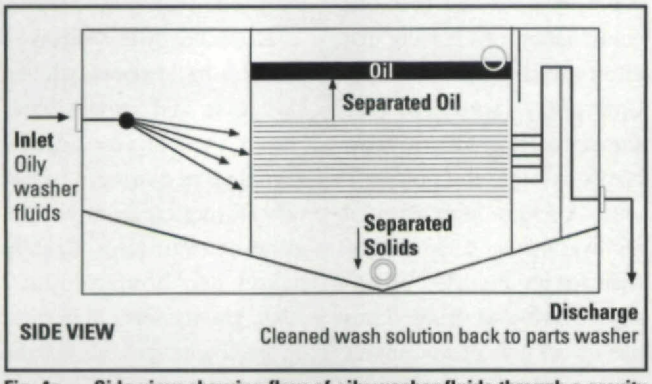

Fig. 4a — Side view showing flow of oily washer fluids through a gravity separator. Oily solution is continuously pumped from the washer surface across multiple separation plates. Oil and solids separate from the flow by gravity while cleaned wash solution is returned to the washer.

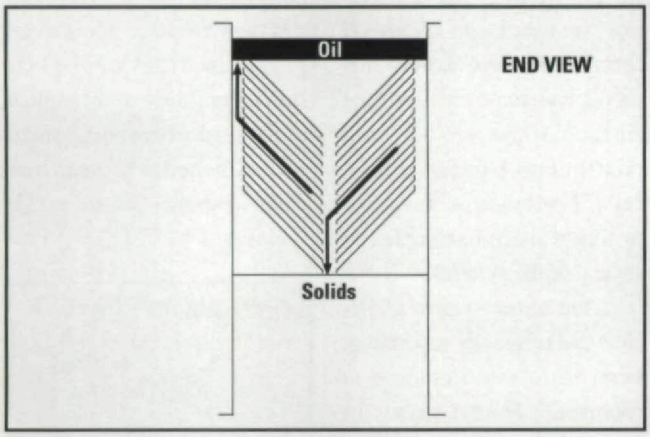

Fig. 4b — End view. Inclined plates inside a gravity separator capture and remove oil and solids simultaneously. Open channel separation pathways insure no clogging. Because there are no moving parts, separator management is greatly simplified.

also be recontaminated when they are dragged through grit held in the oil at the surface of these washers.

Removing these types of solids has been difficult and expensive. Coalescers have been tried but their filters are quickly blinded over by grit. Filtration devices such as cartridges or bags are sometimes used, but these require expensive replacement consumables to stay on line.

Gravity separators do not require any consumables and are not blinded over by solids. Treat-All Metals found that they don't notice any loss of separation efficiency until their gravity separators become half filled up (50% of the separator volume) with solids, which typically takes months.

Treat-All is not the only company which has tried this combination of cleaners and equipment. Tim Hoefft of Caterpillar faced problems similar to Treat-All's with his company's old drag-out system. "A review of existing oil removal methods showed the need for an upgrade," Hoefft says. "Belt and drum skimmers were not able to remove the continuous input of oil from the washers."

Caterpillar tested a surface suction system similar to the one in place at Treat-All Metals. "The test showed that all oil was removed from the surface of the washer on a continuous basis," Hoefft says. Following successful testing, Caterpillar deployed several of the systems.

"Due to the system's efficient use of gravity separation, very little maintenance is required," Hoefft says. "In fact, beyond the initial setup, our rule has been to 'leave them alone.'"

The Bottom Line

The combination in place at Treat-All Metals and Caterpillar offers significant benefits:

- Cleaner parts
- Extended bath life
- Cuts in waste hauling costs
- Decreased cleaner costs
- Profit from a former waste stream
- Worker safety and environmental improvements
- Decreased maintenance requirements

All of this combines into a rapid payback, as opposed to many other systems currently in use. Caterpillar's review of payback issues has indicated that their system will pay for itself in "well under one year," says Hoefft.

However, the switch to oil-splitting cleaners, suction skimming and gravity separators can require adjustments. For example, most oil-splitting cleaners are not good at removing already baked-on contaminants. Also, gravity separators must be sized appropriately for the job to be most effective. Small units can be overwhelmed by the treatment flows common to heat treat parts washing. However, given the right configurations, this new combination can yield powerful, unexpected benefits to heat treat parts washing operations.

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