Choosing the right hydraulic fluid can reduce fire risk in aluminium plants

Fire safety in industrial facilities is a must, but it need not come at the expense of productivity. **Ronald Knecht***, explains how to choose the best fire-resistant hydraulic fluid to keep things running smoothly.

Whatever the manufacturing facility, a fire is amongst the worst accidents that can take place. The most obvious harm is of injury, or worse, to employees. Beyond that, there is always likely to be a loss in both capital and production. These losses not only include damage to the building and equipment, but also the immediate interruption in production – which might see lines idle for days or even months.

Such dangers are inherent within the aluminium production and manufacturing process, given the fundamental requirement for significant heat to produce the desired finished products. With fire hazards at just about every stage of an aluminium plant, this requires a 'safety first' approach throughout. Beyond the obvious approaches towards cooling, eliminating oxygen, removing fuel, or breaking potential chemical reactions, there's one aspect that is relatively neglected.

Namely, the use of combustible hydraulic fluids across the factory. Studying a heat map of the operation will show how in many areas the temperature can reach between 400°C and 700°C. Coincidentally, in most of these processes, hydraulic units are used to operate the equipment.

Often, a mineral oil-based hydraulic fluid is chosen to operate these hydraulic units, a choice based on the definite advantage of a good cost-performance ratio. Yet the clue to the danger lies in the name: such fluids are a distillate from crude oil, and not always the safest choice, due to their tendency to catch fire easily.

The risks involved in using oil-based hydraulic fluids

Consider where hydraulic fluids are used and might come into contact with hot surfaces or materials – and you'll quickly realise that fire hazards exist in many places within aluminium plants. This includes, but is not limited to, areas such as the (re)heating or (re)melting furnace, billet or slab casting or hot strip mills.

For example, most furnaces in the aluminium industry are operated using hydraulic power for movement of the slabs, as well as for opening or closing the door. Likewise, around an aluminium hot strip mill, there are several processes that are driven using hydraulic power, like the Automatic Gauge Control (AGC) system. The presence of hydraulic hoses or components near a hot slab or aluminium strip is a clear risk, with the potential to cause uncontrollable fires – and therefore significant damage or downtime – if a hydraulic hose bursts or leaks.

*Global Strategic Product Line Manager – Hydraulics & Lubricants from Quaker Houghton

It is the ignition of mineral oil-based hydraulic fluids which can lead to a fire. There are two main causes for this type of ignition. Firstly, where the lubricants spill or leak onto a very hot surface. Secondly, when sparks (or even hot liquid metal) land in a pool of lubricant.

The problem is that the mineral oil evaporates easily, and therefore tends to build a vapour of oil droplets. Once ignition takes place, these oil droplets can catch fire and result in an explosion and/or a fire ball. The resulting fire is hard to control as the fire ball can travel quickly to the roof or to cables and ignite further areas of the factory.

The science behind the ignition is simple but has worrying implication. Essentially, a hydraulic fluid derived from mineral oil combines three chemical properties which, in conjunction, make a fire more likely. These properties are: a relatively low specific heat temperature; a relatively low auto-ignition point; and a high heat of combustion.

In other words, it does not take much energy to heat the mineral oil-based lubricant to reach the temperature at which it will auto-ignite… which is also relatively low. At that point, the fluid combusts at a heat of about 43-44 kJ/g, causing a swift catalysis for explosive ignition and propagation of the flames. The mineral oil's properties also mean it has the ability to keep itself burning too.

What to consider when choosing a fire-resistant hydraulic fluid?

Fortunately, there are alternatives to mineral oil-based hydraulic fluids, but careful analysis should be made of their relative properties before choosing a replacement. The first consideration, of course, is the level of fire resistance. This term is often mistakenly understood to be the same as fire retardant but is not necessarily the same. Almost all fire-resistant hydraulic fluids will burn under certain conditions.

So why choose a lubricant that is only fire-resistant rather than fully retardant? It is here that other factors come into play. One obvious point of difference is the cost of switching to an alternative hydraulic fluid. Some will likely be more expensive than others, not only in the actual fluid price but in the potential impact on existing equipment such as component life and operational reliability, which may need to be changed to suit a change in fluid. Consider instead the Total Cost of Operation (TCO), comparing both upfront and ongoing costs to the long-term value derived from reduced fire risk.

The other element to investigate is the environmental impact of any hydraulic fluid. This might refer both to how a lubricant is sourced or manufactured, whether it is biodegradable, or whether any harmful chemicals are released upon combustion.

By triangulating these often-conflicting demands – cost, environmental impact and the level of protection given – along with system reliability – it is possible to strike the optimum balance to protect productivity and profitability while managing an appropriate level of risk. If in doubt, it's worth investigating the most common and generally accepted tests for fire resistance. Such tests are devised by Factory Mutual (FM Global), the testing and approval arm of a major industrial insurance underwriter (www.fmglobal.com). Using an FM Global approved hydraulic fluid can reduce the premium a company needs to pay.

Understanding the different types of hydraulic fluid

The basic distinction in choosing a hydraulic fluid is whether it is water-based or water-free. For each fluid type there are pros and cons, meaning that procurement specialists and maintenance managers should consider the merits of all five types.

The different types are either water-based…

- HFA-E
  (mineral oil containing emulsion)
- HFA-S (a synthetic aqueous solution)
- HFC (a water glycol solution).
  or water-free:
- HFD-R (a phosphate ester-based)
- HFD-U (mainly synthetic
  polyol esters and natural esters).

The fluids marked HFA-E and HFA-S require special hydraulic systems and are generally not found in the Aluminium industry.

How do the other fluid types stack up in comparison? Phosphate ester (HFD-R) based lubricants have a negative reputation. Phosphate ester (HFD-R) fluids are fire resistant by chemistry, but are reported to be CMR (Carcinogenic, Mutagenic, Reprotoxic) materials. Also, the combustion fumes they produce may be neurotoxic. HFD-R fluids can be 10 to 15 times more expensive than mineral oil and need to be carefully maintained as these products generate aggressive acids as they age.

Of the remaining water-based fluids, both have good fire-resistant properties, meaning that other criteria need to be also considered. HFC fluids, also known as water glycols, are widely used in aluminium processing plants as well as other industries and represent about 50% of the total fire-resistant hydraulic fluids market. Their high water content makes them very good for fire resistance, and while they have a comparable price to mineral oil, they do not measure up in performance attributes. Additionally, hydraulic units for HFC are more expensive to purchase, the service components have a shorter lifetime, more fluid management is needed, and energy consumption is 10 to 20% higher compared to mineral oil or polyol ester-based fire-resistant hydraulic fluids.

That leaves polyol ester-based fluids (HFD-U), which are the best solution and alternative to mineral oil. Typically, no changes need to be made to the hydraulic unit when converting from a mineral oil or water glycol hydraulic fluid to a polyol ester fluid. Compared to mineral oil-based fluids, nothing is sacrificed in terms of the fluid's performance, and the polyol ester based (HFD-U) fluids have reduced environmental impact.

The actual price of fluids is around 2-3 times more expensive than mineral oil, but the crucial difference is that polyol ester-based HFD-U fluids have a higher specific heat temperature; a higher auto-ignition point; and a lower heat of combustion. There is no vapour or explosion, and an eventual fire is limited to the place where it comes in contact with the hot surface/ignition source, so the situation remains under control. With this reduction in the risk of fire from the hydraulic fluid, the result is a lower TCO and a much safer work environment.

Making the Aluminium Plant Safer

When considering how to reduce the fire risk from hydraulic fluids, there are several schools of thought. A factory might change design of the hydraulic unit, to avoid mineral oil leakages getting close to the hot surface. This means the company can keep the same oil technology, but it does not avoid using a straight hydraulic oil coming close to hot surfaces.

Others might prefer the installation of a fire extinguisher system to avoid having to change the type of oil used, but not only is this expensive, it can be 'too little, too late' as the main danger caused by oil-based lubricants is the initial explosive ignition and resulting fire balls.

In short, swapping a mineral oil-based hydraulic fluid for an HFD-U type such as QUINTOLUBRIC® is one of the surest ways to improve safety. In our video, available at www.youtube.com/watch?v=bEtlikCMRWM, you can see first-hand the difference in terms of being able to keep a fire under control. When you factor in its strong performance and good environmental credentials, the use of QUINTOLUBRIC®HFD-U fire resistant hydraulic fluids allow a factory to run efficiently and safely. ■