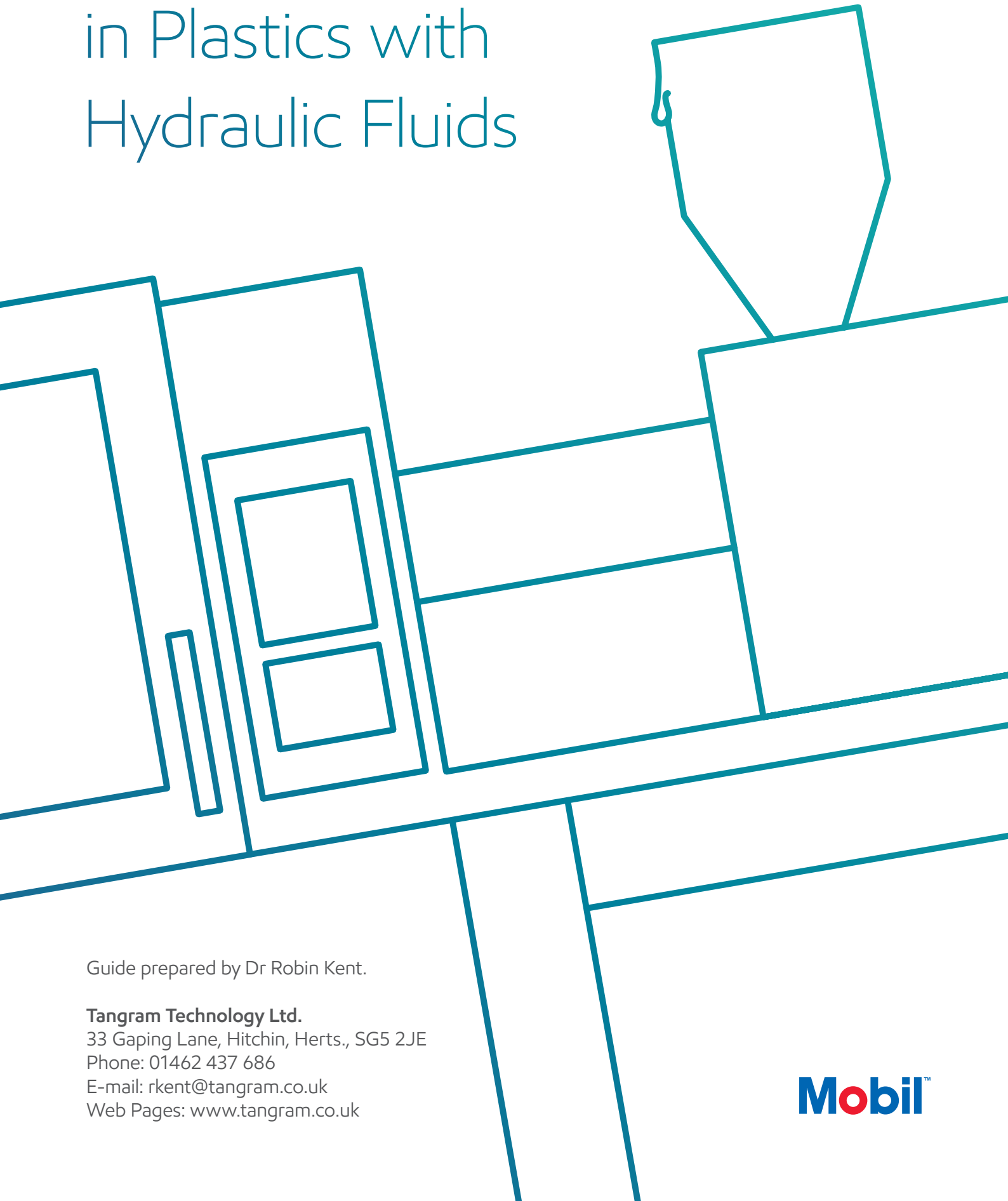
Advancing Industry 4.0 in Plastics with Hydraulic Fluids



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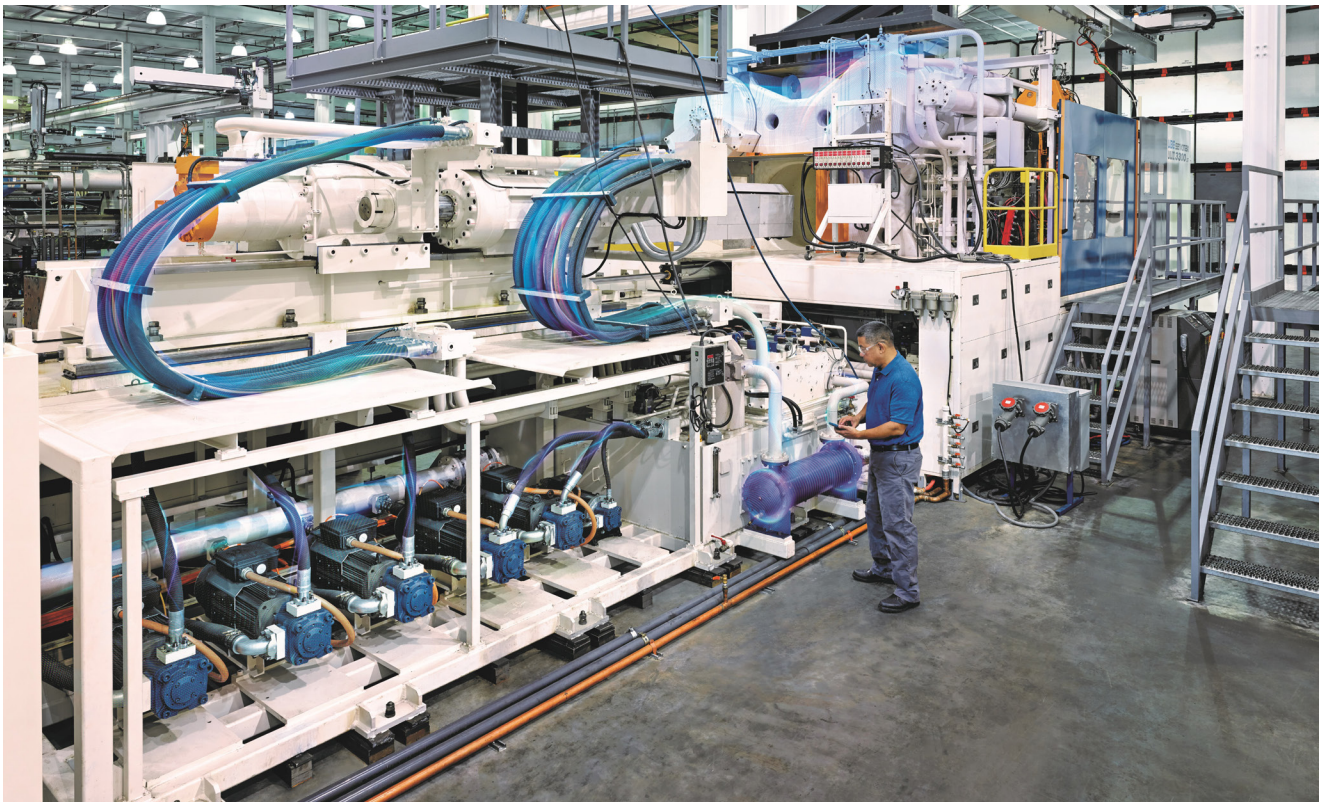


1 Introduction

Opportunities for plastics processing continue to grow across a range of industries. Automotive, construction, medical and many other industries are all eager to take advantage of the latest innovations in plastics processing.

However, the industry also faces challenges to profitability; plastics processing is not only highly competitive, it is also energy intensive.

Basic polymers are the largest single outlay in plastics processing and rising feedstock prices across many grades are squeezing bottom lines. With the emergence of Industry 4.0 and the smart factory, processors need to look at every opportunity to reduce their outlays and increase the overall efficiency of their operations.

High performance hydraulic fluids are one easy opportunity to improve efficiency in a range of areas.

> "Lots of my business is demanding, high quality work for the automotive sector. Unfortunately, my company's overheads are squeezing my profit margin."

1.1 Big impact with a small change

The right hydraulic fluid offers a range of benefits, from improved energy efficiency to enhanced operational performance, which can help plastics processors reduce costs and increase productivity.

This is an easy topic to overlook because the cost of hydraulic fluid is typically less than 1% of operating costs. This is made even worse if the processor has a 'fit and forget' attitude to hydraulic fluids.

This ignores the fact that the hydraulic fluid is literally the 'lifeblood' of any hydraulic injection molding machine.

Choosing a high performance fluid will not only protect the hydraulic system, it can also reduce energy use and help advance your efforts toward Industry 4.0.

A separate Energy Saving Guide for Injection Molders is available, which explains the steps that plastics processors can take to help reduce their energy bills and enhance plant efficiency.

1.2 In this guide

We will explore how to optimize your hydraulic fluid usage and make the most of the many benefits that they offer, contributing to Industry 4.0.

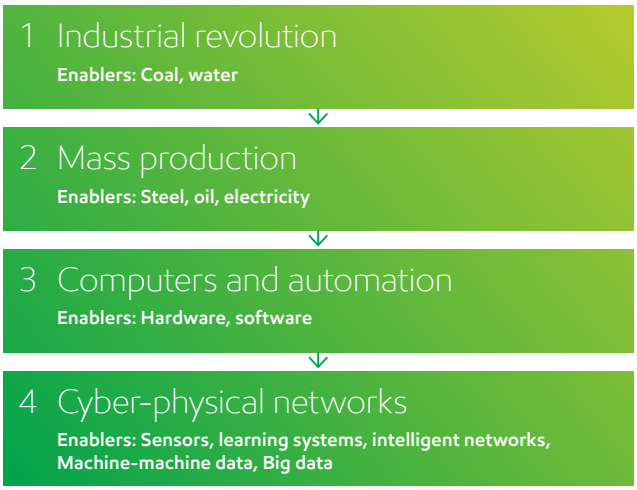
2 Changing industrial landscape

Industry 4.0 – the emergence of the 'smart factory' and the use of big data – is changing the manufacturing landscape. The aim of this process is to better utilize a plant's resources by connecting the devices and analyzing production data and equipment use.

2.1 Why care about Industry 4.0?

The smart factory, also called 'Industry 4.0' from a German government project to promote the use and integration of computing in manufacturing, is claimed to be the Fourth Industrial Revolution. However, as with the others, it will be more of an evolution (see below).

The Four Industrial Revolutions



Computers and machine controllers have a long history in manufacturing, but the smart factory concept is bigger than this. It is about getting machines not only to talk to one another but also to communicate across the site and upwards into the organization – all the way from the production process to business planning and logistics (and back again).

In the smart factory, these layers will all transfer data across, upwards and downwards to give greater control of the company and – hopefully – to get greater information out of what will become mountains of data. The smart factory uses the same data (or parts of it) throughout these four layers of information activity in the business. It links the production process right through to the business planning and provides both data and information to all layers.

Industry 4.0 is about seamlessly collecting data from a range of sources, converting the data into actionable information and transferring it to the right place for action.

> Data are not the same thing as information. Data are a collection of numbers whereas information is what allows management (or machine) action to be taken.

2.2 What role do hydraulic fluids play?

Smart factory technologies are revolutionizing the way we work but machines still need to be properly protected and maintained as the physical production processes remain crucial for Industry 4.0, which requires equipment to be working at its most efficient and be available when required.

A key step in ensuring this happens is the selection of hydraulic fluids. Although it is possible to save small sums of money when purchasing the 'lifeblood' of your machines, it is false economy that could easily place smart factory performance at risk.

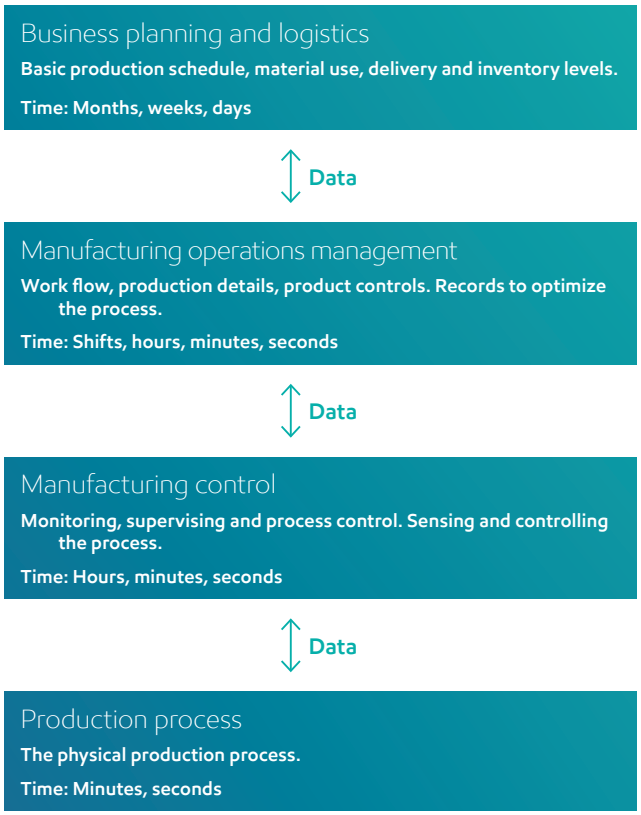
Selecting on price rather than performance could result in reduced equipment protection

and productivity; costly ramifications that outweigh the price of hydraulic fluids, which typically account for less than 1% of a plant's overall spend.
A relatively simple switch to high performance hydraulic fluids can have a big impact, helping to protect injection molding machines and allowing them to be part of Industry 4.0. Choosing advanced fluids can also can help to:

- Reduce start-up times
- Cut energy consumption
- Optimize cycle times

A high performance hydraulic fluid can additionally reduce system deposits, cutting machine maintenance and extending component life. Those formulated to provide thermal stability and resist oxidation can also extend fluid life, even under harsh operating conditions.

↓ The smart factory layers – from the process to the business and back again



2.3 Sustainability

The benefits of high performance fluids are not limited to enabling the smart factory and improving operations. The importance of environmental and energy management is growing rapidly and as an industry we need to prove that we are doing the best we can to reduce our environmental impact at both the input (raw materials and energy) and output phases (product and process waste disposal).
High performance hydraulic fluids that are maintained correctly will have a longer operating life, which reduces oil consumption and waste oil disposal. Given the reduced oil consumption, this also helps reduce an operation's environmental impact.
The use of high performance hydraulic fluids means we can reduce energy use to help meet ISO 50001 (Energy Management Systems) and reduce environmental impact to help meet ISO 14001 (Environmental Management Systems).

3 Hydraulic fluid fundamentals

The lifeblood of an injection molding machine is its hydraulic fluid. Its purpose is more complex than a simple lubricant; its main function is to transmit power from the hydraulic pump to provide the essential machinery movement. This means that hydraulic fluids need to possess very different characteristics to lubricants. The formulation of hydraulic fluids has improved significantly in recent years, especially when it comes to viscosity.

3.1 Viscosity

Viscosity is the resistance of a fluid to deformation by shear or tensile stress. What that really means is that it is a measure of the 'thickness' of the fluid – the higher the viscosity then the 'thicker' the fluid. For example:

- High-viscosity fluids are 'thick' fluids, e.g., honey.
- Low-viscosity fluids are 'thin' fluids, e.g., water.

The original VI scale ranged from 0 to a maximum of 100 but the introduction of new synthetic fluids and VIs means that the scale now goes as high as 400.

Viscosity can be expressed in several different ways (dynamic, kinematic and bulk) but for hydraulic fluids the most important viscosity measurement is the 'kinematic viscosity', which is the ratio of the dynamic viscosity to the density of the fluid. For most fluids, and particularly for hydraulic fluids, viscosity decreases with increasing fluid temperature, i.e., the fluid will get thinner and flow more easily as it gets hotter.

In order to maintain the peak performance of a hydraulic injection molding machine it is essential that the hydraulic fluid is at the optimum viscosity. If the temperature of the hydraulic fluid is not consistent then the viscosity will change and the machine will not be stable. This is why a consistent and controlled fluid temperature is important in injection molding.

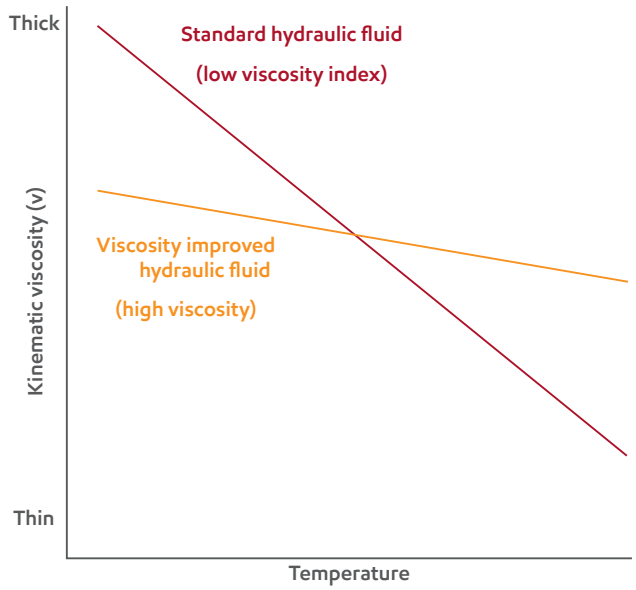
However, the viscosity of a hydraulic fluid will also change over time as the fluid molecules break down in service. Some oils are more prone to this than others so always check performance characteristics.

3.2 Viscosity index (VI)

The potential for a fluid's viscosity to vary as a result of a change in temperature is expressed using the viscosity index (VI). This measure was devised by the Society of Automotive Engineers (SAE) for lubricating oils but also applies to hydraulic fluids:

- A low VI means a high change in viscosity with temperature.
- A high VI means a low change in viscosity with temperature.

This is important for hydraulic oils because a high VI fluid will maintain its viscosity better when temperatures rise (see diagram). An injection molding machine using a high VI oil will be able to maintain a more consistent operation if hydraulic fluid temperatures rise. It will also be able to start production faster because the oil reaches the required viscosity faster and is easier to pump at low temperatures. Just as importantly, the oil will retain its ability to lubricate moving parts at high temperatures, helping reduce wear-related maintenance.



↑ The change in viscosity of a hydraulic fluid with temperature.
The viscosity of hydraulic fluids decreases as temperature increases. Viscosity improvers reduce the amount of change with temperature. This means decreased losses at low temperatures and better wear protection at high temperatures.

3.3 Viscosity index improvers

The VI of a hydraulic fluid can be improved by the use of VI improvers. These are typically high-molecular-weight polymers that are added to a base hydraulic fluid that expand or contract with temperature. These polymers minimize the effect of temperature on the viscosity:

- At high temperatures, the polymer additive expands and increases the viscosity of the fluid.
- At low temperatures, the polymer additive contracts and the viscosity of the fluid is determined by the viscosity of the base oil.

VI improvers increase the VI of the hydraulic fluid to give a consistent and optimized viscosity across a wide temperature range. This is vital for hydraulic injection molding machines because any decrease in hydraulic fluid viscosity will result in a reduction in pump efficiency and increased energy consumption.

4 Hydraulic fluid benefits

It is easy to forget about the importance of hydraulic fluids as they operate out of sight. However, their role in injection molding machines is vital – that's why plastics processors should take time to understand the benefits of switching to a high performance formulation. Making an informed choice of hydraulic fluid can improve efficiency, save money and boost cycle times – further advancing your operation to Industry 4.0.

4.1 Cold start

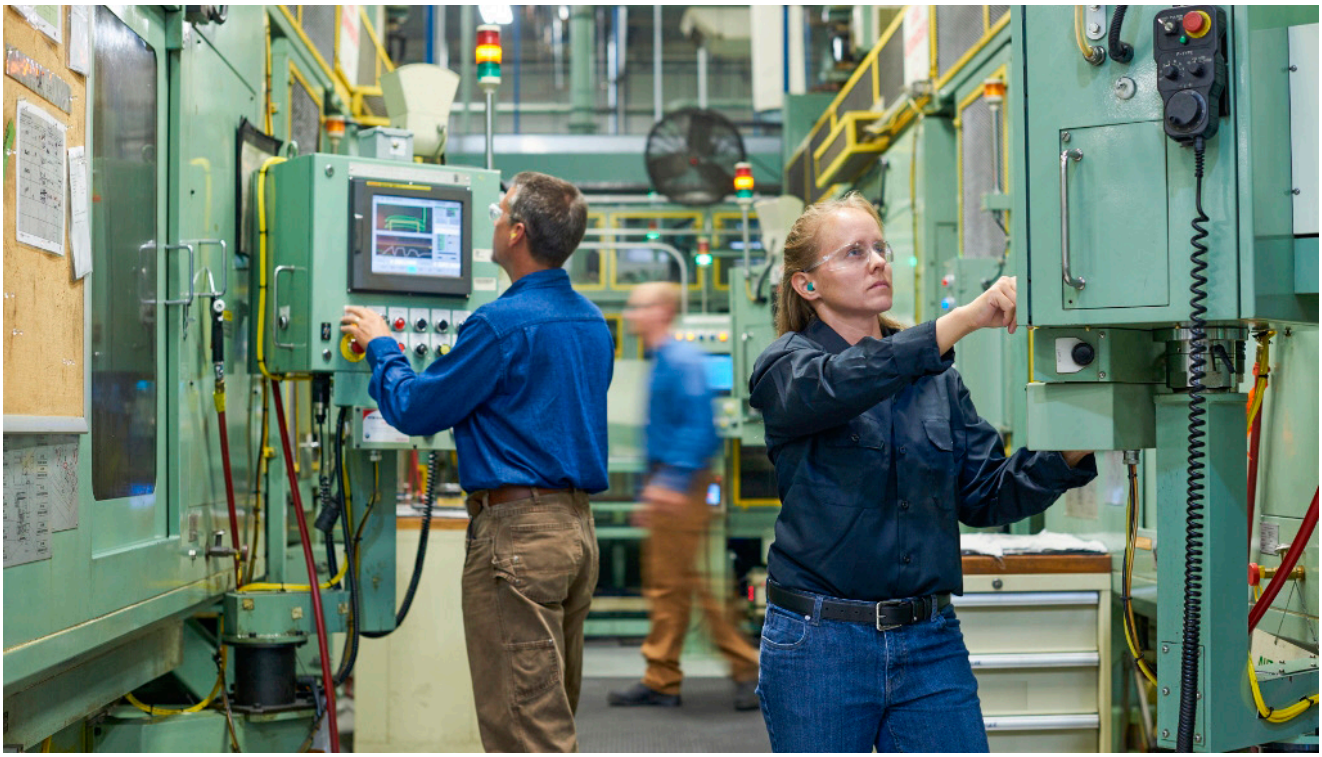
Identifying efficiencies in your plant can reveal some surprising areas for improvement. Even established practices, such as start-up times for injection molding machines, present opportunities for change.

A manufacturer of plastic components for the automotive industry switched its injection molding machines to Mobil DTE 10 Excel™ 46 hydraulic fluid. The high performance fluid's enhanced viscosity index (VI) cut the need to pre-warm it at equipment start-up, while its formulation reduced friction. These features resulted in average energy savings of 3.7%.

To start an injection molding machine, the hydraulic fluid must be heated to ≈ 122°F to ensure it has the correct viscosity to properly flow and protect components. This is why sites spend hours and a great deal of energy getting the fluid up to the right temperature.

Many processors heat the hydraulic fluid by pumping it around the machine (rather than using external heaters or a heat source within the fluid tank). This process takes around two hours and costs ≈ $11-17 per machine in electricity. Hydraulic injection molding machines use ≈ 75% of their operating energy when idling with no platen movement.

Using a high performance lubricant with a high viscosity index enables operators to start



their machine sooner, as the fluid achieves the required viscosity at a lower temperature.
Some plants run their machines 24/7 but many shut down for the weekend. This means that every week a single machine is costing at least $17 to start up. For a factory with 20 machines, that is a cost of more than $17,700 a year.
Using hydraulic fluids with a high viscosity index can help reduce costs and improve a plants environmental impact by:

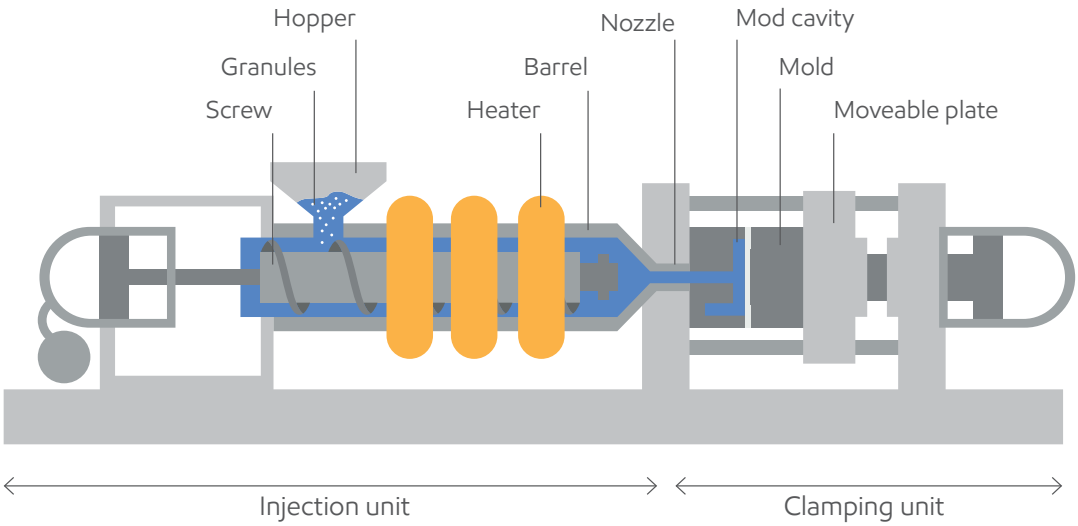
- Reducing start-up times, making molding machines more productive
- Cutting the energy consumption needed to get a molding machine into production

4.2 Energy savings

Changes in hydraulic fluid viscosity can directly affect the energy consumption of an injection molding machine. This is because any decrease in viscosity will result in an equivalent reduction in hydraulic pump efficiency, which increases energy use.
The energy savings reported from using high VI hydraulic fluids are typically in the range 4-10% of the energy used by the hydraulic pump. These savings will vary depending on machine, the application and other factors. Sites are advised to verify the savings through controlled trials.
Energy savings of up to 6% through a change in hydraulic fluid are too good to ignore. Sites using hydraulic injection molding machines are therefore strongly advised to examine their hydraulic fluid and to use fluids containing VI improvers wherever possible. The changeover can be part of a planned maintenance program to improve energy efficiency.
However, it's not all about processing equipment. Companies should also look at their plant's 'energy fingerprint' to identify savings in other potential areas, including cooling, compressed air etc.

4.3 Cycle times

Optimizing a plastics processing plant is all about fine details. Cycle times can already be as low as 2-3 seconds, depending on what's being made. However, enhancing plant operations can help enhance cycle times, improving productivity and a plant's bottom line.
Using a hydraulic fluid with a high, consistent viscosity will raise the volumetric efficiency of the



pump, which can improve the system response time. This has the potential to reduce cycle times for high-speed injection molding machines where the system response time is the limiting factor.

4.4 Noise

The use of a high viscosity hydraulic fluid can also reduce noise levels in an injection molding site. The new fluids suffer from less cavitation and this is one of the main causes of high noise levels in hydraulic injection molding machines.

4.5 Energy performance

ExxonMobil's Mobil DTE 10 Excel™ Series hydraulic fluids can provide up to 6% efficiency gain in hydraulic pump performance, compared with conventional Mobil-branded hydraulic fluids when tested in standard hydraulic applications under controlled conditions.

The fluids are also specifically designed to offer high performance, anti-wear protection for modern industrial equipment, including injection molding machines.

6 Used oil analysis

Industry 4.0 focuses on making the most of available technologies. Predictive maintenance, in particular, is already starting to transform a range of industrial processes including used fluid analysis.

If hydraulic fluid is the lifeblood of an injection molding machine then used fluid analysis is the blood test. Properly implemented, it can help spot potentially damaging issues before they become a problem – not only in the fluid but in the machine itself.

ExxonMobil's next generation Mobil Serv℠ Lubricant Analysis (MSLA) takes this process to the next level, helping plastics processors avoid unscheduled downtime while improving productivity and equipment life.

MSLA offers a range of automated features, including scan-and-go technology and a 24/7 cloud-based platform. Taken together these can enhance predictive maintenance by providing bespoke machinery insights when and where they're needed from any device. Benefits include a cloud-based mobile app, which enables users to access the information they need, when they need it, and pre-labelled sample bottles to reduce time-consuming paperwork.

The service also offers a wide range of testing options, including ones for hydraulic systems and gears, meaning that plastics processors can choose the right test package for their specific needs.

ExxonMobil continues to work closely with Original Equipment Manufacturers (OEMs) to ensure that its customers have access to the best possible lubricant solutions. Selecting high performance oils and greases, in combination with next generation used oil analysis, can help plastics processors remain competitive.

6.1 Protecting your fluid

In addition to switching to high quality hydraulic fluid, sites should also look at maintaining the fluids that are in use. Fluid breakdown occurs as a result of high temperatures, high pressures and shear stresses. These will reduce any fluid's viscosity, decreasing its protective properties and therefore increasing the risk of avoidable maintenance. A used oil analysis service will help spot oil degradation before it becomes an issue.

ExxonMobil's used oil analysis service is part of its comprehensive suite of Mobil Serv services, which includes a wide range of offerings that can help operators further optimize their plants. For example, filtration analysis, contamination control and fluid system maintenance are among the additional services best suited for injection molders.

To deliver the best solution for your business, ExxonMobil's Field Engineering Services (FES) team of industry specialists design tailor-made lubrication solutions that combine the right products and services to suit individual operator needs.

Used oil analysis is a vital 'blood test' for your equipment, helping spot issues before they become problems. →

7 Conclusion

Plastics processing continues to be a highly competitive industry. It is also a sector experiencing inexorable change. Next generation technologies are accelerating the rate of automation, which is enhancing productivity and improving market responsiveness. These developments, in combination with the latest digital tools, are forging Industry 4.0 – the next step in manufacturing.

High performance hydraulic fluids play an important role in this revolution, ensuring that your plastics processing equipment is operating at its optimal level, when and where you need it. By combining outstanding fluid performance with a predictive maintenance program, plastics processors can help ensure that they maximize productivity and protect their bottom line.

Because the plastics industry is getting more vigorous in its performance, choosing the best possible 'lifeblood' and proactively monitoring its health should be an essential part of every processor's daily operations.

While hydraulic fluids typically account for less than 1% of a plant's overall spend, choosing a high performance product, backed by the right expertise and maintenance program, can make a big difference.

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Additional resources:

- Energy Saving Guide for Injection Molders
- www.mobil.com/industrial
- Technical Helpdesk Email