When times are tough, companies usually look to reduce headcount. But a careful approach to energy management can lead to substantial savings, says consultant **Robin Kent**

Energy management in pipe and profile extrusion

It doesn't grow on trees: many 'free' resources in an extrusion plant – such as cooling water – are actually expensive. Realising this can save you money

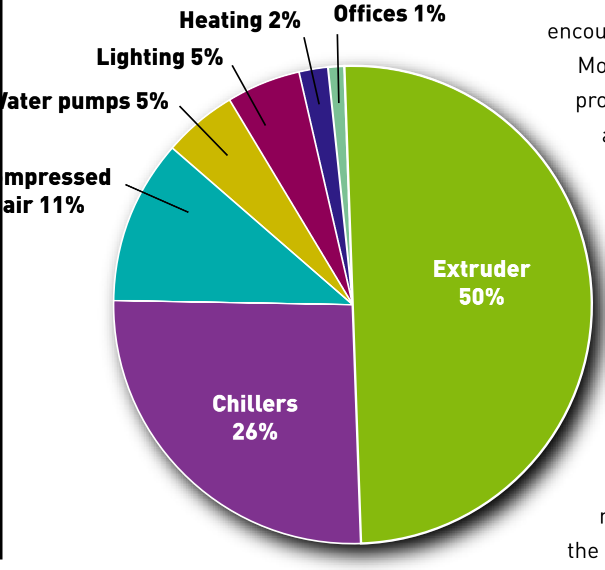
Extrusion of any description is highly dependent on electricity and most of the energy usage at an extrusion site is in operating the extruders. For pipe and profile extrusion, about 50% of the total site energy is used at the extruders, with the remaining energy used for services and ancillaries.

The initial cost of energy-efficient extruders may be higher but they will give rapid returns on this extra investment. Older extruders generally use DC motors but the new generation of extruders are often available with AC motors controlled by variable speed drive (VSD). VSD-controlled AC motors can be retrofitted to many extruders, which is also strongly recommended.

Whatever the type of motor, it is essential is to match the extruder to the job. Extruders run most efficiently (not only in energy terms) when operating at the design conditions. As far as possible, the extruder should be set to run at the maximum design speed, as this is usually the most efficient speed. The screw speed should be controlled to give an extrusion rate as close to the maximum as possible and still make good product.

Extruder motors commonly run at high speeds and are geared down to the required screw speed. When the existing gear ratios are not right for the job, the motor will not be operating at the correct speed, the energy used will be excessive and the torque generated will be well below the optimum levels. Changing the motor and

FIGURE 1: ENERGY USE AT A TYPICAL PROFILE EXTRUSION SITE. CONCENTRATE ON THE BIGGEST ENERGY USERS TO GET THE QUICKEST RESULTS



the drive ratio can be a simple project to optimise motor usage.

Hot and cold

Most of the thermal energy needed to plasticise and heat the plastic comes from frictional heat developed as the material is moved by the screw. In most cases, mechanical energy is more efficiently transferred into the material than external heater bands, which act only on the outer layer of the material at the barrel interface. This can actually reduce frictional heating by creating a molten layer at the inner surface of the barrel.

Optimising the extruder speed maximises the heat from mechanical work and minimises the amount of electrical energy needed to heat the plastic. As long as the downstream equipment does not limit the output, the energy consumption of an extruder (in kWh/kg) can be decreased by nearly 50% by doubling the rotational speed of the screw.

Where frictional heating is excessive, fan blowers are needed to remove the excess heat from the barrel. This also aids the extruder operation by cooling the barrel, increasing the friction at the plastic/barrel interface and encouraging mixing and forward movement.

Monitoring of the barrel heaters and blowers will provide an understanding of the exact heat flows for a specific extruder/product and will show when (and which) heaters and blowers are coming on and off load (preferably not at the same time).

Good extrusion requires plastic to be kept at the optimum temperature, but at the same time not overheating. Depending on the material, the processing window is small and overheating from shearing is common unless accurate temperature control is present.

If the heaters are on at all times then the motor is not providing enough shear heating for the process and there are two choices:

- The main extruder can be run harder to increase the shear heating and decrease the need for the heater bands. This is the preferred option but may be limited by downstream cooling efficiency.
- The barrel can be fitted with insulation to reduce heat losses but this is rarely required for the complete barrel. The rear section may need almost continuous heating due to the inflow of the cold material before it has undergone any shearing and the front of the barrel may need heating due to reduced shearing in this area.

Where shear heating is low, barrel insulation is beneficial and effective in reducing the energy input needed from heaters. It reduces energy usage, temperature fluctuations and Health and Safety issues.

Downstream control

There is very little shear heating downstream of the screw tips and heaters are always needed to keep the plastic at the correct temperature in breaker plates, adapters, transfer tubes and dies. This is particularly important for hollow products where the mandrel is held in place by spiders and full re-welding of the melt stream must take place after the material passes the spiders (otherwise weaknesses will result).

Heating is generally necessary for all areas downstream of the screw tip and heat losses will be significant. Insulation will reduce heat losses and energy usage in these areas as well as reducing health and safety concerns.

Calibration and cooling take place at the same time although a variety of different methods are used. For simple profiles, the calibration may be a single plate followed by a chilled water bath whereas for complex PVC-U window profiles calibration is usually by multiple metal plate calibrators in a full chilled water bath or in a spray bath.

The effectiveness of cooling is often a controlling

Barrel temperature control

- Check the extruder controls to make sure that the heating and cooling are working efficiently together and not competing with one another. Make sure there is a 'dead band' between the operation of the heaters and blowers.
- Accurate temperature control will produce good product and minimise energy costs.
- Insulation is effective on barrels but not in all sections or for all applications. Installing insulation at all sections of a barrel can lead to a 'runaway process'.

factor in the overall line speed. The profile must be fully cooled by the time it reaches the haul-off and if cooling is ineffective then the line speed must be slowed down.

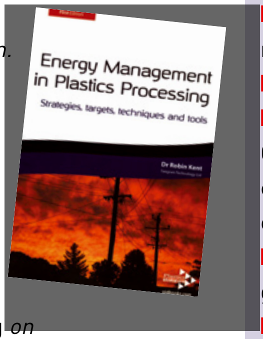
Many pipe and profile sites treat cooling water as a free resource and allow chilled water to flow freely even when it is not being used productively. This warmed water is then fed back to the chillers where it is recooled at great expense.

Vacuum pumps are used to remove air from the water system and to encourage good contact between the extrudate and the calibration system. These are usually fixed speed and uncontrolled.

In conclusion, pipe and profile extruders have many opportunities to reduce energy usage and costs without significant investment. They can carry out many simple actions to reduce costs, which have no detrimental effect on the product or operations.

Dr Robin Kent (rkent@tangram.co.uk) is managing director of Tangram Technology, consulting engineers specialising in energy management in plastics processing.

A similar article, on energy management in film and sheet extrusion, will appear in the next issue of Film & Sheet Extrusion.



Robin Kent's book, Energy Management in Plastics Processing, *was recently published by Plastics Information direct. For more information,* ***click here****.*

He will also be running a full-day masterclass on Energy Management in Plastics Processing *on Thursday 4 June in Coventry, UK. To download a brochure for this training seminar,* ***click here****.*

www.tangram.co.uk

Downstream tips

- All areas downstream of the screw tip can be insulated, to reduce temperature changes and energy use.
- Find the maximum acceptable extrudate temperature after cooling and set the cooling water temperature to achieve this. Do not overcool the product.
- Check that cooling water is used wisely and not wastefully, and that it is treated, chilled and distributed efficiently. Make sure it is not circulating through idle machines and calibrators; turn off cooling water on idle machines.
- Check that the vacuum supply is the minimum needed and that it is generated and distributed efficiently. Switch it off when it is not needed.
- Consider using VSDs (with feedback loops) on vacuum pumps to control the vacuum achieved instead of simply supplying the maximum possible.
- Check that cooling tanks using vacuum are sealed correctly to reduce the vacuum usage.

Extruder tips

- Always consider energy efficiency at the purchase decision stage.
- Always ask for the VSD + AC motor option in new purchase and consider retrofitting VSD + AC motors for existing extruders.
- Using large extruders for small profiles wastes energy and costs money.
- Investigate the option of switching extruder motors to match the job. Cost the time taken to switch motors and the energy saved. The calculations sometimes show that switching the motor is a very cost effective operation.
- Check the loading on extruder motors and modify the motor size and gear ratios to optimise motor energy usage.
- Where the drive uses pulleys, this can be as simple as using pulleys of different diameter but be sure to get alignment correct when changing pulleys.

FIGURE 2: ANCILLARIES HAVE VARYING ENERGY NEEDS. THIS TRACE SHOWS SIGNIFICANT ENERGY USE IN HEATING. THE EXTRUDER DRIVE IS NOT PROVIDING THE ENTIRE SHEAR HEATING REQUIRED AND BARREL INSULATION COULD BE CONSIDERED.