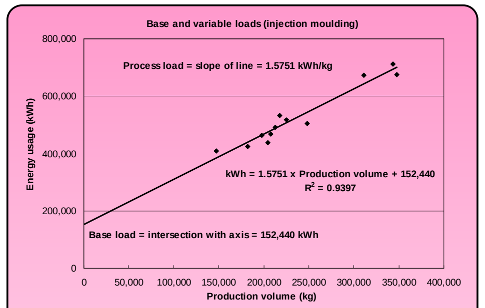
Tangram Technology
Energy management in plastics processing - Top Tips

TANGRAM TECHNOLOGY | Consulting Engineers

Energy management

- Energy costs are rising and there is no reason to believe that they will decrease.
- The use of taxation and other financial instruments will increase.
- Supply and distribution shortages will increase.
- Security of supply (at any cost) is a rising issue.
- Environmental issues are increasing in importance and public perception.
- Corporate social responsibility is increasing in importance.
- Energy costs are reaching the same magnitude as labour costs.
- Energy costs are reaching the same magnitude as profits.
- Energy usage and costs can be reduced by over 30% in most cases and add directly to the site profits.
- Energy costs can be reduced by:
    - Management
    - Maintenance
    - Investment.
- The payback for most investment in energy management is 6-9 months.
- The source of the current costs in plastics processing can be established very quickly.
- The returns from efforts in energy management are quick, certain and need only internal effort.
- The returns from energy management are better than the returns from increasing sales.
- Implementing energy management requires an energy management system.
- The energy management system must cover:
    - Energy policy
    - Personnel
    - Planning
    - Resources
    - Training
    - Auditing
    - Reporting
- Energy managers must show results to get resources.

Base and variable loads



- Energy management requires measurements and understanding of the process.
- The measurements are very simple to obtain and can come from most standard accounts packages.
- The measurements need very little treatment to give vital information on the site and process operations.
- Energy usage is not an uncontrolled and unknowable variable - it is directly related to the production volume of the site.
- Plot energy usage for the month (kWh) versus production volume (kg) as a scatter chart and use a best fit trend line to generate the Performance Characteristic Line (PCL).
- The PCL gives the 'base' and the 'process' loads of the site.
- The base load of a site is the intersection of the best fit line with the vertical axis. It is the 'energy overhead' and will typically range from 10 to 40% of the total load of the site. A low base load generally indicates good management control of energy at the site and a high base load generally indicates poor management control of energy at the site. Reducing the base load is easy to carry out, low cost and has rapid payback. Savings in the base load are very profitable because the base load is largely a dead weight that is unrelated to production output.
- The process load of a site is the slope of the best fit line and is the energy needed to run the process. Reducing the process load is difficult to achieve because it generally (but not always) requires more fundamental and expensive process improvements. The process load depends on the type of process being used at the site.

Performance and budgets

- The PCL can be used to internally benchmark a site against historical performance.
- Set up a simple spreadsheet to calculate the predicted kWh for a given production volume using the PCL.
- Determine the volume of material processed in the previous month and calculate the predicted energy usage.
- Determine the actual energy usage for the past month.
- Compare the predicted energy usage to the actual energy usage.
- If the actual energy usage is less than the predicted energy usage then the site performed better than it has done historically - find out what the site did right and do more of it.
- If the actual energy usage is more than the predicted energy usage then the site performed worse than it has done historically - find out what the site did wrong and do less of it.
- Weekly data collection gives faster feedback to production departments on how to improve.
- For plastics processing, it is best to use 'kg' as a reference for the production volume but it is also possible to use 'parts' or any other convenient measure of production provided the product mix doesn't vary greatly.
- Recording kWh/kg as a process efficiency measure on a monthly basis will lead to inaccurate conclusions due to the effect of production volume changes.
- The PCL can also be used to provide an accurate model for energy budgeting into the future. Use the forecast sales volume to produce a forecast production volume (in kg) and simply use the PCL to predict the energy usage.
- It is possible to set up model systems for both sites and machines to show how the energy usage of sites and machines will vary with production rate.
- Model systems open the way to effective external benchmarking of sites and machines.
- External site benchmarking is possible using industry data but the results are only relevant for a specific process and production rate.
- External machine benchmarking is possible using industry data but the results are only relevant for a specific process and production rate.

Monitoring and targeting

- An energy map of a site is easily prepared and will show where most of the energy is being used at a site.
- An energy map can be used to target efforts in the most rewarding areas and to decide on sub-metering arrangements.
- Simple plots of energy usage versus time will reveal abnormal events and allow these to be investigated.
- Integrating energy usage into the accounting system is a vital element of controlling energy costs.
- Energy consumption and savings need to be expressed in terms that the accounts function can recognise and deal with (£).
- The cost drivers for energy usage can be 'activity' (generally related to production volume) or 'condition' (generally related to the weather) drivers.
- Measuring and understanding the drivers allows cost assignment to the relevant areas and ownership of the costs can be created.
- Energy costs are not 'somebody else's problem'.
- Monitoring and targeting can be used to set targets based on the PCL of the site.
- Targets can be set on the basis of simple control charts, similar to those used for SPC, e.g. CUSUM charts are very sensitive to changes in performance.
- A 'challenging but achievable' performance target can be set from the data used to generate the PCL. This is the best possible historic performance of the site.
- Energy management needs a formal structure that ensures that the output of the system is translated into real financial performance improvements.
- Energy reporting must be adjusted for the audience.
- Simple graphs are the key to attracting and retaining the audience's attention.
- Investment in improving energy usage performance can change the rules of energy usage and make energy cost reduction automatic.
- Investment in improving energy efficiency is often neglected because of the lack of a recognisable income stream from the investment.
- Investment in capital equipment should consider the whole life cycle of the equipment and particularly the energy costs over the life cycle.

Power supply

- Understanding the energy consumption (electricity and gas) is a key task.
- Simply knowing how to read the energy bills can save money.
- Improving the power factor, reducing the maximum demand and reducing the available capacity will reduce energy costs.
- Suppliers data is a vital tool and can provide important information.

Motors

- Motors are the largest energy user in plastics processing.
- Turning motors off (by any means possible) is one of the most effective methods of reducing energy usage.
- Operating motors at the maximum efficiency means getting the size right.
- New high efficiency motors (EFF1) offer significant energy savings over the life of the motor.
- Variable speed drives (VSDs) allow motors to be slowed down to match the demand and offer energy savings and improved process control.
- VSDs are one of the most important tools available to plastics processors to reduce energy usage and costs.
- Motor management is a necessity for modern plastics processing. This allows sites to make the repair/replace decision before the motor fails.
- Sites should set up a 'motor register' to manage the motors on the site.

Compressed air

- Compressed air is NOT free, it is an expensive resource.
- A compressed air map of the site is a vital tool to locate leaks and poor usage. Map where compressed air goes and how it is used.
- Compressed air leakage is an avoidable waste.
- Compressed air leakage uses between 20 and 50% of the compressed air generated.
- A 3mm diameter hole can cost up to £1,500/year.
- If you can hear a compressed air leak ('ssssss') then it is costing at least £100/year.
- Compressed air usage should be reduced by using other means of power where possible. Almost any other method of doing a job will be cheaper than using compressed air. For air-operated power tools the delivered power costs 10 times that of direct electric drives.
- Compressed air generation, treatment and distribution offer many low-cost areas for energy usage reduction.
- Compressed air costs can be reduced by feeding cold air to the compressor.
- Compressed air costs can be reduced by reducing the system pressure to the minimum required to actually operate the process.
- Heat from compressors is often wasted but can be recovered and used in a variety of applications.

Drying and cooling water

- Drying of many polymers is not needed if good materials handling practice is used. Insurance drying is not free - costs money.
- Drying to the correct level is essential, over drying increases energy usage and costs and can damage material.
- Desiccant drying is the traditional method of drying and can be very effective if good practice is used.
- New technologies for drying can be very effective.
- Cooling water (chilled and cool) is a major hidden cost for plastics processing.
- Increasing water temperatures will reduce energy costs.
- Chillers are basically compressors and good maintenance can reduce energy usage significantly.
- Cooling towers offer low cost cool water and offer good opportunities for energy saving through low-cost actions. Legionella controls are an essential for cooling towers.
- Air blast cooling removes the need for cooling towers and can be used with chillers to reduce operating costs when the external temperatures are low.
- Insulate machines and chilled water piping where possible to reduce parasitic heat gains.

General

- Plastic processing technology is improving in energy efficiency. Old machines are inevitably less energy efficient than new machines.
- Processors using old machinery are not saving money they may well be putting themselves at a permanent cost disadvantage.
- The rate of change in improvement needs to accelerate and the machinery manufacturers need to recognise this.
- Most processing methods offer opportunities for energy management and energy efficiency improvements.
- Sites need to investigate the energy usage of all machinery before purchasing new machinery.
- Look for large motors that are not used to their design specification on small machines.
- There is no conflict between energy efficiency and productivity - they can both be achieved.
- Idling machines in any process are not free - they are costing large amounts of money (up to 90% of the full running costs) but are often ignored by site management.
- Machine monitoring can be rapid and low cost.
- Machine monitoring allows processors to see inside the machine cycle and to adjust the settings to get the most energy efficient settings for the job.
- Machine monitoring is a sensitive indicator of a machine's general condition.

Injection moulding

- Always ask for data on injection moulding machine energy use as part of the purchasing process.
- Accumulators can reduce transient power requirements.
- Check that the machine is right for the job. Large machines making small products are inherently energy inefficient.
- Process setting is the key to energy efficiency in injection moulding. Optimised process settings will increase productivity and reduce energy usage. To repeat: There is no conflict between productivity and energy efficiency.
- Controlling machine operations (start-up, stand-by and shut-down) is a key factor in reducing energy costs.
- Barrel heating in injection moulding machines is a major energy user and can easily be reduced.
- Ensure that barrel heaters are 'bedded-in' and use a conductive metal compound between the heater and the barrel for good heat transfer.
- Barrel insulation will reduce energy use in heating with good pay-back times. Barrel insulation also reduces Health and Safety concerns with hot surfaces.
- Ensure that barrel heater thermostats are accurate and can control the heater.
- New technologies exist for improved barrel heating and insulation.
- Injection moulding machines have made a huge leap in efficiency with the introduction of all-electric machines and these can give processors a permanent advantage over competitors using conventional hydraulic machines. All-electric machines are a 'no-brainer'.
- All-electric machines not only use up to 60% less energy in operation but also have lower standing losses, are easier to maintain and are more accurate in operation.
- Retro-fitting VSDs to hydraulic machines is very cost effective if the machine parameters are right. VSDs will save energy by slowing down or stopping the hydraulic motor when the cycle does not need it.
- Investigate if machines are suitable (large fixed displacement motors, long cycle times and long operating hours) but always ask for relevant industry experience and guarantees.
- VSDs are NOT the same thing as motor voltage regulators (MVRs), these reduce the supply voltage to the motor to reduce motor losses and improve operating efficiency.
- Mould temperature controllers (MTCs) are a hidden cost in injection moulding and the need to use these should be examined carefully.
- Insulate piping between MTCs and tooling to reduce parasitic heat gains or losses.
- Initial mould design can affect energy usage and designers need to be aware of the cost of their decisions.
- Minimise sprue and runner sizes to minimise the material processed in the cycle. Sprues and runners are not free even if they are regranulated.
- Investigate the cost of running machine-side regranulators versus the cost of the recovered material.
- Design handling systems to operate 'on-demand' only and use gravity wherever possible. It is free.
- Link downstream equipment to the machine so that when it stops then the downstream equipment shuts down too.

Extrusion

- Extrusion costs can be reduced by using VSDs and AC motors (EFF1) instead of DC motors. Reliability and ease of replacement are also increased by using AC motors.
- Using large extruders for small profiles wastes energy and costs money.
- Extruder motors can be switched to match the job. Cost the effort of changing the motor versus the energy cost.
- Barrel insulation in extrusion is not generally needed because shear heating should supply most of the heating load. Extruders will generally need barrel blowers to cool the barrel and insulation can sometimes lead to a process runaway.
- Check heating/cooling controls to make sure that heating and blowing are not fighting one another.
- Insulation can be cost effective in areas where shear heating is low, e.g. in the first zone where the incoming material absorbs a lot of heat and most areas forward of the screw tips where heating is needed such as dies, melt pumps and filters.
- Check the loading on extruder motors and modify gear ratios to optimise the energy usage. Extruder motor gear ratios should be managed to optimise the motor load and maximise energy efficiency.
- The economics of edge-trim recycling in sheet extrusion need careful examination.

Blow moulding

- All-electric machines are now available for both extrusion and injection blow moulding. These have all the benefits of all-electric injection moulding machines. They are again a 'no-brainer' for most applications.
- Shear heating in extrusion blow moulding does not contribute greatly to the heat input and barrel insulation can be very profitable for both extrusion and injection blow moulding.
- Minimising the melt temperature will reduce the need for cooling and will improve both cycle times and energy use.
- Good parison control in extrusion blow moulding will improve product quality, process efficiency and reduce energy use.
- Management of compressed air is vital in both extrusion and injection blow moulding. This is particularly true for injection blow moulding where compressed air pressures are generally much higher. Reduce compressed air pressures when holding after initial blowing.
- Tops and tails management is a key energy issue in extrusion blow moulding.
- Recrytallisation of regrind from PET mouldings can be combined with drying through the use of infra-red drying.

Thermoforming

- Pre-warming ovens should be well sealed and insulated to prevent excessive heat losses.
- Minimise the distance between pre-warming ovens and thermoformers to minimise heat losses.
- Minimise the size of entrances and exits on pre-warming ovens and thermoformers to minimise heat losses.
- Thermoformer heater banks should use heating elements that match the emissivity of the heater to the absorption of the material.
- Heaters should be kept clean to ensure good emissivity at the right wavelength.
- Heater banks should be sealed and insulated where possible to reduce heat losses from radiation, convection and conduction.

Rotational moulding

- PCLs for rotational moulding should be generated for gas and electricity use.
- Monitor burner efficiency to get complete combustion of the gas.
- Investigate methods of improving combustion efficiency.
- Investigate methods of getting the heat into and out of the mould quicker. This determines the process efficiency.
- Carry out a thermographic survey of ovens and use this to improve sealing and insulation of ovens.
- Reduce door opening times to minimise heat losses from the oven.
- Use VSDs on recirculation and exhaust fans to improve process control and minimise energy use.

Operations

- Operations is where technical improvements are put into practice - it is where the 'rubber meets the road'.
- Operations depends on people, improvements are cheap but can be difficult to implement and sustain.
- Initial process setting needs a scientific approach for the best results. Optimized settings must be adequately recorded and used to be effective. No settings should be changed without justification and high-level approval.
- Start-up should follow setting sheets at all times. Correct sequencing and a simple time-line will reduce energy use. Machines should be set into 'stand-by' when they are not going to be used for a short time. If they are not going to be operated for a long time then they should be shut-down.
- Shut-down should take the high energy loads off-line as soon as possible.
- Fast tool changes will reduce energy costs.
- Quality costs should include energy lost from rejects.
- Training should explain the process, motivate staff and needs to be relevant to the role of the staff.
- Maintenance is a key issue in achieving and sustaining the energy efficiency of machines.
- Process control improvements can reduce energy usage at a range of levels.

Buildings

- Building energy costs are a significant percentage of the total energy costs. Improving building energy efficiency reduces costs and improves staff comfort and work output.
- Monitoring and targeting for buildings is 'condition' driven.
- The energy use of office equipment is low but can be reduced through simple staff measures.
- Lighting should provide a safe environment, it does not use large amounts of energy but is a visible sign of commitment.
- Ambient and task lighting are very different. Taking action to separate them can reduce costs.
- A 'lighting map' is vital in reducing lighting energy use.
- Investment in controls can automatically reduce lighting costs without affecting product or lighting quality.
- Heating should provide a comfortable work environment.
- Quality and comfort heating are very different. Taking action to separate them can reduce costs.
- Reducing the heating load is the first task and heating levels should be set to match the activity.
- Investment in heating controls can reduce heating costs but they must be set correctly and tamper-proof.
- Maintenance of heating can reduce energy costs.
- Hot water is best provided by local 'on-demand' heaters.
- Air conditioning is a rapidly rising energy user but is mostly 'comfort cooling' for a few days of the year, this can cost as much as the yearly heating bill. Air conditioning controls are often tampered with by staff.
- Building fabric improvements can reduce both heating and air conditioning loads and reduce costs.
- The main tasks are to reduce air leakage and to improve building insulation. Air leakage is not the same thing as ventilation. Insulation can be improved through simple local measures.

Site surveys

- Site surveys are a key part of energy management. They show the status of a site and are a reference point for future progress.
- Information is the key to an effective site survey.
- Basic energy consumption data, and an energy map are needed for a site survey. These allow targeting of the largest energy usage areas to provide the greatest rewards.
- The equipment needed for a basic site survey is minimal. It is possible to carry out a site survey with virtually no equipment. The equipment needed for an advanced site survey is inexpensive but allows more value to be added.
- Site surveys should be planned and carried out during normal production and also, if possible, during shut-down periods.
- Site surveys should drive action to reduce energy usage.
- Site surveys should produce a range of clearly defined projects that will pay back rapidly and should report in financial terms to gain top management support.
- Site surveys should be regularly repeated to check progress, to report success, to close out completed projects and to generate new projects.

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