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SELECT TECHNICAL ASPECT OF ENERGY USING AND MANAGEMENT IN INJECTION MOLDING PROCESS

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Abstract

Technical aspect of energy using and management in Poland industry of injection molding plant are not well known. Energy management is assignment of increasing importance to plastics processors. However there is no well-known structure for measurement, estimation and prediction. Many technical workers sometimes are trying to measure something, but don't know techniques how to do it in a good way. Next then get the bad answers. This paper describes and illustrates some basic techniques and aspect of measurement, estimation and prediction. This engineering element can be used for most plastics processing companies. More importantly, the paper looks at how this information can be used to get better both operations and performance in injection molding industry and per analog in other plastics industry.

Keywords: *energy using, management, plastics processing, injection molding*

1. Introduction

The idea of aspect in energy using and management is relatively new to the injection plastics industry but is now being strongly driven by the recent rises in world energy costs and the rising unreliability of supplies for the near future. Twelve years ago a topic of energy using and management was a marginal activity in Europe. It was not easy attract the interest of plastics industry in energy management. During the time this thinking was changing and today this area is a real business issue. Very often this area is not visible yet in Poland industry, but this thinking are slowly changing. The reason of this situation is small amount of specialized institution in energy management of plastics industry [3, 9]. Energy costs represent the third largest variable cost (after materials and direct labour) and in some companies is even the second largest variable cost. No information on energy consumption by individual plant (site) in the plastics processing technologies, not to take steps to reduce energy consumption in each technical process can be fatal to the company [1, 4, 5].

Aim of this work is describes and illustrates some basic techniques and aspect of measurement, estimation and prediction that can be used for most plastics processing companies (internal benchmarking) [3]. Also looks how this information can provide real benefits in realized plastics process. The basic structure of energy using and management system in plastics processing is shown in Fig. 1. Example graph about typical average energy consumption in plastics plant is show in Fig. 2. The main energy usage and cost is in processing machinery and services (92%). Lighting, heating, and offices are minor energy costs (8%) [7].

We will first look at concept base and process load in internal benchmarking [3] for the site with hypothetical example for injection molding and next present some area of technical improvement affecting minimize energy using in injection molding process and show results.

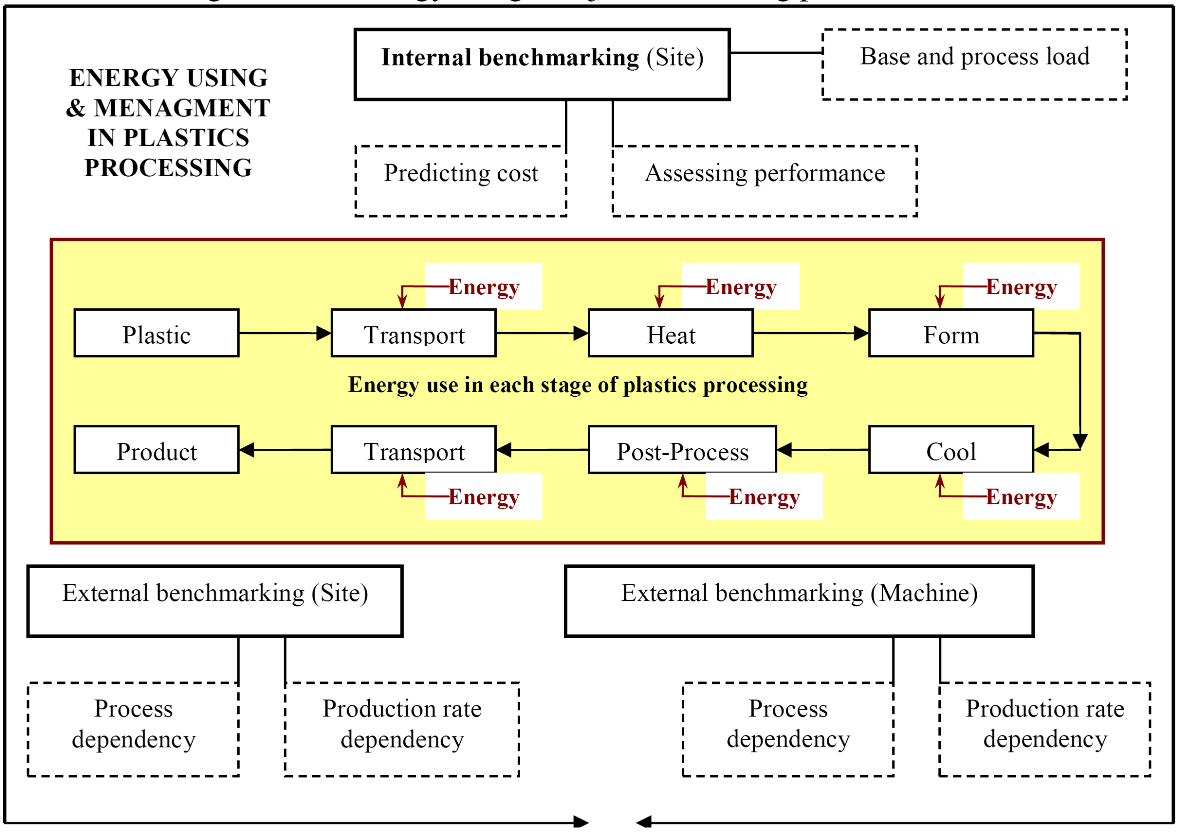

Fig. 1. System of energy using and management in plastics processing

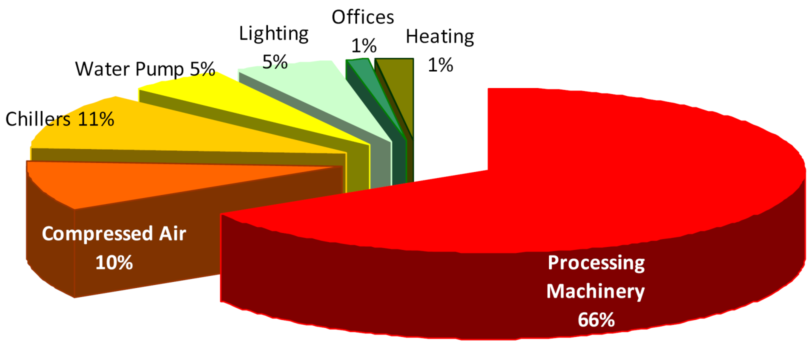

Fig. 2. Average energy use in plastics plant [7]

2. Base and process load in internal site benchmarking

The base load inform about energy consumption when plastic machine is stopped but all service media are available. Most factories will have a base load, which will be present even when there is no production. This may be background heating, water pump, light, compressed air and equipment that have been left on standby. Process load inform about using energy during running processing and has different value for plastics techniques ex. injection molding, extrusion [10].

In injection molding processing site, also in other plastics manufacturing method, it is possible to determine the base and process/variable loads for the site. This is possible when simple energy usage and production volume data are available. On the start it will be illustrate the method using a sample injection molding factory (hypothetical) and next information that can be obtain from this data. There are two basic steps to get base and process load [3]:

- write or record factory output (in kg) for a number of weeks or months and write at this same time the energy usage (in kWh). Some hypothetical data for injection molding factory shown in Tab. 1.
- next plot the energy usage (in kWh) versus production level (in kg) in a Excel chart. A graph with this data is shown in Fig. 3. Point graph are with trend line (linear) and the best fit. Visible intersection of the line 'kWh' axis indicates the base load of factory. Base load is like something no effective production but all service media and injection molding plant are available. The slope of the best fit line is the process load. Observer manager can see the average energy consumption for each kilogram of processing plastics. In our case the equation of the best fit liner is:

$$kWh = 1{,}6 \cdot Production\ volume + 143297. \quad (1)$$

The R^2 value about 0,95 indicates that the data set is relatively consistent with the function line. Reading of this line can show that the base load is a constant energy cost for 143297 kWh and process load is 1,6 kWh/kg of polymer processed. Next observer can obtain the middle cost of base load assuming 0,40 PLN/kWh, which is 57318 PLN/month or 687825 PLN for a year. In literature data can see that base load is about 20% even to 50% of factory energy consumption [1].

Tab. 1. Energy usage and production volume date during 1 year (sample hypothetical data)

Num.	Month	Energy usage, kWh	Production volume, kg
1	January 2009	425000	181000
2	February 2009	460000	198000
3	March 2009	505000	249000
4	April 2009	440000	205000
5	May 2009	492000	210000
6	June 2009	518000	225000
7	July 2009	535000	220000
8	August 2009	460000	205000
9	September 2009	680000	350000
10	October 2009	720000	340000
11	November 2009	680000	330000
12	December 2009	400000	150000

Reduction of the base load can be generally made and achieved without influence on production part rate. It is very important to making some technical aspect that influence on reduction energy using. The process load inform us (for our hypothetical sample factory, Fig. 1) that for each polymer kilogram whole plant using 1,6 kWh and how management and efficiency is in this place.

Reducing the line slope is in more case difficult to achieve [3]. However knowledge of this information is very important to start doing technical service improvement and note the information about base/variable load.

In other hand equation (1) can be name Performance Characteristic Line (PCL) [1], because this line provides an operational signature of the plant that is closely related to the way the plant management runs the plant.

Base load and process load for different plastics processing technique have different value. Example extrusion typically has a lower process load (flatter slope of the PCL) than injection molding. In turn extrusion blow molding has a relatively low base load but a higher process load than extrusion or injection. Note is also that extrusion plus thermoforming generally has a process load in the range of injection molding [10].

Typical example of site energy day usage over the time can be note in each hour. This is very important for understanding how plastic machine work and for get invaluable information on how to reduce the energy cost (Fig. 4). This information should be analyzed to critical asses where and when energy is being used. In unproductive injection molding time, longer then (30-50) minutes, sometimes less energy will be consumed if machine turn off and next turn on [2].

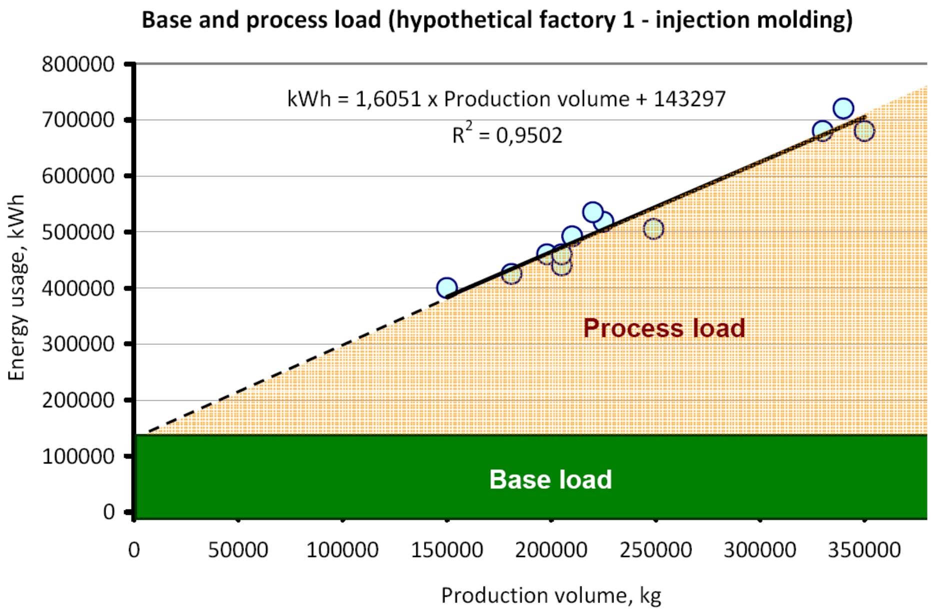

Fig. 3. Base and process load for hypothetical injection molding plant/machine

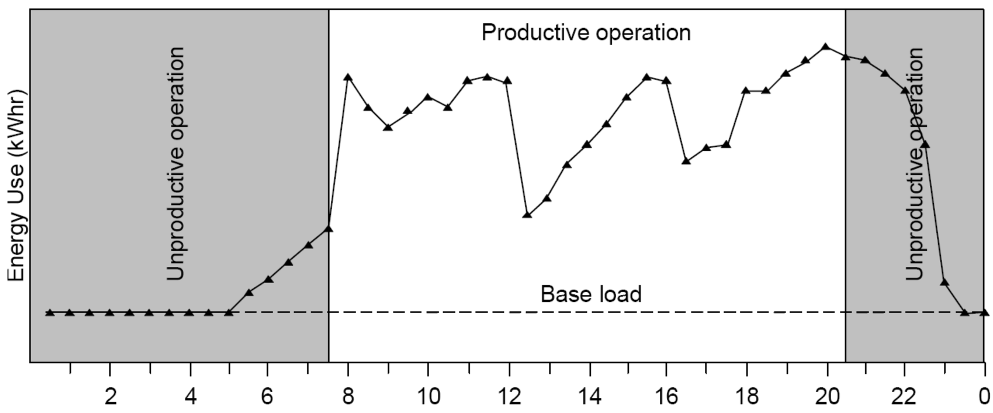

Fig. 4. Typical example site energy usage over time [2]

3. Technical improvements affecting minimize energy using in injection molding

It is commonly known that often with most machines, the initial cost of an injection molding machine will be less than the cost of energy used during its lifetime [4]. The energy cost can be even more for machines that are not energy efficient. Though it may cost more initially, energy efficiency is more economic in the long term. Also other aspects are important not only machine. Smaller energy using can be achieved for other basic technical service equipment and elements which include: motors, compressed air, cooling fluid and construction of injection mould etc. In Fig. 5 presented the area where technical improvement can be made to achieve lower energy consumption. There are four basic areas: processing, utilities, materials, administration offices [2].

Motors are the largest energy user in injection molding processing. Turning motors off when they are not using (and it is possible) is one of the most effective methods of reducing energy usage. It should be know that maximum efficiency of motor is when they have right size. 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 of their technical aspect is a necessity for modern plastics processing. This allows plastic sites to make the repair/replace decision before the motor fails [5].

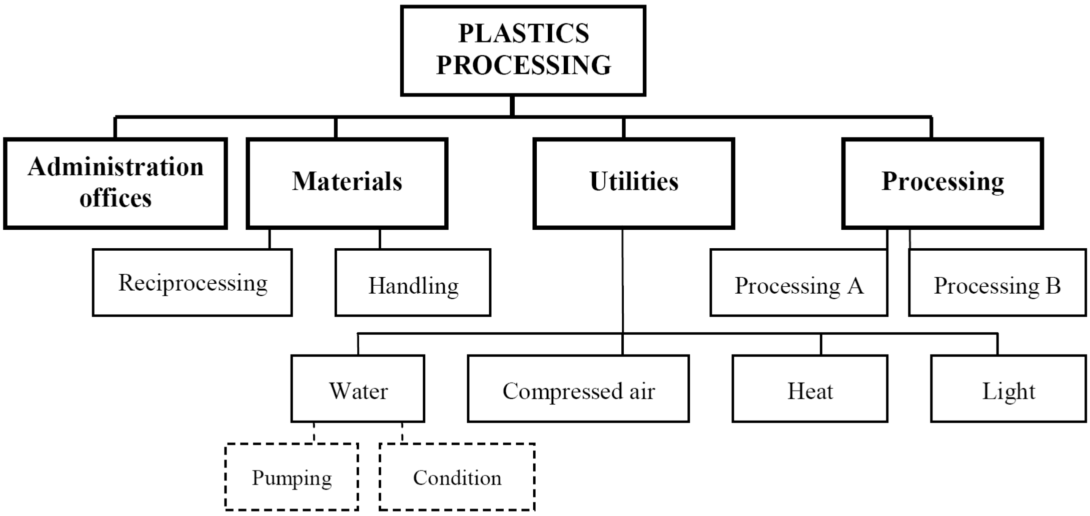

Fig. 5. Opportunities for energy savings through technical investment [2]

Often in injection molding plants other second basic using medium is compressed air. Producing of this medium is not cheap. The biggest problem in compressed air installation is leakages. Even this smallest installation leakages uses between 20 to 40% of producing air medium. Only little hared leakage can use 1000 kWh/year. It is important economical aspects. Sum of this leakages give a big amount of the energy which is not free. Moreover in injection molding plant compressed air usage should be reduced by using other means of power where possible. For air supply power tools the delivered power costs 7-8 times that of direct electric drives. Besides this compressed producer should only generate required demand pressure for machine sites [8].

Thermal efficiency of injection molding system can also be improved by barrel and pipe line insulation. Product cooling time is generally more than 50% of the cycle time. Efficient cooling can greatly reduce cycle times and energy usage - a double benefit. Conformal cooling is very important technical aspect to short cycle time and using energy [2].

Each technical improvement which influence on less energy consumption can give different benefits but it is always a payback. Overall aspect of equipment and process improvements always give lower energy consumption: lower base and process load. Typical example of this can show on graph comparison (Fig. 6) with energy consumption.

This simple data presentation and equation can also be used to assess the performance of the factory on a monthly basis. The equation of the line of best fit for the data of Fig. 6 is:

$$kWh = 1{,}5702 \cdot production\ volume + 110000. \qquad (2)$$

This equation can be then be used to assess the energy usage for a given production volume in a month, e.g. If the production volume is 100 000 kg, then the predicted energy usage will be:

$$kWh=1,5702 \cdot 100000 + 110000. \tag{3}$$

Therefore the predicted energy use is 267020 kWh and predicted energy cost is 106808 PLN for the month. For pervious state of technical state machine and equipment the cost will be achieve the value of 136483 PLN. Benefits are visible. Year cost saving is about 356100 PLN. The equation (2) can be used to assess performance and generate production responsibility. This include: determine the volume of material processed in a week/month/year and calculate the energy usage in the future, compare the predicted energy usage to the actual energy usage and if energy usage is higher than predicted energy usage then find what the machine/site/factory did wrong. Also it can be visible when plastics factory using less energy then predicted value.

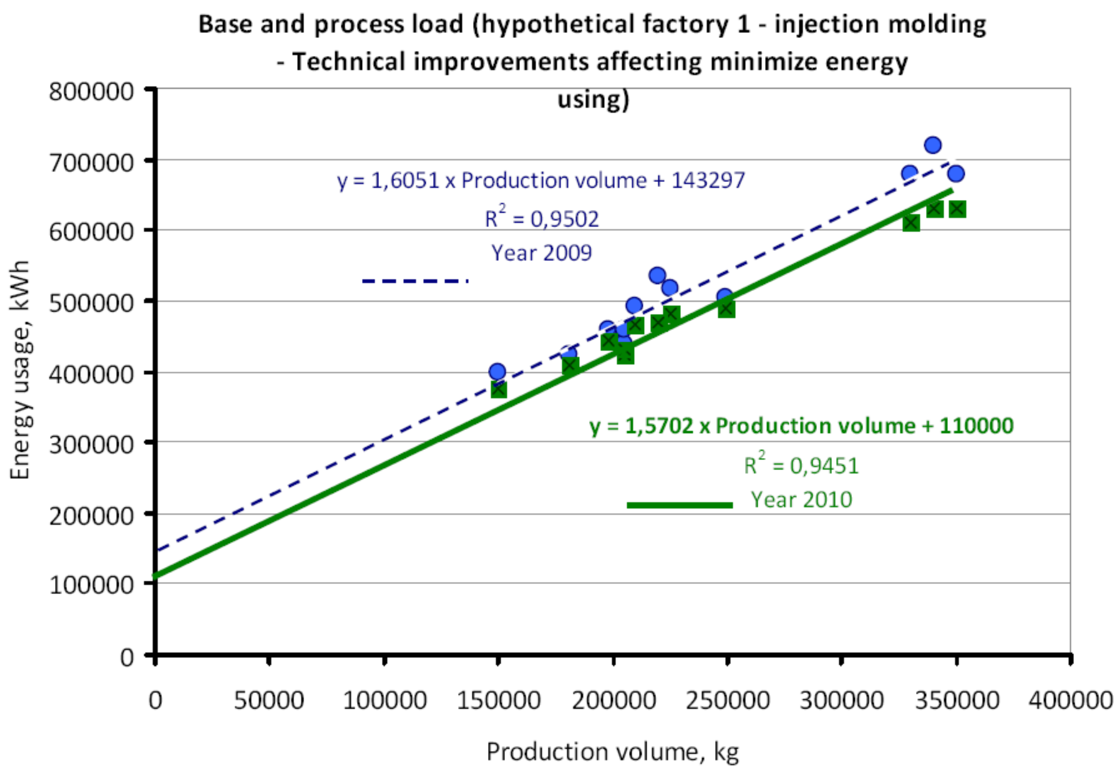

Fig. 6. Comparing base and process load after overall technical improvement with some new injection molding plant and equipment

4. Final consideration

Presented concept on energy using and management for injection molding machines and plant can be using for other plastics machines like extrusion blow molding or thermoforming. Making simple periodic measurements of energy consumption can be extremely helpful to evaluate the plastics processing system performance, as well as planning and cost comparison of energy consumption during processing in the near future (for example: 1month, 1 year). Also, the objective of this paper has been to provide an easily understood structure that will generate real improvement rather than paper and statistics.

Possession of knowledge about technical aspect of energy using and management in injection molding process is really at the sensitivity of energy efficiency, without good management, neither energy efficiency nor any other change in operating practices will be valuable. Energy efficient injection molding is simply good quality molding practice. It is low-cost and reduces all costs – not just energy costs.

References

[1] Archila S., Golzarian S.: *Energy Reduction and Sustainability through Total Energy Management* (TEM), Husky 2009, www.husky.ca.

[2] Kent R.: *Energy efficiency in plastics Processing. Practical worksheets for industry*, Tangram Technology Ltd. 2007, www.tangram.co.uk.

[3] Kent R.: Energy management in plastics processing — framework for measurement, assessment and prediction, Plastics, Rubber and Composites 2008 vol. 37 no 2/3/4.

[4] Kanungo A., SwanAll E.: *Electric Injection Molding Machines:How Much Energy Can You Save?* Proceedings from the Thirtieth Industrial Energy Technology Conference, New Orleans, LA, May 6-9, 2008.

[5] *Guide to energy efficiency opportunities in the Canadian plastics processing industry*, Canada 2007, www.cpia.ca.

[6] *Accounting for energy efficiency*, Tangram Technology Ltd. 2007, www.tangram.co.uk.

[7] Kent R.: *Introduction to energy management for plastics processors*. Plastic Technology 2009, www.ptonline.com.

[8] *Energy management in plastics processing – top tips*, Tangram Technology Ltd. 2007, www.tangram.co.uk

[9] Jones F. R.: *Strategic Management for the Plastics Industry*, 2003 by CRC Press LLC.

[10] Kent R.: *Know Your Plant's 'Energy Fingerprint'*, Plastic Technology 2009, www.ptonline.com.