Grant agreement no. IEE/07/585/SI2.500402

Foundrybench

Foundry Energy Efficiency Benchmarking

Intelligent Energy – Europe (IEE)
SAVE – Industrial Excellence in Energy

D9 Concept of an energy efficiency index, report

Document ID: Foundrybench_D9_EN_30062010
Revision [1.0]

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Distribution: Public (PU)

Due date of deliverable: 31.1.2010
Actual submission date: 30.6.2010

Start date of project: 1.1.2009 Duration: 36 months

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Date: 05.05.2010

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1. FOREWORD

The first step to save energy is to know your energy consumption. It is impossible to handle your energy saving options if you can not measure the energy consumption in main processes. With measuring devices foundries can follow their energy consumption based on time and production phases.

Nominal energy consumption of production and premises is one of the best tools in the follow-up of energy consumption. To calculate nominal energy consumption or index for a foundry we need a specified data of the foundry processes. Accuracy of the index of course depends on the amount of available information about the foundry. The more we have data the more accurate we can calculate. All kinds of energy are to be followed up: electricity, coke, district heat, natural gas, liquid gas etc.

1.1. HOW TO GET THE DATA

This is why you need to carry out a through energy analysis of all energy flows in the foundry. All the necessary data from foundries is not available. Sometimes one has to evaluate energy consumption of some separate processes and/or one has to calculate the missing data.

The nominal energy consumption (here an energy index) for the whole foundry is quite easy to calculate because the foundries usually know how much energy they have bought annually. What the foundries do not know is how their energy consumption is divided into different processes and equipment. Energy consumption should be divided in all main activities. Significance on each activity may vary in different foundries but usually these are the most important energy users:

-Melting
-Laddle heating
-Heat treatment
-Equipment (drives, fans etc.)
-Compressed air
-Lighting
-Ventilation and heating
-Miscellaneous

Foundry should know how much energy each of the activity uses. Foundries always know their total electricity consumption, but where the electricity is consumed is usually unknown. If we can separate electricity consumption to activities we can calculate energy index for each of these units.

With more energy consumption figures one can not calculate energy index, but one also needs data about foundry processes. These are the most important facts:

-What is the actual production during the time of energy consumed
-Yield
-Type of the furnace
-Working hours per day and working days per year
-Laddle heating method
-Amount and temperature of heat treated products
-Area and volume of the premises
-Ventilation
-Heating
-Lighting

2. ENERGY EFFICIENCY INDEX

2.1. BASCIC ENERGY EFFICIENCY INDEX

To calculate the basic energy efficiency index for the whole foundry one only needs the amount of products and the total energy consumption.

$$EEI_{basic} = \frac{\text{Total energy consumption (MWh)}}{\text{Product tons (t)}}$$

2.2. ENERGY EFFICIENCY INDEX FOR THE FOUNDRY PROCESSES

This index is useful in comparing foundries which operate in different climatic conditions. This is a simple and easy way to calculate. The difference between the energy efficiency index and the basic index is that the energy efficiency index excludes heating energy of the premises. Also if there is any kind of major energy consumers in the site that are not associated with foundry process those should be excluded also.

$$EEI_{processes} = \frac{\text{Total energy consumption - heating of premises (MWh)}}{\text{Product tons (t)}}$$

2.3. ENERGY EFFICIENCY INDEXES FOR DIFFERENT PROCESSES OR ACTIVITIES

2.3.1. Melting

Energy efficiency index just for melting should be calculated with melting tons because that is the energy the furnace uses per melted ton. If we are calculating energy efficiency index for the whole foundry then we should use product tons. These both values are to be calculated. Of course we also want to know melted ton per product ton ratio. This does not have a direct effect on energy efficiency index but has a big influence on the energy efficiency of the foundry. The fourth valuable factor about melting is operating time compared with the working hours of the foundry.

Energy efficiency index for melting

$$EEI_{melt} = \frac{\text{Energy consumption of furnace (MWh)}}{\text{Melted tons (t)}}$$

Energy efficiency index of melting when calculating EEI for the whole foundry

$$EEI_{furnace} = \frac{\text{Energy consumption of furnace (MWh)}}{\text{Product tons (t)}}$$

Operating hours of melting compared with foundry’s working hours

$$= \frac{\text{Energy used for melting}}{\frac{\text{Nominal power of furnace}}{\text{Foundry's workinhg hours}}}$$

Melted tons per product tons are calculated as follows:

$$\frac{\text{Melted tons (t)}}{\text{Product tons (t)}}$$

2.3.2. Ladle heating

Ladle heating consumes a lot of energy with very poor efficiency. In case the ladles are heated with gas burners and the amount of gas the burners consume might be very difficult to find out. When calculating EEI just for ladle heating we should use *melted tons* and in case of a whole foundry we should use *product tons* (see formulas below).

Energy efficiency index for just ladle preheating

$$EEI_{ladle} = \frac{\text{Energy consumption of laddle heating (MWh)}}{\text{Melted tons (t)}}$$

Energy efficiency index of ladle heating when calculating EEI for the whole foundry

$$EEI_{ladle} = \frac{\text{Energy consumption of laddle heating (MWh)}}{\text{Product tons (t)}}$$

2.3.3. Heat treatment

This is one of the processes that should certainly be handled separately. Heat treatment uses a lot of energy and all the foundries do not heat-treat their products. Energy efficiency of the oven depends on the heating energy source. With electricity the efficiency is much better than with gas or any burner system. Because the heating of the oven material and the carrier also consume a lot of energy the teat treatment should be carried out with full ovens.

Energy efficiency index for heat treatment

$$EEI_{heat\ treatment} = \frac{\text{Energy consumption of heat treatment (MWh)}}{\text{Product tons (t)}}$$

2.3.4. Equipment

In foundries there are big energy consumers that usually do not have their own energy consumption measuring. This equipment may have a big role in the energy efficiency of a company. The major equipment to be followed are:

-Ventilation fans
-Filter plants
-Shake out

-Mixers
-Blast
-Cranes
-Sand reclamation
-Sand convoying
-Lighting

To keep working conditions acceptable for employees the ventilation must be effective. Large supply and exhaust fans consume a lot of electricity. Energy consumption on fans can be calculated with electric power of the fans and operating times.

$$E = \text{Operating time of fans} * \text{nominal power of the fans} * \text{average power factor}$$

Average power factor takes into account that the drives of the fans do not work on nominal power. Usually this factor is about 0,85. This factor includes the conversion of electricity to mechanical power.

The shake out contains quite big drives that use a lot of electricity. Shake out is not running all the time so we need to find out activity ratio, that can be logged in the practice. During the measurement period one can define operating time, average power consumption, maximum power and etc. An enough accurate way to calculate the energy consumption is to use average power during the work shifts multiplied by annual working hours.

$$E = \text{Average power} * \text{working hours}$$

The measuring data is illustrated in Figure 1.

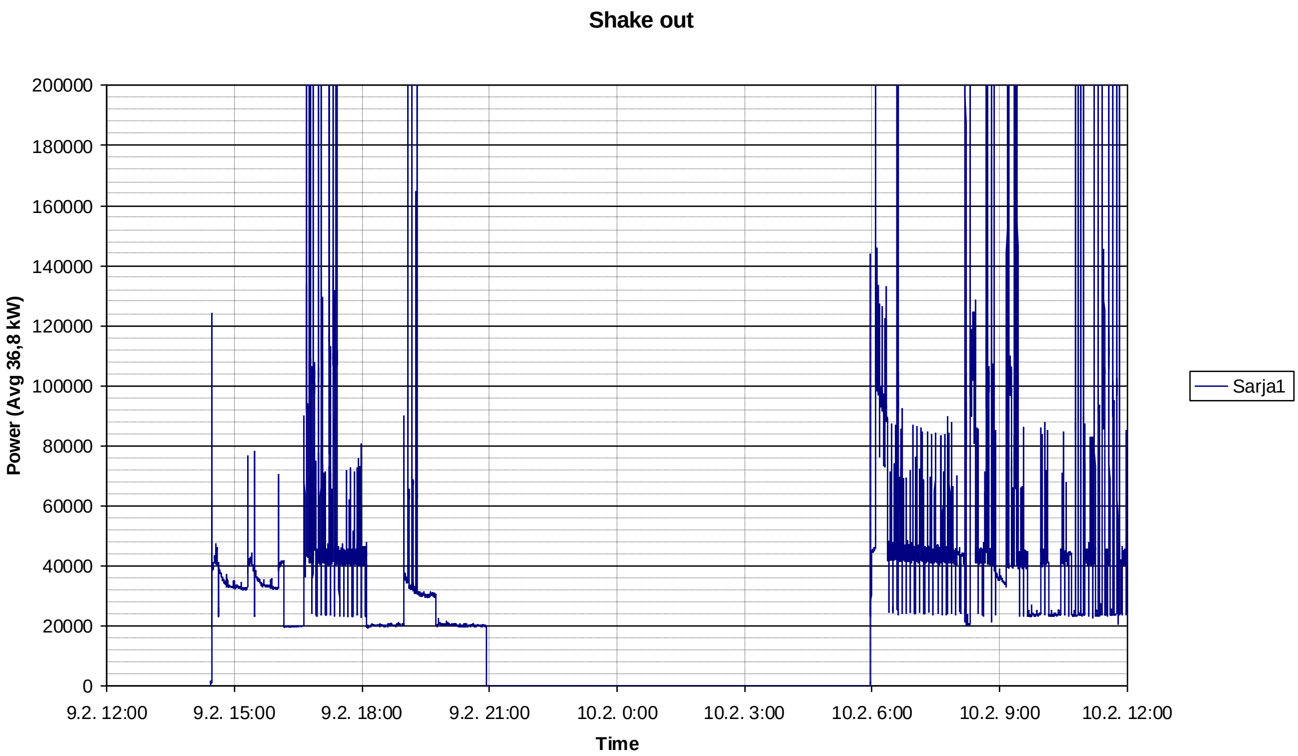

Figure 1 Operating power of shake out, sand reclamation system and fan of dust filter

Electricity consumption of mixers can be calculated in the same way as shake out. Figure 2 illustrates the power data of a mixer.

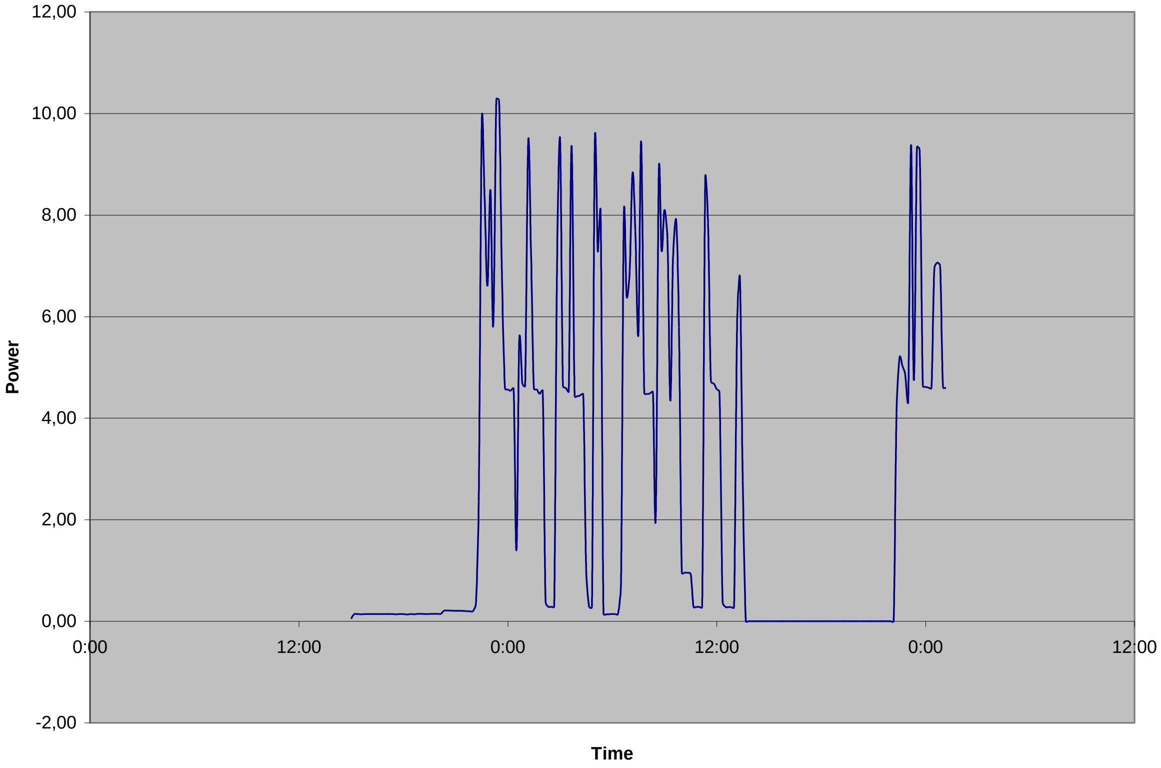

Figure 2. Electric power of mixer versus time.

In this case the nominal power of mixer is 35 kW and during the measurement average power was 4,25 kW.

Electricity consumption on sand blasting machines and cranes can be evaluated with the follow-up or measurements. Both of them have quite a short operating periods during working hours.

2.3.5. Compressed air

The air compressors consume energy some 5 - 12 % of total energy consumption. A specific power meter for electricity consumption of compressed air is recommendable. For calculating energy efficiency index we need to know the electricity consumption per product ton. But that figure does not tell us anything about energy efficiency of compressors. When defining the efficiency of compressed air (CA) system we need to measure the energy use of compressors per one cubic meter of compressed air. For CA-systems in the 7 bar range roughly 0,1 … 0,15 kWh of energy will be used to produce one cubic meter of compressed air.

The energy efficiency of compressor can be difficult to measure because we need to know the actual air flow output of the compressors. Air Leakage can mean a significant source of wasted energy in any industrial compressed air system, sometimes wasting 20 to 30 percent of a compressor’s output. Air leaks have to be defined separately in the measurement of the compressed air system efficiency. When calculating energy efficiency index for whole foundry then the EEI for CA is calculated as follows:

$$EEI_{CA} = \frac{\text{Energy consumption of compressedair (MWh)}}{\text{Produced tons (t)}}$$

2.3.6. Lighting

The energy efficiency of lighting does not depend on the production. The energy efficiency of lighting depends on the area of premises. Lighting uses energy in foundries an average of 10 - 15 W/m². In case of lighting we have to also consider the working conditions where less energy is not always the better. In this case the calculation is different when considering the whole foundry. The third important factor with lighting is the burning time. Too often lighting is left on even there is no one working in the area.

Energy efficiency for lighting

$$EEI_{lights} = \frac{\text{Power of lighting (W)}}{\text{Floor area (m}^2\text{)}}$$

Energy efficiency for lighting when considering the whole foundry

$$EEI_{lights} = \frac{\text{Energy consumption of lighting (MWh)}}{\text{Produced tons (t)}}$$

2.3.7. Ventilation and heating

Energy consumption of heating in a foundry depends on the location of the foundry. In the northern countries heating of premises might even be a bigger energy consumer geographically than the melting. Foundries in the Southern Europe need heating of the premises only couple months in a year and even then the heating power is quite low. The differences in the heating energy consumption make the comparison challenging between foundries. The heating energy consumption has to be scaled with the local degree day factor. In the northern countries the energy efficiency of some foundry equipment can be increased with the heat recovery. For example the mechanical efficiency of compressor is less than 10 % but in the northern countries if a compressor is equipped with the heat recovery the energy efficiency of compressor might rise up to 50 %. Using the surplus heat from the compressor to heat the premises increases the energy efficiency. Even though the energy efficiency is better the same amount of electricity energy is required to produce the compressed air.

When calculating the energy efficiency index for the whole foundry including the heating energy the calculation should be as follows:

$$EEI_{HVAC} = \frac{\text{Energy consumption of premises heating (MWh)}}{\text{Produced tons (t)}}$$

This formula does not give any information on how energy efficient the heating of premises is. More important is the factor that describes how much energy is consumed per cubic meter. If you want to compare this figure with other factories than foundries the surplus heat of the foundry process must be taken into account.

$$\text{Heating energy / cubic meter} = \frac{\text{Energy consumption of premises heating (MWh)}}{\text{Floor area (m}^3\text{)}}$$

Maybe the most important factor in foundries is how much of the potential surplus heat is consumed to heat the premises. Even in the Northern Europe most of the foundries have enough surplus heat during production periods from process to heat premises without any external energy sources. A good indicator for energy efficiency is how much of the potential surplus heat is recovered. The index for heat recovery requires a lot of work to examine total potential of surplus heat.

$$\text{Index for heat recovery} = \frac{\text{Heating energy (MWh) - Potential surplus heat for recovery (MWh)}}{\text{Heating energy (MWh) - Heat recovered (MWh)}}$$

2.3.8. The index

The index for the whole foundry is a sum of these process indexes. The sum index should be the same as in the chapter 2.1 “Basic energy efficiency index” if we are considering the whole foundry. If we want leave some processes out of calculation then the results are of course different but are comparable with other foundries.

$$\text{EEI} = \frac{\text{Total energy consumption (MWh)}}{\text{Product tons (t)}} = \text{(Energy consumption of melting}$$

$$+ \text{Energy consumption of laddle heating} + \text{Energy consumption of heat treatment} + \text{Energy consumption of equipment}$$

$$+ \text{Energy consumption of compressedair} + \text{Energy consumption of lighting}$$

$$+ \text{Energy consumption of heating and ventilation} + \text{Energy consumption of miscellaneous use)/Product tons}$$