WIRE MILL ENERGETIC MODEL AS A CONTROL SUPPORT

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Abstract

The present state of energetic management is facing several issues, including force to lower production power consumption, to increase efficiency of the production and among others to eliminate financial penalties for energy spikes drawn from the power grid. Especially financial penalties can be eliminated keeping power consumption of the production line in specific boundaries and has immediate financial effect. One solution, how to keep power consumption right, is by the digital energetic model of the production line. This paper originate from real operation measurement and describe methods used in digital model.

Keywords: Model, energy consumption, penalty fees, power grid

1. INTRODUCTION

Current economic situation in heavy industry branch is quite simple. The companies are forced to increase efficiency of production by lowering input costs. Usually, if somewhere were a potential to innovation, it was set up already. Opportunities for fast economic return innovations has been depleted, so now the companies looking for another way how to lower input costs. One way how to lower electric energy fees, could be avoiding some sort of penalties. Penalties could be applied for many reasons. Too much or too little withdraw of energy in specific time period, generating of unwanted interferences, overlarge breaker and so on. This penalties are relatively invisible, because they are hidden in final invoice. But in closer look it could be find out that the penalties could take significant part of the fees. Energy consumption is about 10 - 20 % of total input costs of the company, regarding on its production focus. Lowering energy fees by 20 % by avoiding penalties is simple way, how to increase overall production efficiency with minimum effort. This article is focused on wire mill manufacturing concern in Trinec. We applied several energy meters in power grid line and monitor each production section for a few weeks. Obtained energy consumption data were then used to analyze energy consumption in global point of view with the intention of penalties.

In term of need to control energy flow in company and avoiding penalties for overrun ¼ hour maximum, it was take into account creation of numerical model of company's power grid. It would be a great help, if the such model would exists. In that case it would be possible to predict (in short time period) overall consumption at the end of the period and forecast which production stage to shut down. With this knowledge it could be possible to disconnect that production stag, which has also minimum effect to overall production chain a no reduction of production volume will occur. Numeric model could be made only for that production stages, which has major affect to overall energy consumption. The goal of this article is to verify measurement repeatability in terms of days. Comparing energy consumption day to day is critical. The company economical manager always tells that "every day is the same, because shifts is always the same and volume of production is also the same". This statement is unfortunately misleading. Of course, it is generally true, but it is necessary to take into account environmental temperature, season of the year, shut downs, planned maintenance and so on. The difference in terms of % are very important and has to be explored and determined.

2. RELATED WORKS

As were mentioned in [1] [2], the prediction models and numeric models in general are important and will be a common part of the companies in future. The authors presents software support and state the necessity to use and develop various types of prediction methods. “To avoid these conditions, the prediction model is necessary. Aim of the article is to present a prediction model based on averaging current and passed energy consumption. This approach can be applied on those factories or workshops, which has stable withdraw of energy. If the seasonal variations are in place, the other methods have to be used. The goal of the prediction model is to tell us, how much energy will be consumed in the end of specific time. If the final number is in limits, no actions are required. But if the final consumed energy value, predicted by model (**Figure 1**), will be over the limit, some action has to take place to avoid unwanted penalty. Further presented averaging methods should clearly defined theirs proper usage.”

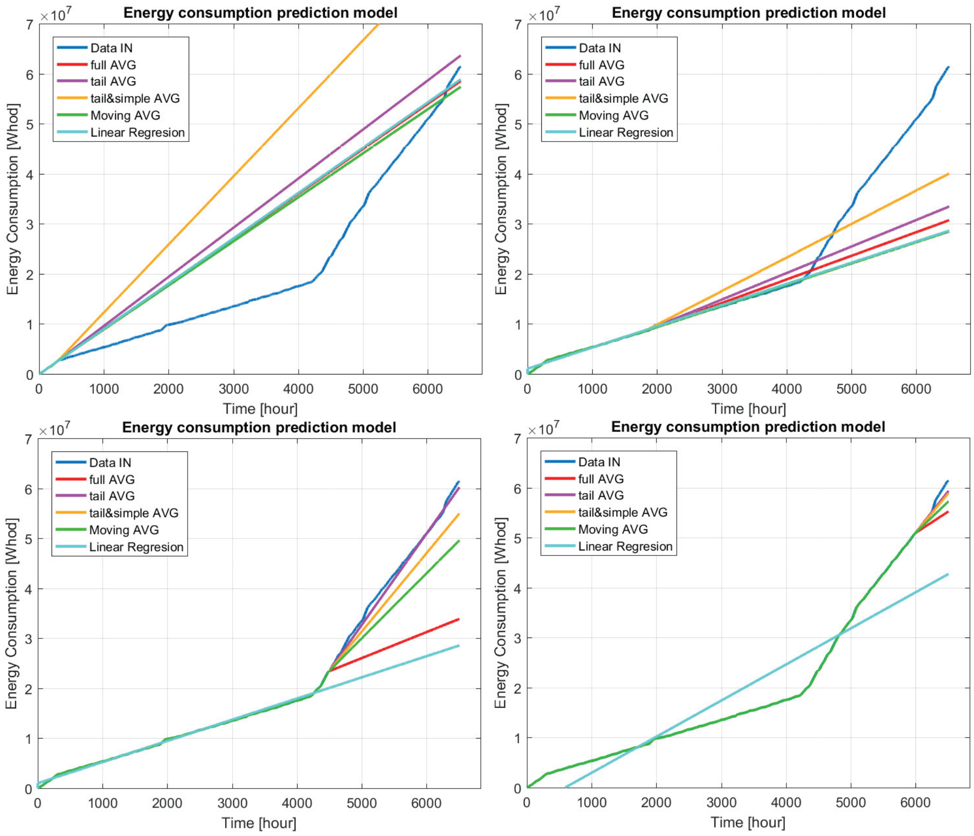

Figure 1 The authors of [1] used prediction model on the long time period basis

This type of prediction is able to avoid long time energy overlaps usually identify with stock market. Our paper goal’s is focused on short time period prediction in terms of minutes. Both penalty types are important to avoid and cannot be tell which one is worse, relative to money loss.

3. WIRE MILL ENERGY CONSUMPTION

For energy flow measuring were used specialized devices, energy meters, with wireless interface and central database access. [3] These devices are capable to measure electric power with superior accuracy in all three phases. Measurement proceed every one second, but for simplification we used 15 min integrated intervals. This period is sufficient to obtain general overview of the “standard” day, from the energy consumption point of view. Typical day is presented in (**Figure 2**). The curve represent power consumption over time period, typical day, the X axis represent time in seconds and Y axis volume of drained power in kWh. The presented power consumption is continuous, but not always. If there is a discontinuity, it is usually done by wireless connection dropout to energy metering devices. If this dropouts exceed reasonable boundary, the curve cannot be used to creation of numeric model. There were chosen only fault free data sets. [4]

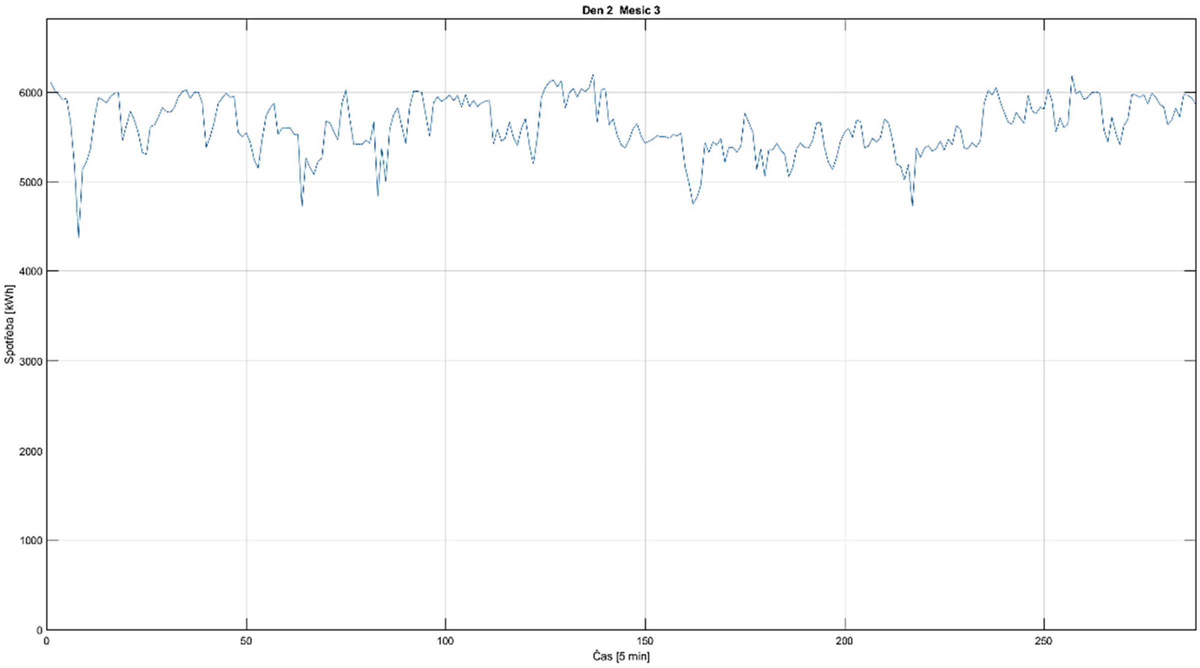

Figure 2 "Typical" day of wire mill factory from the energy consumption point of view

The basic idea was to compare two or more curve and verify concordance rate. If the concordance rate would be satisfied, the "typical day" paradigm could be accepted and simply model could be created. For that reason the one purpose script was created. This script, an algorithm, compares power consumptions in specific time and create a difference in kWh. In (**Figure 3**) are printed both compared curves and its differences.

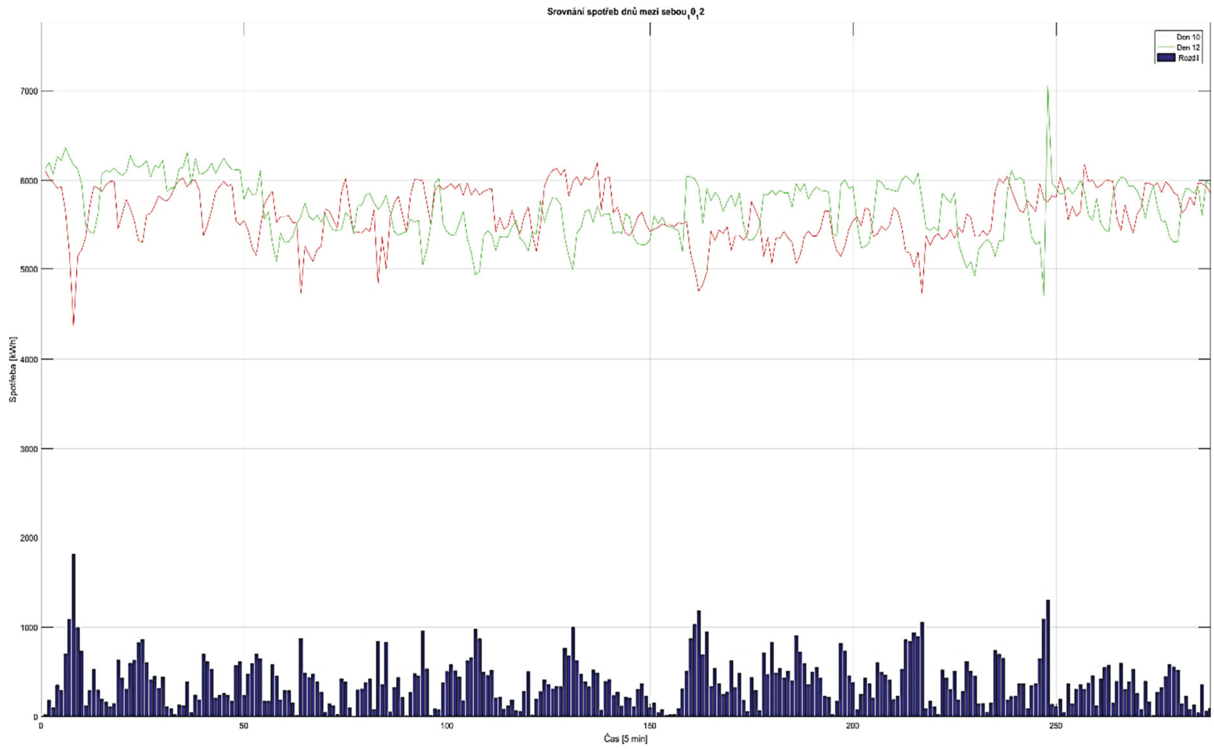

Figure 3 Compare of two curves with and its differences (bar graph at the bottom)

It is obvious, that both curves are not the same. The data were obtained from one day delay, respectively two successive “typical” days. In the top area are both curves represent energy drain during time and in the bottom is then its differences. It were used only these data, which belong to specific production stage, with the same production schedule. It were compared 16 days with more or less same results. It could be claimed, that even if there are three-shift operation during day, that there is produced only one type of final product and production line is working on the same manner, it is not possible to direct compare the energy curves without any other adjustment. The mean differences value is 380.69 kWh with standard deviation of 272.3 kWh. [5]

The next step was creation of algorithm, which was capable to compute and visualize ¼ hour maximums. In theory, it is performed by summing drawing energy in current time with overall time duration of 15 minutes. This computing mechanism is very important, because it is necessary to run all the time and compute overall ¼ hour maximums (**Figure 4**) online, unless the penalty can occur.

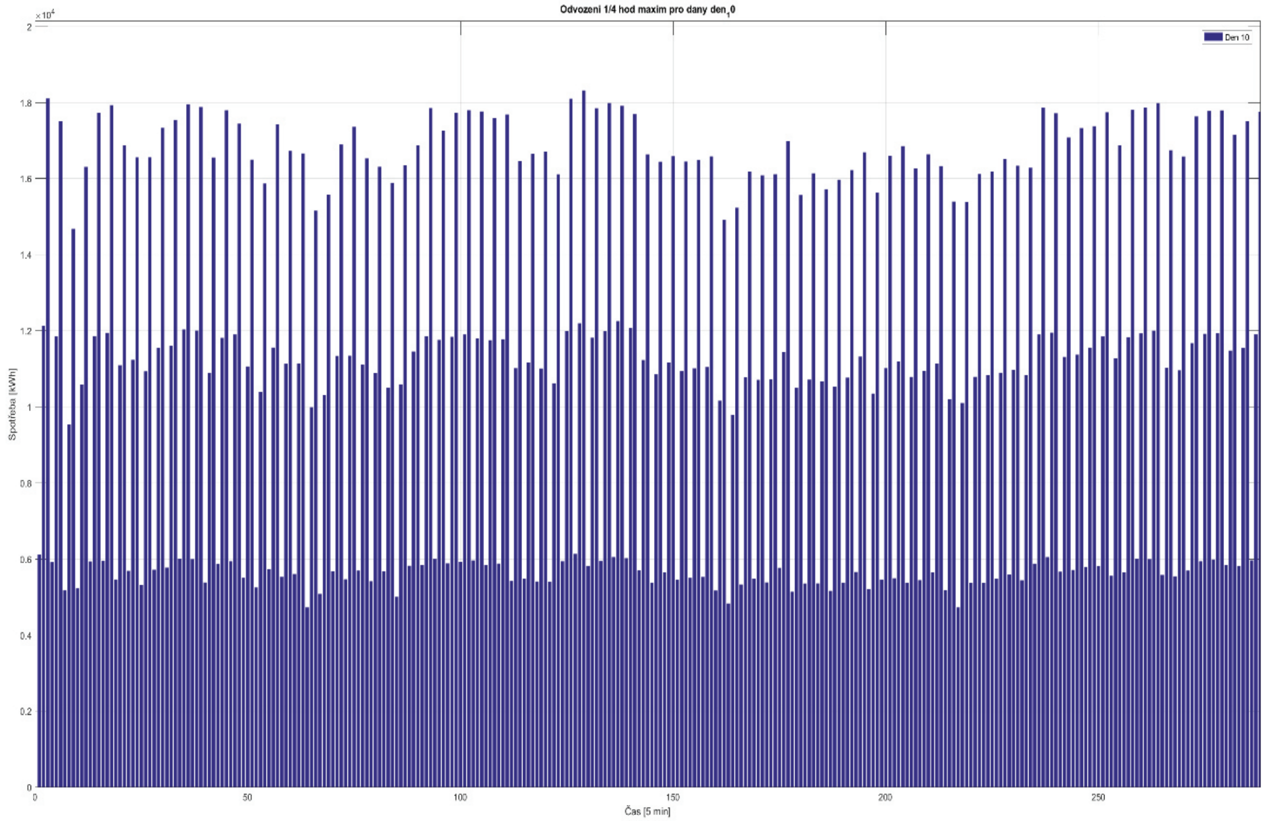

Figure 4 ¼ hours maximums over the day period

In real operation it is defined as specific maximum given by energy provider and in case of overrun this maximum is automatically generated penalty. In case of examined wire mill is this value at the level of 6 MWh. In presented figures is only a single production stage, it is obvious, that it must be summed all the stages to obtain overall consumption. On the other side, presented figures (**Figure 3** and **4**) belong to one production stage and in case of disconnecting it from power grid, it will save specific amount of energy and ¼ hour maximum will not overrun the top value. [6] [7] [8]

To be able to better describe each stage power consumption, it were performed calculations of mean values and mean square deviation. The presentation of such calculation is on (**Figure 5**).

On the performed calculations basis could be objectively evaluated “coherency” of energy drawn during the day. In ideal case we would obtain continuous energy drawn during the day with deviation approaching zero value.

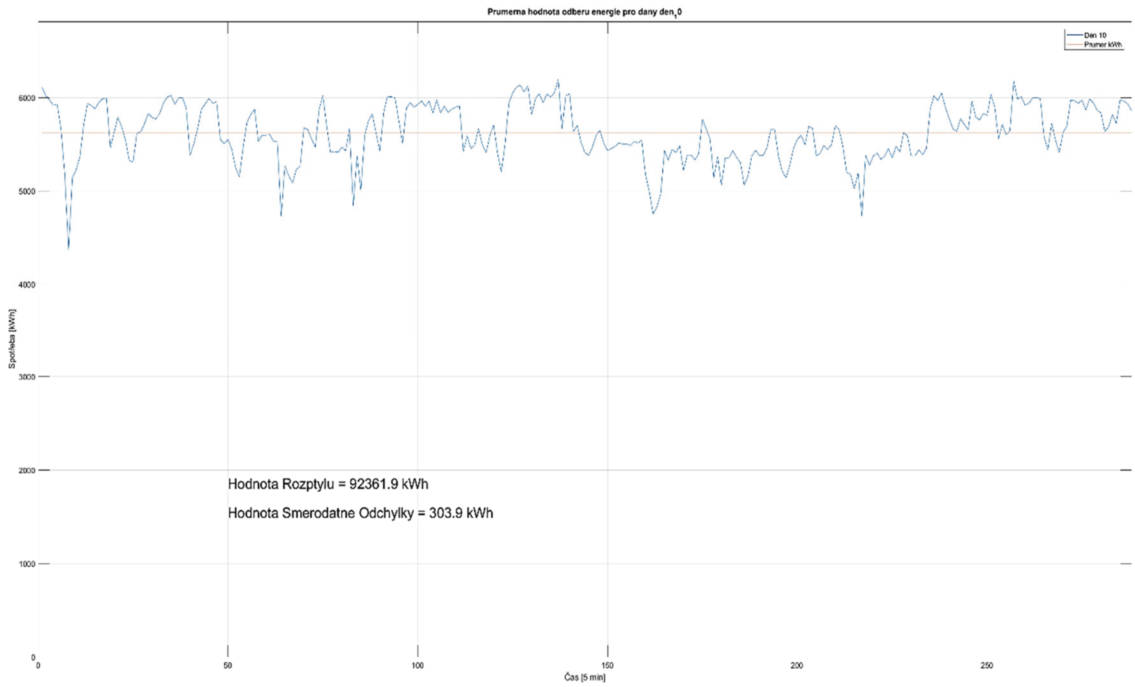

Figure 5 Visualized mean value (red line), statistical variance, and a mean square deviation

4. CONCLUSION

From the made tests over the gained energy consumption data it is obvious, that it is not possible to create simple energetic model of single production stages with the aim of total energy consumption prediction of the company. The difference between two successive days is too high to simply claim, that they are the same. In case of creation of numeric model of wire mill production stages and in case of perform prediction in short time period, the results must be take into account an error directly proportional to the mean square deviation. Then has to be objectively determined if the overall statistical error is lower than predicted company's energy difference in given time interval. From the statistical point of view it would be needed to make many measurement during the standard work days to continuously improve average consumption level, to create prediction with minimal deviation. [9] [10]

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