Scheduling4Green

Jürgen Sauer

Department of Computer Science
University of Oldenburg
D-26111 Oldenburg
juergen.sauer@uni-oldenburg.de

Abstract: Reducing energy consumption is one of the actual challenges in all parts of industry. This can lead to a low carbon footprint for activities under consideration as well as to cost effective reductions of overall energy consumptions. This paper shows two examples how intelligent scheduling strategies can be used to limit energy consumption in production to a given range.

1 Introduction

Nearly all areas of production and logistics have presented their own „we are going green“ proposals. Most often green means the reduction of power consumption but also reducing waste, reducing the usage of dangerous ingredients etc. can be found here. To meet the reduction goals several actions may be taken:

- using new technologies e.g. in the production process may reduce ingredients, waste as well as energy consumption
- using new machines may reduce energy consumption and waste
- changing ingredients may reduce energy consumption
- rescheduling the production process may reduce energy consumption.

The last topic shall be tackled in this paper. Especially the “right” scheduling of energy intensive production processes can lead to a reduction of overall or peak energy needs and this also has some advantages regarding costs.

This paper introduces the actual project “Scheduling4Green” and will present at first some of the problems and production processes in which the scheduling according to energy consumption will lead to main advantages. This is followed by some ideas and approaches on how to cope with the scheduling regarding energy consumption. Two examples from glas production and injection molding shall illustrate the problems and approaches.

2 Energy consumption and costs in production

Most of the production processes are using special equipment within the single steps that are performed. This equipment, typically machines or apparatus, needs energy on a constant basis or on a fluctuating basis. The fluctuation is generated by the energy consumption within the production process. Such fluctuation is found e.g. in most of the processes in which material has to be heated.

Example 1: Production of security glass. The production process consists mainly of three steps. In a first step, the existing sheet of glass is heated up to 640 °C and then cooled down quickly by air. The third step is a quality control. Figure 1 shows the power consumption profile of this process.

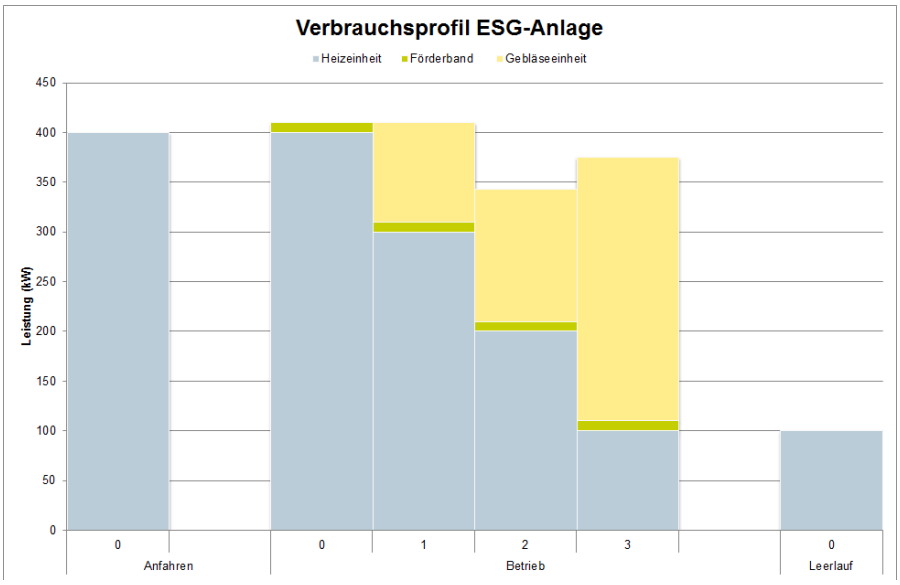

Figure 1: Power consumption profile in security glas production [Ben12]

Example 2: Injection molding. This technology is used for the production of a lot of products and parts mostly made up of plastics. The process has three major steps. In a first step, the needed material is fed into a barrel. In the second step it is mixed and heated up to its melting point and then pressed into a mold cavity. There it is cooled down and hardens to the configuration of the cavity. Figure 2 shows the power consumption profile of this process. The difference in the power consumption of the process steps is considerable higher than in the example before.

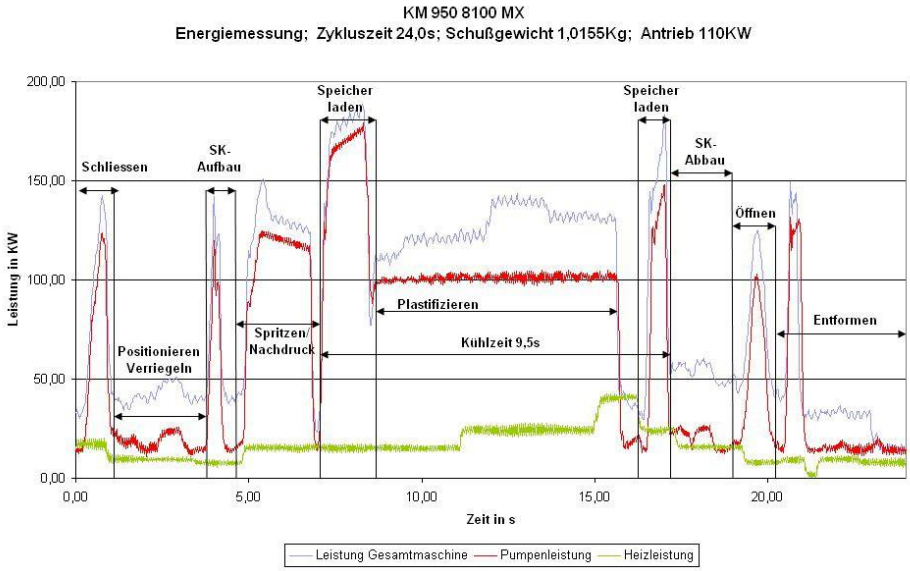

Figure 2: Power consumption profile in injection molding [Wil08]

The energy consumption of production is typically result of a forecast process and is used to calculate energy costs on the basis of specific contracts. These contracts usually contain peak energy needs (upper bounds) that are basis of the rate. With this forecasts the energy producer plans the energy production. If the consumer exceeds the upper bounds then a penalty or the next higher rate has to be paid, normally for the whole time period. This can easily occur if machines are used in parallel and several of the energy peaks of the production processes will superimpose. Therefore most of the companies have some kind of emergency plan, if the energy consumption approaches the upper bounds, e.g. the unplanned shut down of machines. But this is disturbing the whole manufacturing process and eventually damaging the machines. This is the reason for looking for a scheduling solution that can lead to a production schedule that avoids the power consumption peaks.

3 Scheduling regarding energy consumption

As stated in section 2 the main goal of a scheduling algorithm that regards the energy consumption should be to keep the energy needs in a given range and avoid peaks.

Figure 3 and 4 [Giz12] show what this means. Figure 3 shows the accumulated energy consumption of five injection molding machines if it is allowed to start them randomly, which especially means that they can start at the same time.

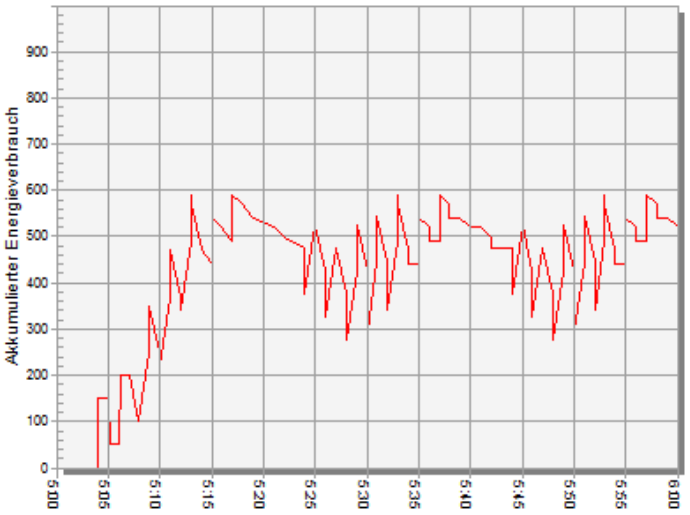

Figure 3: Example of accumulated power consumption

Figure 4 shows the diagram with the reduced accumulated power consumption when a fixed delay is used between the start of the machines. This works well because we have a simple problem with a few identical machines and processes, which is not the case in other examples.

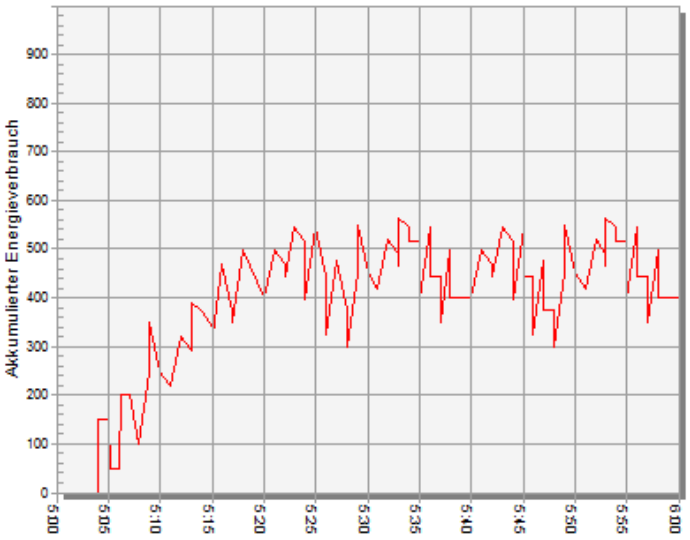

Figure 4: Example of improved accumulated power consumption

In our project we created in a first step a simulation model to show the effects of superimposed energy consumption profiles. Figure 5 gives a sketch of the model build with PlantSimulation. During the simulation the energy consumption is collected and leads to the profiles in figure 3 and 4.

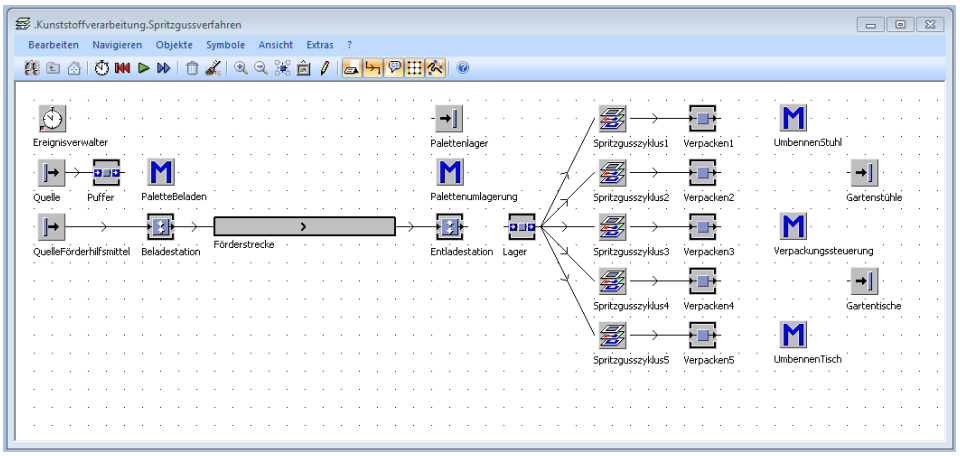

Figure 5: Simulation model in PlantSimulation [Giz12]

Actually we are developing a scheduling algorithm that takes into account the energy consumption of the process steps and tries to keep the energy consumption within the given range. Main conceptual parts in the development of the algorithm are

- to create a more abstract view of the energy consumption profile that makes it easier to schedule it, e.g. use a rectangular function for energy consumption.

- to find some heuristics that can be used to create a schedule in an easy way, thereby using a general order-based heuristic [Sau04] for scheduling.

References

[Ben12] Bender, T.: Dynamische Lastganganalyse für eine Produktions- und Energieoptimierung, Masters Thesis, Universität Oldenburg, 2012.

[Giz12] Giza, N.: Simulation von Energieverbrauch in der Produktion am Beispiel der Spritzgussindustrie, Bachelor Thesis, Universität Oldenburg, 2012.

[Sau04] Sauer, J.: Intelligente Ablaufplanung in lokalen und verteilten Anwendungsszenarien, Teubner, 2004.

[SRB13] Sauer, J., Runge, S.A., Bender, T.: Lastgangbezogene Prioritätsregeln für eine Produktionsplanung bei der Veredelung von Glasprodukten, in: J. Marx Gómez et al. (Eds.), IT-gestütztes Ressourcen- und Energiemanagement, Springer-Verlag, Berlin Heidelberg, 2013, pp. 3-9.

[Wil08] Wilken, M.: Entwicklung eines Systems zur Optimierung der Energieeffizienz in der Kunststoffspritzgussindustrie, Diploma Thesis, Universität Oldenburg, 2008.