An Approach for Energy Saving in the Compound Feed Production

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Abstract. The importance of energy efficiency has increased significantly in recent years. By rising commodity prices and energy costs for electric and thermal energy the compound feed plants are forced to improve their processes. Significant savings are expected in the material changing refining stages. This paper, at first, gives an overview about the characteristics in the compound feed production, followed by the analysis of high energy consumption. There after followed a description of the uncertainties in the compound feed production. The next chapter demonstrates the efficient control of the compound feed production process.

Keywords: raw material, uncertainty, agricultural commodities, expert system, manufacturing processes, quality

1 Introduction

The dynamics of price developments in recent years for raw materials and energy will tend to persist. The global competition for resources and the legally mandated emission limits placed will determine the conditions of stronger companies. The competitiveness of an increasing productivity can be achieved only if the available resources such as energy, materials and personnel will be handled efficiently. The resulting gaps have to be closed by increasing efficiency [1].

Effectiveness and efficiency are to be distinguished from each other. The effectiveness generally referred to the Ratio of the achieved to a defined target. The efficiency in turn describes the performance and economic efficiency. Efficiency is thus understood as the ratio between a defined input and a fixed size of an output. Energy efficiency means reducing energy consumption in a system to providing a service [2]. The European Union defines energy efficiency as the ratio of the return of performance, services, goods or energy to use of energy [3].

adfa, p. 1, 2011.

The significant energy cost increases in recent years have been creating high economic incentives for rational energy budgets in the compound feed industry [4]. In Germany the annual production output of the compound feed production exceeding approximately by 22,500,000 tons in 319 factories [5]. The total yearly electricity consumption of this branch of industry lies at 1.65 billion kWh per annum [6]. Our case study is the production of compound feed in a commercial feed processing plant in Northern Germany. The energy consumption accounts up to 4-6 GWh per annum by an annual production output up to 240,000 tons of feed. The biggest part represents the pig feed with 80 %, followed by chicken feed with 15 % and 5 % bovine animal feed. For various costumers the plant is producing 200 different feed recipes with over 60 different ingredients. All these recipes are produced batchwise on one single plant.

2 Characteristics in the compound feed production

The industrial feed compounding is focused on the refining of natural resources like grains. Feed recipes are consisted of up to 40 different natural resources, for example wheat, barley, corn, soy, molasses, limestone and micro components like vitamins and enzymes. The composition of feed recipes depends on the animal species as well as the period of growth and is currently adjusted for example by availability and market price of raw materials.

In the compound feed production the demands of customer are at the forefront and the lead-time of the order of feed are only few hours. In our case study the production plant has to produce 200 different composites in short-term.

The compound feed production process could be divided into four process steps. At first the feed processing starts with the incoming of different natural resources like wheat, barley, rye and so on which are delivered by trucks, discharged into collecting vessels and short-term stored in silo compartments.

On the respective feed recipes the components could mixed automatically. All recipes are registered in a control system. If the process is starting, the refinement begins with the transportation of the raw materials to the following process step to weigh and to mix the natural resources. The next step includes the comminution of the grainy raw materials by the use of hammer mills or roller mills. Every time it is necessary to aspirate the dust, which comes out by hurrying the materials. After the milling process the mealy material gets an admixture of molasses, linoleic acid and other ingredients. To produce the final product the raw materials have to be pressed to pellets. Thus the mealy material with the admixture has to be transported to the pelletizing process [7].

The pelletizing process comprised the pressure grouting of the mealy material. Before the mealy material could be pressed the floury texture will be added with steam and grease in the conditioner. The next step includes the compactor process. This step manufactured the pellets with high quality performance and physical impacts against pressure, abrasion and critical strength. The quality of a pellet must have an uniform length, hardness and has to be resistant against all strains. Pelleting in combination with short-term conditioning is most common as hydrothermal treatment in feed mills. After the pelletizing process the material has to be cooled and as a last process step transported in the corresponding silo compartments.

3 Analysis of high energy consumption

Among the most important forms of energy in a compound feed production process are the thermal energy, mechanical energy and electrical energy. Figure 1 shows the percentage of the consumption of electricity of the compound feed production in the case study.

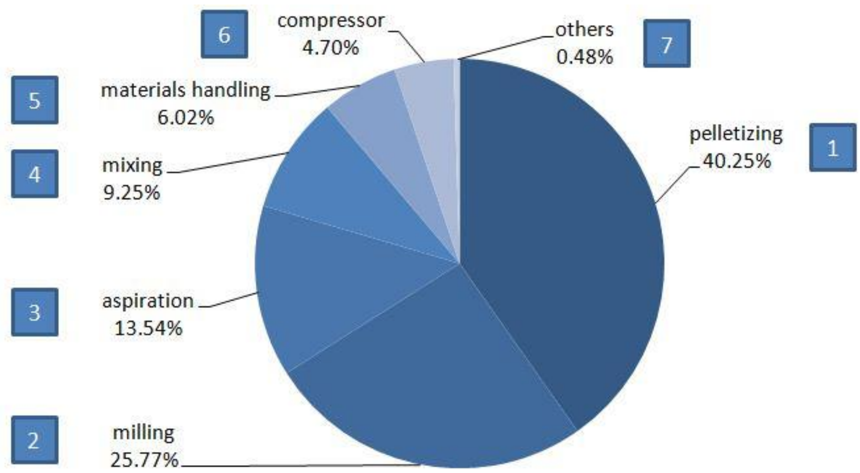

Fig. 1. Consumption of electricity in percentage of compound feed production in the case study

The pelletizing process provides the highest energy consumption in front of the milling process. These two processes have a total electricity consumption by more than 60 %. Figure 2 gives an overview of the process steps in the feed industry as well as an allocation of the current energy consumption of the individual process steps. It is necessary to have a closer look at the process step pelletizing and milling in order to ensure a more efficient production.

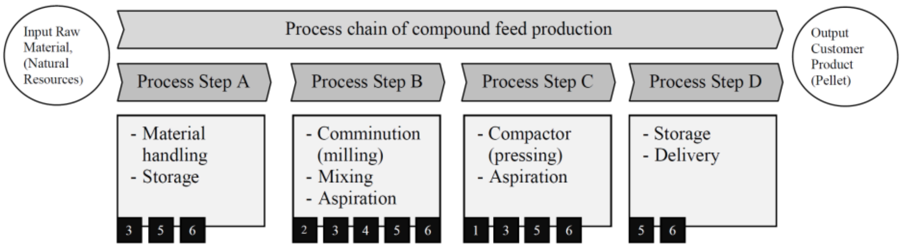

Fig. 2. Process chain of compound feed production

To actuate a hammer mill more energy-efficient it must be known the texture about the raw materials. In connection with the conclusion of milling it concerns the elastic force and the strength of the mill material. By increasing influence on the elastic force and the strength, the product moisture and the energy consumption are rising. Therefor it is important that the output data are known for the humidity and the bulk weight.

A pelletizing process should have a high throughput rate and low energy consumption. The quality and the efficiency of the compactor process will be influenced by the physical quality of the pellets and the specific energy demand (kW/t). These requirements are difficult to reach. The manufacturing of hard pressed pellets demanded high pressure and therefore high energy consumption as soft pressed pellets. Depending on the composition of the raw materials the energy consumption fluctuates between 10 up to 25 kWh/t by pressing pellets based on the ratio of moisture and quality [8].

Essential for the energy consumption and the product quality is in addition to time, the temperature and the moisture. The temperature is determined by adding steam. The temperature rising by 10 degrees by increasing the raw material from 0.6 to 0.7 of the moisture. On account of this it has to be detected the optimum between the quantity of steam and product quality to reduce the energy consumption.

For example industrial products (like automobile, aircraft, etc.) can be constructed by reducing the weight without loosing quality properties. But in the food and feed processing industry reducing weight means that we put the animals on diet. The research focus therefore must be placed on the investigation of energy efficiency of the production process without changing the end-product quality.

4 Uncertainties in the compound feed production

The uncertainties in the compound feed production can be divided into two parts, on the one hand in properties that can be influenced and on the other hand in properties that cannot be influenced. Figure 3 shows graphically the general connection between the product quality and the uncertainty of the process steps compacting (pressing), comminution (milling) and adding steam (conditioning). The bars in the chart show that fluctuations of the product properties are available. Mainly for example the water content of raw materials for the compound feed production can changed by a controlled steam entry.

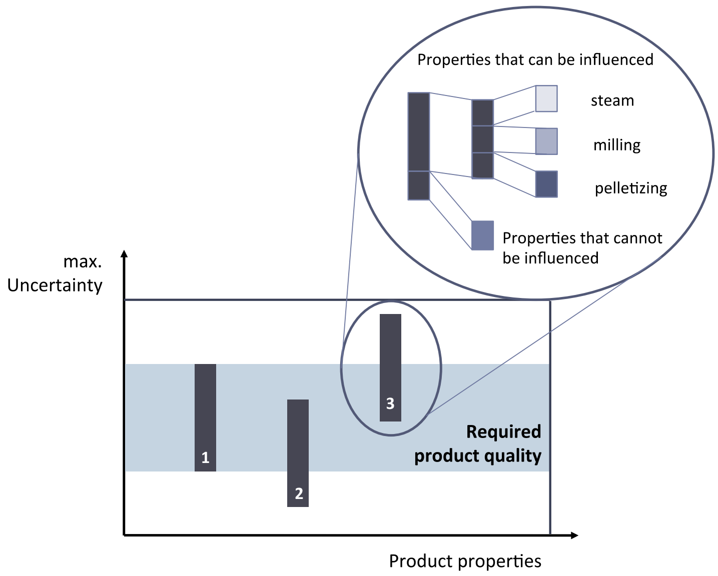

Fig. 3. Uncertainties of product properties

For example different natural resources will trigger different grinding characteristics and will reveal different particle size distributions.

5 Efficient control of the compound feed production process

In the case study, the product quality will be considered only at the end of the process chain. To save the energy it is important to analyse the different ingredients in different process steps, which does not exist in the current compound feed production. For example, information is needed about the particle sizes during milling process. The same applies to the moisture content of raw materials before the pelletizing process is starting.

One possibility is to detect the uncertainties during the production process with measurement instruments. For Example the analysis of the grain sizes during the production process could be done with computerized particle analyser (CPA) which could be integrated in the milling process step to analyse the grain size at the beginning of the manufacturing process. They, in turn, support information about how the parameters must be set in the milling process in order to the optimal size of the raw material before passing into the pressing process and thus provide information on how the machine settings must be made so that energy efficiency works. CPA-Measuring instruments used to perform particle size and particle shape analysis of dry and non-agglomerated particles in ranges from 0.010 mm to 400. The systems can also be used as particle counters. CPA measuring instruments are used for digital image processing for analyzing the particles. A CPA measuring device is connected after a comminution unit to monitor the particle size distribution of the comminuted material. In strong or less comminution the measuring device can guide them on the desired particle size distribution. However, this requires a good calibration of the instrument and to be determined at the beginning experience on the process parameters. Furthermore a pre-sieve should be installed to separate fines before grinding in order to unload the milling process and reduce its energy consumption.

The diode array base spectrometer (NIR) is used for the ingredients description and causes the optimized control of the conditioning and compacting process steps. The sample material is irradiated with light in the range of the near-infrared wavelength range. The reflected light is read out by a diode array spectrometer. The reflections vary depending on which of the parameters of concentration in the raw materials and feed mixtures and provide information on the material composition of sample materials. With this device single samples can be measured. In addition to product moisture is usually the protein, fat and crude fiber and starch content can be determined. In addition to product moisture content of protein, fat and fiber content of the starch content and can be determined.

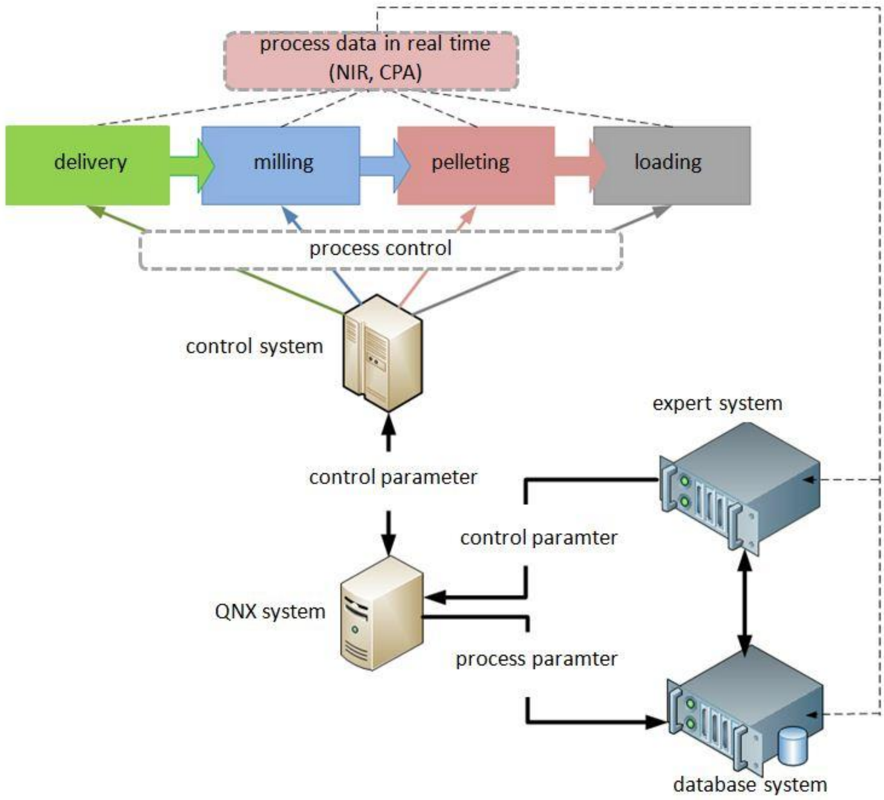

Fig. 4. Process control in real time

Figure 4 shows a possible process control in real time to get high quality products with low energy consumption. The system receives information during the production process about the grain size and moisture content and is directly put in a position to influence the machine parameters.

6 Conclusion

The integration of these instruments within the process can provide information on the uncertainties and allow a process control. The development of the control system of the production process is performed according to uncertainty management. Uncertainties are present at any time in the process and has therefore taken into account during the decision making process. The uncertainties are formed into fuzzy rules and are implemented as a new software tool that supports the process control. It will be possible to simulate the production process with varying parameters to evaluate the result of the simulation.

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References

1. Neugebauer, R.: Energieeffizienz in der Produktion - Untersuchung zum Handlungs- und Forschungsbedarf, Fraunhofer Gesellschaft, Chemnitz, Germany (2011)
2. Pehnt, M.: Energieeffizienz: Ein Lehr- und Handbuch, Springer-Verlag, Berlin Heidelberg, Germany (2010)
3. EU: Richtlinie 2006/32/EG des europäischen Parlaments und des Rates vom 5. April 2006 über Endenergieeffizienz und Energiedienstleistungen und zur Aufhebung der Richtlinie 93/76/, http://europa.eu (2006)
4. Stelling, M: Notwendige Schritte zur Implementierung eines Energiemanagementsystems in Mischfutterwerken, In: Mühle + Mischfutter, vol. 149 Iss. 9, pp. 266-270, Verlag Moritz Schäfer, Detmold, Germany (2012)
5. Kunkel, S.; Platz, U.: Struktur der Mischfutterhersteller in Deutschland - Wirtschaftsjahr 2009/10. Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (BMELV), Bonn, Germany (2011)
6. Heidenreich, E.: Gestaltung der Zukunft durch Schüren von Ängsten?, In: Mühle + Mischfutter, vol. 149, pp. 266-270, Verlag Moritz Schäfer, Detmold, Germany (2007)
7. Kirchner, A., et. al: Manufacturing with minimal energy consumption – a product perspective, to be published, Braunschweig, pp. 4-5 (2012)
8. Kersten, J, Rohde, H, Nef, E.: Mischfutterherstellung. Agrimedia, Bergen, Germany (2003)