Research on optimizing automatic dosing systems

CRISTEA LUCIANA¹
MANESCU MIHAI¹
REPA NOVICI ANGELA¹
ROGOZEA LILIANA²
¹Precision Mechanics and Mechatronics Department
²Medicine Department
Transilvania University of Brasov
Eroilor 29, Brasov
ROMANIA
lcristea@unitbv.ro http://mfm.unitbv.ro

Abstract: The analysis of general systems in closed loop control could outline an algorithm for automatic control of dosing process which is tested during the experimental research to determine optimum dosing system working for bulk materials used in industrial applications. Research consisted of the creation of a tool meant to optimize the dosing process, this involving the creation of a stand used for testing several new methods to increase process efficiency by comparing the results with those obtained by analyzing the existing systems.

Keywords: Dosing systems, optimisation, microcontroller, automation, and mechatronics.

1. Introduction

The dosage is a set of components that direct the flow of bulk solid material, each having a major impact on the flow of material. Thus, the bunker supply assures a uniform material flow to the dosing body, which in turn, depending on functional parameters, maintains this type of flow, thus providing doses of material uniformity and of constant density.

Depending on the material and its degree of compaction and different technical solutions used in the measurements, and the different operating principles, the systems can be called dosing devices, dosing and measuring systems, assemblies consisting of measuring / dosing and batching installations.

The dosing operation is not independent in the manufacture of products, but it is integrated in various technological processes so that the operation result is not separate but combined in the resulted final product. [5]

As a result, the quality of dosing directly influences the final product quality [3].

2. Theoretical Aspects

To define the operation of dosage the following is required: knowledge of the volume to be portioned, the determination of control parameter and the product transportation.

Factors influencing the dosing process can be divided into three main groups: constructive parameters, working parameters, parameters related to dosing material.

Parameters that can influence the operation of the dosing devices are:
• debit or the dosing rate;
• sensitivity;
• response time;
• timing of the operation;
• response characteristic of the frequency;
• dosing accuracy and its reproducibility.

The operation of dosing systems with Vibration is based on the effect of the micro-throwing of the material particles driven by the jolt in an advance movement.

The important parameters that influence the dosing by vibration are: vibration frequency and their amplitude, the angle between the stimulus and the eccentric axis and solid bulk properties: size, shape and distribution of particles and the friction between particles and the carrier.

Due to uncontrollable factors that influence the dosing process it is recommended to use a closed loop control of actuators according to the dosing flow during the process.

The adjustment of the process variables such as speed, frequency, amplitude, is made most accurate when using a control circuit in operating system of the dosing device with a feedback loop that
constant influences the adjustable parameter of the dispenser.

Optimization of the analysed dosage system was done by:

- Application of closed loop control theory.
- Devising an effective dosing algorithm, whose dosing speed is set to vary in real-time, in the dosing moment, in a unique way for each dose in part, in other words, the system automatically adjusts itself based on certain parameters whose variation cannot be mathematically modelled.
- Shaping an algorithm for automatic control of the dosing process, this being tested during the experimental research for establishing optimum working regime of dosing system for bulk materials used in experiments.
- Design of the logical scheme by implementing the software for microcontroller and computer taking into account the optimization of work speed of the processor and the economy of the internal memory of the microcontroller by using pointers’ global variables and functions.
- The algorithm optimization after its testing in terms of reducing the energy consumption and of vibration at the end of the dosing process.

To assure a controlled flow of material in the bucket weighing is used a PID algorithm regulating the flow depending on the material weighed at a time.

The controller commands actuators (engine vibration and engine generator that changes the angle jolt) to maintain the flow of material to the desired value during the dosing process.

The full proportional derivative control (PID control) is the control in closed loop widespread in industry control systems. A PID controller attempts to correct the error between the measured values of the process and set the desired value [4].

Correction of the error is made by calculating and then correcting process control actuator based on three parameters. PID controller operation (algorithm) involves three separate parameters: proportional, integrative and derivative.

Closed loop control consists of three steps:

- Measuring the size of output using a sensor connected to the process;
- Generating and implementing the decisions of the control unit;
- Actuator driving control process.

Inside the dosing system, the actuator element is dosing the material until the amount reaches the desired value. The problem of optimizing the process in terms of speed without losing accuracy of dosing is very important.

The solution is to have a variable rate because dosing with high speed leads to impaired accuracy of dosing.

A sensor will determine the dosage amount and will continuously send data to the controller. The controller is set to point to the desired dosage (SetPoint).

The controller is connected to the actuator output of the dispenser that actually pushes the material, and will use the measured value of
quantity of the dosed material to calculate how the actuator should be controlled to reach precisely the dosage amount in as short time as possible.[6]

Starting from the logic diagram in figure 2 the algorithm was structured (fig 3) carrying out the function application, then it is materialized in the implementation of programs for both the microcontroller and the computer.

Adjust process variables such as speed, frequency, amplitude, is most accurate when using a control circuit in the operating system for the dosing device with a feedback loop that influences constant the dispenser adjustable parameters.

The software application offers for monitoring purpose the graphs in real time for the measured weight, the theoretical debit flow (according to the number of rotations made by the screw and the constructive dimensions of the dosing screw), angular displacement and angular speed.

Fig. 2. Logic diagram for carrying out experiments.

Fig. 3. Dosing algorithm implemented on the microcontroller.
After the ending of one dosing batch, the application allows the user to save all the data gathered through the transducers from the dosing stand in an Excel worksheet.

4. Conclusion
The main purpose of this research is to generate optimised feeding, transport, and proportioning and alignment systems for more mechanical efficiency. Because of that, the entire mechanical and electronic structure of the analysed automata is based on a modular concept. Each important component of the automata control system has a modular structure, which assures a very large working flexibility.

The basic idea underlying this research was to organize a complex system (such as a large program, an electronic circuit, or a mechanical device) as a set of distinct components that can be independently developed and then plugged together.

The optimization of the software contains the implementation of an intelligent command that has: projecting and implementation of an automat control algorithm with feedback response using PID theory algorithm (debit regulator), projecting and implementation of an automat control algorithm PID (just P argument) that modifies the debit according to the rest of the material which remained to be dosed.

Within our further research activities we plan to develop: the elaboration of some combined solutions between the existent study and multi-head technology, which will satisfy both the performance and the cost, the implementation of the positive results from this study in industrial solutions, the optimization of the reaction of the control system, which leads to the achievement of a higher resolution.

References