An Application Using Stability Increasing for the Grinding Machine Performance Improvement in the Automobile Industry

Mehmet Cakmakci, Ece Sonmez, and Melis Kucukyasar

Abstract At the beginning of the third millennium, the use of the Industry 4.0 process has been accelerated and spread in different parts of production. With the rapid development of technology in production, the workload also increases due to the role of the human being. The workload is a concept in which the human processing system is expressed in terms of its ability to process information and produce responses within the framework of its physical and mental characteristics. Especially in the manufacturing sector, the contribution of the human being to the production increases with the technological function while physically decreasing with the developing machinery technologies. With this study, it aims to increase the production capacity in line with meeting the increasing demands in these production units, and improve the production plans of these units with the help of solution models to be developed by using appropriate analysis techniques of injector nozzles model measurements especially by using SMED approach within the lean manufacturing.

Keywords Performance improvement · Grinding machine · Improvement potentials · Injector nozzles model · Single minute exchange of Dies-SMED · Workload analysis

Introduction

At the beginning of the third millennium, the steps of change worldwide are accelerating. The most important of these changes is the globalization of production. It is prominent for companies operating internationally to spread their activities to other countries and continents. Market demands contain more product variants in parallel to customization. This evolution is not limited to certain types of industry,

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rather it is a general phenomenon. As a result, customer demands and diversity are also increasing, so in order to respond to these demands, industries need qualified personnel to meet the required workforce. In order to adapt to globalization, businesses aim to reduce their annual production costs by using their resources more effectively and have a larger share in the market. Due to globalization, customer demands and demand diversity increase in industrialized countries. We see continuous improvement and lean production in key roles in the rational use of resources. Therefore, customer-oriented production becomes more important.

At this point, the terms "continuous process improvement" and "lean manufacturing," namely Toyota Production System comes into play. Lean manufacturing systems must have the ability to achieve responsive, small-batch manufacture so that they can meet rapidly changing market demands [1–5]. In fact, the lean manufacturing system is a part of corporate culture, such as tools and approaches.

The Bosch Group's business activities with the largest area in Turkey is the Bosch Automotive. It was established on an area of 92,000 square meters in Bursa. It manufactures products for diesel injection systems, namely injector nozzles, complete injectors, and Common Rail and Unit Injectors, with a team of 3000 people. The spray nozzle consists of three main parts: hard body, needle, and spring plate. These three parts are produced in three different product lines in the Spray Nozzle department and then combined in the assembly line in the same department.

In this study, the effective use of the labor force that exists in the production process and therefore in the injector nozzle production processes is examined in order to meet the need of qualified personnel, which is one of the factors required for the industries to be at the targeted level or rate in production and sales in the globalized world. With this study, it aims to increase the production capacity in line with meeting the increasing demands in these production units, and improve the production plans of these units with the help of solution models to be developed by using appropriate analysis techniques of injector nozzles model measurements (see Fig. 1).

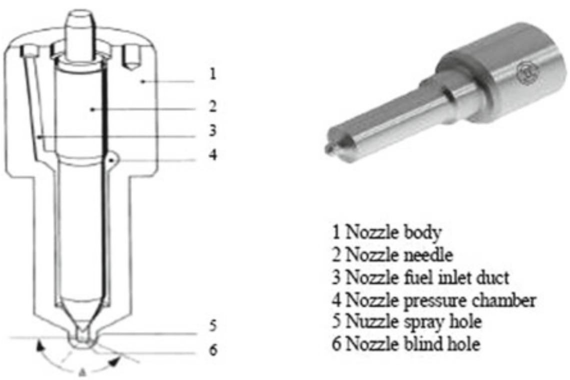

Fig. 1 Sectional view of an injector nozzles model [8, 9]

Grinding Process

An abrasive machining process using a grinding wheel as a cutting tool, the grinding machine can make precise cuts and allow very fine surfaces to be formed. In the grinding machine, the grinding head can be controlled to move along a fixed working area. Otherwise, the workpiece can be moved while the grinding head remains in a fixed position. The most important component of a precision grinding machine is the power-driven grinding head that runs at speed it should be. There is also a bearing with a fixture to guide and hold the workpiece. Grinding machines remove the material from the workpiece by abrading the material with the process where a significant amount of heat emerges due to friction. Cooling oil is used to prevent this heat from reaching levels that will change the crystal structure of the material. In high precision cylindrical and surface grinding machines, the final grinding steps are usually set to be removed approximately 2/10000 mm per pass.

Workload Analysis of Measurement Process of Injector Nozzles Model

Performance is defined as the effectiveness of a roughly specific task and is influenced by two main factors [6, 7]. These are defined by the degree of task, environment and work environment, operator duties, and features of the human factor, i.e., operator. Operators who take part in production can be affected during their duties due to their work or working environment. This interaction determines both operator workload and operator performance (hence system and task performance).

The workload is a general term used to describe the cost of fulfilling task requirements for the human element of human-machine systems (Sandra and Wickens). In this study, it is aimed to increase and optimize the performance; hence, the workload of the operator in injector nozzles model measurements. Measurement activities and actions that support and supplement these activities are grouped as follows (see Fig. 2).

A. Seat angle and cone angle measurement of injector nozzles model:

- Six pieces are taken for the frame consisting of 150 pieces
- Go to the measuring table with measuring apparatus
- By holding compressed air, oil and particles in 6 pieces are cleaned
- With the technoscope, six pieces are subjected to eye control, and errors such as scratches, wrong grinding that can be found in the piece are checked
- Taking six pieces by the operator and walk to Mahr machine
- Three pieces are connected to Mahr machine
- The machine makes its measurements automatically. Whether the computer and data are within the quality control limits are checked by the operator

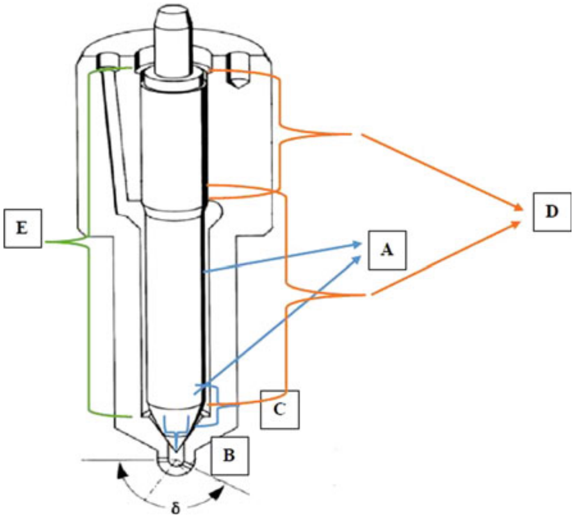

Fig. 2 Measurement process groups and activities of an injector nozzle

- According to the data received, if necessary, the machine is given the correct setting by the operator, and the correct operation of the machine is ensured

B. Blind Hole Diameter Measurements injector nozzles model:

- It takes 6 pieces for the operator shift
- Go to Squat Diameter measuring device
- In the device, the cord diameter is measured. The part is connected to the machine. It measures the diameter values with the program on the computer
- The values taken to save on the computer are noted by the operator
- The data is saved by walking to the computer

C. Blind Hole Depth Measurements injector nozzles model:

- Six pieces are taken for the operator shift
- Walking to the measuring apparatus table
- Parts are placed in the blind hole depth measuring apparatus
- With the help of the apparatus, the blind hole depth of the piece is measured

D. Shoulder and Belt Length Measurements of injector nozzles model:

- Taking six pieces by the operator from the machine
- Walking to the hommel machine
- With the air holding apparatus located next to the machine, the air is drawn into them
- One piece is connected to the machine by the operator, and the result is observed on the computer
- Then it repeats the same process for the other for five parts

E. Plan Length Measurements (plan length includes half of the breast body from the end of the initial seating line):

- Taking six pieces by the operator from the machine
- Walking to the measuring apparatus table
- With the help of measuring devices, the length of the injector nozzles body is measured.

Using Single Minute Exchange of Dies—SMED Approach for the Measurement Process of the Injector Nozzles Model

Short set-up times are a must in any industry today. In current situations, there is a good methodology to reduce these set-up times. In practice, even for very modern and high-tech equipment, there is much that can be improved about the technical concept of the equipment to make it more installation-friendly. Just in time production or JIT is one of Lean's main pillars. It is all about doing whatever the customer wants, when he wants, wherever he wants, and in the desired amounts without keeping anything in the inventory. As can be seen from the applications and literature, SMED adapts to the production approach just in time. First of all, it allows you to adapt to an increasing market, where customers are increasingly demanding diversity and responsiveness. The degree of flexibility will need to be increased (takt time) to better adapt to customer demand. This requires a reduction in inventory and a move towards working with small batch sizes. In addition, the flow of processes needs to be improved and balanced (see Table 1).

The ideal process is the process of having One Piece Flow, creating only one product when searched. Generally, One Minute Change (SMED) techniques will be used to shorten set-up times to reduce batch size. In this context, the Spaghetti diagram, from which SMED techniques are used, in which the movements of the operator to the machines, the travel distances are measured, the time and purpose of each operation performed by the operator is measured, the vehicles and devices used are determined. Therefore, all the data related to the operator are observed, analyzed, and analyzed.

Table 1 The portion of basic set-up steps before SMED implementation [3]

Steps in set-up	The proportion of setup time before SMED (%)
Preparation, after-process adjustments, checking of materials and tools	30
Mounting and removing blades, tools, and parts	5
Measurements, settings, and calibrations	15
Trial runs and adjustments	50

By observing the movement of the operator with the spaghetti diagram, it will be seen which movement has occurred within a limited time by constantly monitoring its movement in the floor plan of the area in which it operates. A few hours will be enough to draw the motion model. The result can help identify the movement that can be reduced by rearranging the workplace. Although a rough outline of the floor plan along with the basic equipment is sufficient, the drawing should be done on an architectural layout. A graph that shows the actual movement that takes place when a particular transaction is executing or doing a job in a particular area. It can help identify unnecessary movements and opportunities for improvement. This finding may mean changes in the location of the equipment, reassigning job responsibilities, or changing the layout of the facility.

Relationship Between the Set-up Time Reduction—SMED and Spaghetti Diagram

Short set-up times in production, set-up, is a must in every industry today. In current cases, there is a good methodology to reduce these set-up times. In practice, even for very modern and high-tech equipment, there is much that can be improved about the technical concept of the equipment to make it more installation-friendly. Just in time production or JIT is one of the lean's main pillars. It is all about doing whatever the customer wants, wherever he wants, and in the desired quantities without keeping anything in the inventory. As can be seen from the applications and literature, a single minute exchange of dies (SMED) adapts to the timely production approach. First of all, it ensures adaptation to an increasing market, where customers are increasingly demanding diversity and responsiveness. To better adapt to customer demand, it is necessary to increase the degree of flexibility (takt time).

This results in a reduction in inventory and working with small batch sizes. In addition, the flow of processes needs to be improved and balanced. The ideal process is the process of having one piece flow; it is to create only one product when it is searched. Generally, a single minute exchange of dies (SMED) techniques will be used to shorten set-up times to reduce the batch size (see Table 1). In this context, the Spaghetti diagram will be used within the framework of the SMED technique, in which the movements of the operator to the machines, the distance of movement, the time and purpose of each operation performed by the operator are measured, the tools and devices used are determined. Therefore, all data related to the operator are observed and analyzed (see Fig. 7).

By observing the movement of the operator with the spaghetti diagram, it will be seen which movement has occurred within a limited time by constantly monitoring its movement in the floor plan of the area where it works. A few hours will be enough to draw the motion model. The result can help to identify the movement that can be reduced by rearranging the workplace. Although a rough outline of the floor plan along with the basic equipment is sufficient, the drawing must be made on an architectural layout. This chart shows the actual movement that takes place while a particular transaction is being carried out or doing business in a particular area. It can help identify unnecessary movements and opportunities for improvement. This finding may mean changes in the location of the equipment, reassigning job responsibilities, or changing the layout of the facility.

Measurement Process Improvement of Injector Nozzles Model

The aim of improving the process is to increase the number of machines used by the operator for measurement operations from two to three while minimizing the operation times; in other words, optimization. Within the framework of the lean manufacturing approach, when using the spaghetti diagram technique in the context of the SMED technique and assuming that 3MMB is improved, the total working load rate was reduced to 63.07% (see Fig. 5). During the improvement process, the basic actions required are determined when analyzing any manual operation by the operator. Each of these basic movements required a predetermined standard time based on the factors affecting it. These operations will be carried out using the Method Time Measurement MTM (Methods-Time Measurement) technique.

Problem Definition

As can be seen in this study, the purpose of the study is to increase the number of machines used by the operator for measurement operations from two to three. In other words, the machines that the operator manages operations are increased from two to three. Before improvement, when the operator-controlled two machines, the current working load, i.e., the total occupancy rate, was 60.29% (see Fig. 3). In the improvement process, when the operator's workload increased from two machines to three machines, the operator's workload, i.e., the total occupancy rate, increased to 87.10% (see Figs. 4, 6 and 7).

An Application

In the industry, which is an automotive supplier industry and maintains its leadership in the market of injector production, the problem about the effective use of the workforce has been addressed to be realized in the inside grinding process (see Fig. 5). Inside grinding is a very precise process in the production of the injector nozzle body. The inside of the nozzle body is grinded from three main points and

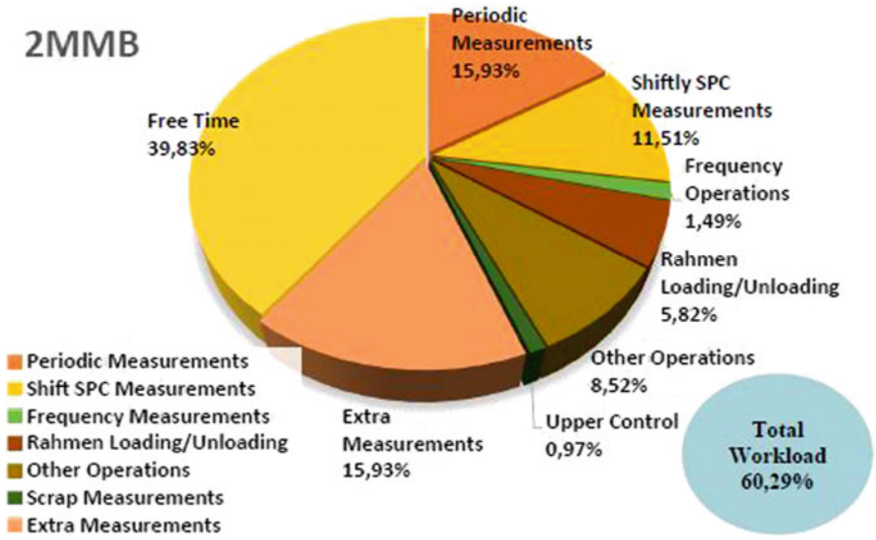

Fig. 3 Measurement process groups and activities of an injector nozzle

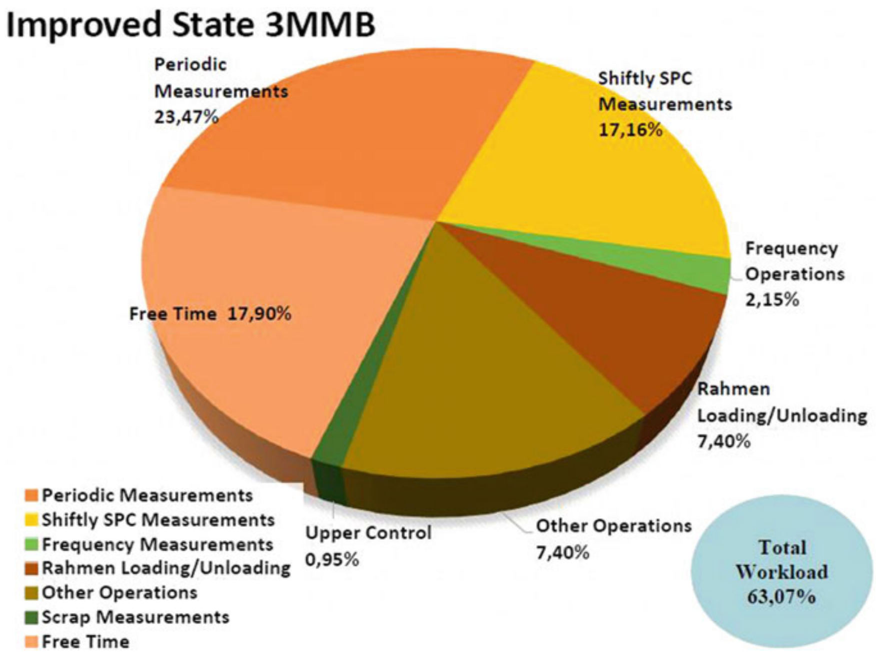

Fig. 4 Measurement process groups and activities of an injector nozzle after process improvement

Fig. 5 Inner grinding 3MMB model nozzle body process [8]

observed with the control cards in order to keep it at the desired level. Control of machine stability is provided by various measurements. Thus, measurements are made whether the part is at the desired level or not.

In the initial situation in the problem under the lens, the operator controls and manages two machines. The main task of the operator is to perform standard works and keep the machine under control within the specified time. At this point, it is very important to provide this data from the average operators at the production site to understand and analyze how full the operator is during the working period. In the targeted situation, the operator is intended to look at three machines. In order to understand and analyze the data just mentioned (see Figs. 6 and 7);

- Single Minute Exchange of Dies (SMED)
- Spaghetti Diagrams
- MTM Analysis
- Layout location selection with AutoCad
- Workload Analysis
- Shift Machine Tracking.

work will be done.

Conclusion and Future Works

Future studies will be aimed at increasing the performance of the operator, making measurements on multiple machines in the production of injector nozzles model using different techniques determined in this study. As a continuation of this study, data will be collected by the operator from the ongoing measurement processes. The obtained data will be evaluated by using the techniques determined in this study. The operator load will be analyzed primarily, and the improvement will be provided to the results to be obtained. Secondly, it will be discussed whether different techniques determined to improve the measurement process of the injector nozzles model, such as SPC techniques, simulation, SMED technique, spaghetti diagram, and so on techniques are accurate. By using the techniques listed below, the bottlenecks that may occur during the measurement process will be recognized, thereby preventing performance losses from bottlenecks.

- Sensitivity analysis of performance measures
- Analytic Hierarchy Process (AHP)
- Comparison of Discrete Event Simulation Modelling with current and future situation
- Identification of Improvement Potentials.

The use of simulation techniques in the production of the injector nozzle module is applied as a successful technique in increasing operator performance in measurement processes. Within the framework of the simulation technique, product, process, and system design can be made, and the configuration can be tested and approved. The system can be modeled and analyzed with the simulation program, and forecasting alternative models to the system can be provided.

In real life, it can be impossible or too costly to observe any system or sequence of operations. The system observed can be so complex that it may be impossible to define this system with mathematical equations and to obtain predictive analytical solutions for system operation. Even if the mathematical model of the system under consideration can be established, the analytical techniques required to solve the model may be insufficient. Experiments to verify mathematical models that define the system can be either impossible or too costly.

References

1. Cakmakci M (2009) Process improvement: performance analysis of the set-up time reduction-SMED in the automobile industry. Int J Adv Manuf Technol 41(1–2):168–179
2. McIntosh RI, Owen GW, Culley SJ, Mileham T (2007) Changeover improvement: reinterpreting Shingo's SMED methodology. IEEE Trans Eng Manage 54(1):98–111
3. Shingo S (1985) A revolution in manufacturing, the SMED system. Productivity Press, University Park, IL
4. Van Goubergen D, Van Landeghem H (2002) Rules for integrating fast changeover capabili ties into new equipment design. Rob Comput-Integr Manuf 18(3–4):205–214
5. Womack JP, Jones DT (1997) Lean thinking. Simon and Schuster, London
6. Miller S (2001) "Workload Measures" literature review, Document ID: N01-006
7. Paas F, Vanmerrienboer JJG (1993) The efficiency of ınstructional conditions an approach to combine mental effort and performance-measures. Hum Factors 35(4):737–743
8. Bosch Nozzles (2019) https://www.boschautoparts.com/en/auto/diesel-parts/nozzles. Accessed 22 Oct 2019
9. Dogru B (2007) Enjektör parametrelerinin motor performansına etkisi. Master thesis
10. Sandra GH, Wickens CD, Workload assessment and prediction, manprint, pp 257–296