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# ANALYSIS OF EFFECTIVENESS ON PRODUCTION SYSTEM FOR PRODUCTION OF THE TOOLS FOR HYDRAULIC PRESS BRAKES

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**Abstract**: This paper provides an analysis of the project of production system for the production of tools for hydraulic press brakes with application of production process simulation. The analysis is based on modeling and simulation of the process planning design for tools for hydraulic press brakes, with application of Experimental Manager module within the program system Tecnomatix Plant Simulation. Computer simulation shows the results of a working of production system and with interacting actions of designer it was achieved more balanced production and increased the effectiveness of the production system design.
**Keywords**: Effectiveness, Simulation, Production processes, Process planning

## 1. INTRODUCTION

Tools for sheet metal angle bending are integral parts of hydraulic press brake for sheet metal bending (Figure 1), which are equipped with adjustable tool holders on the upper tools - punch and lower tools - die, that are placed on the press table (Figure 2). Adjustable tool holders on punch allow adjustable assembly of upper tools, used to perform all types of neutralization of deformation and tool wear, thus achieving consistency of bending angle along the entire length of sheet metal.

Figure 1. Hydraulic press a brake for sheet metal

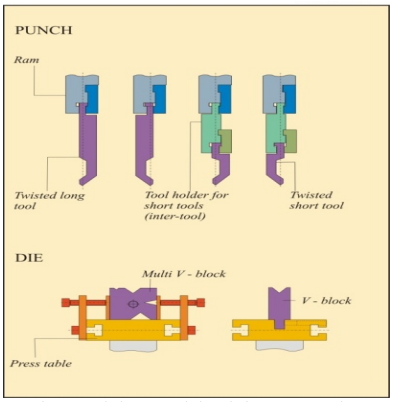



Figure 2. Adjustable tool holders on the ram of the press and bottom tools - dies on the press table

Punch and dies for sheet metal bending are manufactured from high tensile steel of 1000-1100 N/mm$^2$. The punches are placed on the ram of the press and short segment punches are installed via tool holders for short tools. Segment tools are also part of application in bending process, which are made in standard sizes, according to manufacturer recommendation or at the request of customers. Bottom tools or dies are placed on the press table in standard execution as V-block on center of table or multi V-block (matrix), which is usually produced in the size of the working length of the press.

Demands for manufacturing of tools for hydraulic press brakes are all the more pronounced with development of new products based on metal deformation. There are delivered in the standard version with hydraulic press brake for sheet metal bending and also according to individual customer requirements.

Technology for manufacturing of tools for hydraulic press brakes is very demanding and therefore it is justified to design a dedicated production plant (system) for the production of tools for hydraulic press brakes.

Striving to increase the efficiency of production systems, the need for computer applications, that have the ability to display and simulate of manufacturing systems and process planning are necessary. These applications have the ability to manage the cycle of production, collection of manufacturing flow data and allow the optimization of the production process.

One of these advanced applications is Tecnomatix Plant Simulation, which provides a full range of tools for the analysis of production models with stochastic algorithm for computing and managing experiments, and determination of the parameters for the optimization of the production process.

## 2. TECHNOLOGIES FOR PRODUCTION OF TOOLS FOR HYDRAULIC PRESS BRAKES

On the basis of a wider product range for manufacturing of tools for hydraulic press brakes sheet metal bending, which includes the upper tools (punches) - curved, straight and sharp tools and lower tools (dies) symmetric V-block and multi matrix, there was executed a reduction of programs on representative workpieces. For representative workpieces it was elected technological sub-group i.e. lower tool (die) for bending (Figure 3), for which were designed process planning for pre-determined reduced year amounts.

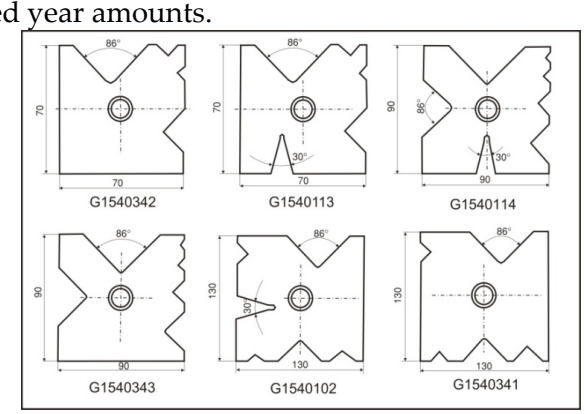



Figure 3. Technological sub-group i.e. lower tool (die) for sheet metal bending

Table 1. Technology for manufacturing of dies

| No. | Operations | Machines | Setup time [min] | Processing time [min] |
|---|---|---|---|---|
| 10 | Sawing | Band saw | 10 | 7,3 |
| 20 | Milling 1 | Milling/drilling mach. | 25 | 22 |
| 30 | Milling 2 | Portal milling mach. | 90 | 348 |
| 40 | Flattening | Press for flattening | 5 | 15 |
| 50 | Grinding | Grinding machine | 60 | 350 |
| 60 | Control | Worktable | 5 | 6,3 |

Table 2. The year amounts of dies

| ID of die | ID in model | No. of pieces per year |
|---|---|---|
| G1540113 | Part A | 120 |
| G1540114 | Part B | 10 |
| G1540342 | Part C | 100 |
| G1540343 | Part D | 4 |
| G1540102 | Part E | 20 |
| G1540341 | Part F | 150 |

Thus, the modeling and simulation of the production system is based on technology which is already developed for example of the lower tool (die) for bending -multi matrix, which is shown in Table 1 and Table 2.

## 3. MODELING OF PRODUCTION PROCESESS

Tecnomatix Plant Simulation is a software system which is designed for modeling, simulation and optimization of manufacturing process planning. Optimization of manufacturing process planning using this software system is based on time-oriented simulation and event-oriented simulation. Time-oriented simulation takes into account a wide range of different types of production time,

while event-oriented simulation takes into account only these points in time which events have an impact, within the simulation model.

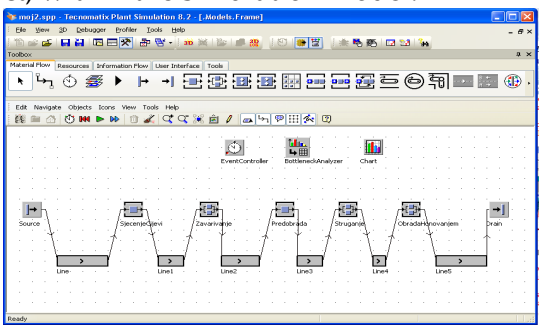


Figure 4. Modeling of manufacturing processes in a 2D environment

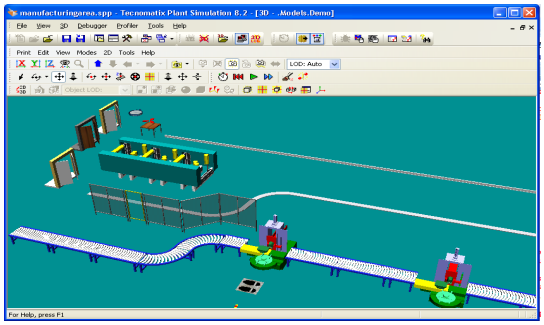


Figure 5. Modeling of manufacturing processes in a 3D environment

Modeling of technological processes and the creation of simulation models of real production processes by applying the system Tecnomatix Plan Simulation can be performed in 2D and 3D environments.

Modeling in 2D environment, shown in Figure 4, is applied to complex optimization problems, related primarily to the time balancing the technological process, i.e. analysis of the production process from the point of time (production times, extra and additional times, a preliminary-final time, cycles production, etc.). Modeling in 3D, shown in Figure 5, is primarily used for monitoring the distribution of technological systems and devices, which is necessary to spatially arrange in the appropriate production system.

## 4. OPTIMIZATION OF PRODUCTION PROCESESS

In this paper it was executed analyze of the project of the production system for the production of tools for sheet metal bending using the modeling and simulation of manufacturing processes. The analysis is based on modeling and simulation of the process planning design for tools for sheet metal bending, using a general module for the simulation of manufacturing processes and module Experimental Manager in the program system Tecnomatix Plant Simulation.

The basics for analysis and optimization of the manufacturing process, generated from the project of the production system are:

- process planning,
- type and number of machines,
- time duration of the operations,
- number and capacity of buffers.

The objectives of the analysis and optimization of production processes using the software system Tecnomatix Plant Simulation are: time reduction of the total execution time for production of the workpieces in the cycle of optimization, the optimal number of machines, the buffer capacity and high coefficient of efficiency for machines. According to previous solutions from the project of production system for manufacturing of tools for sheet metal bending, based on the process planning design and technology demands, positions of workplaces were adopted with appropriate technological systems - machines that are shown in Table 3.

Table 3. Workplaces with appropriate technological systems

| No. | Operation/ workplace | Machine | No. of machines |
|---|---|---|---|
| 1 | Sawing | Band saw | 1 |
| 2 | Milling 1 | Milling/drilling machine | 1 |
| 3 | Milling 2 | Portal milling machine | 1 |
| 4 | Flattening | Press for flattening | 1 |
| 5 | Grinding | Grinding machine | 1 |
| 6 | Control | Worktable | 1 |

Based on above mentioned technological information it was developed an initial model for the simulation of manufacturing systems for the production of tools for sheet metal bending, as is

shown in Figure 6. The simulation results of the manufacturing process for the initial model are shown at Figures 7.a and 8.a. These results indicate that, within one calendar year and the effective capacity of 180 000 min / year (two work shifts), it is possible to produce the necessary amount of tools for hydraulic press brake for sheet metal bending.

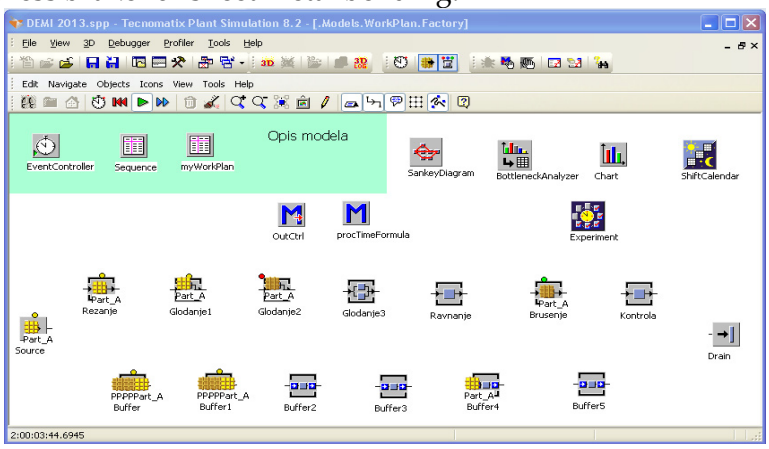



Figure 6. The initial model for the simulation of manufac. sys. for the production of dies

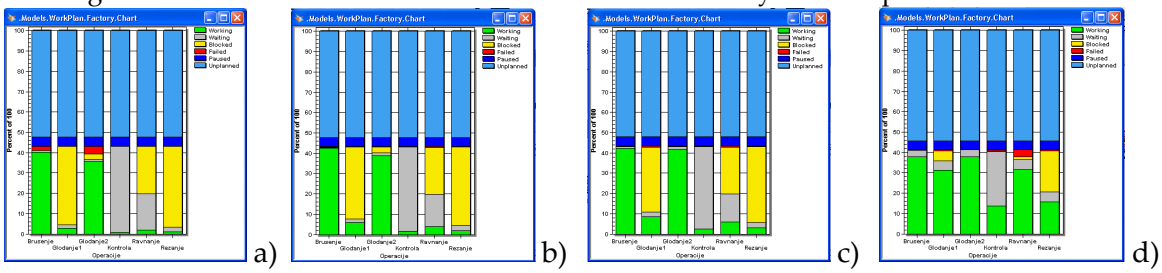



Figure 7. Percentage utilization of machines based on the number of adopted machines by operations

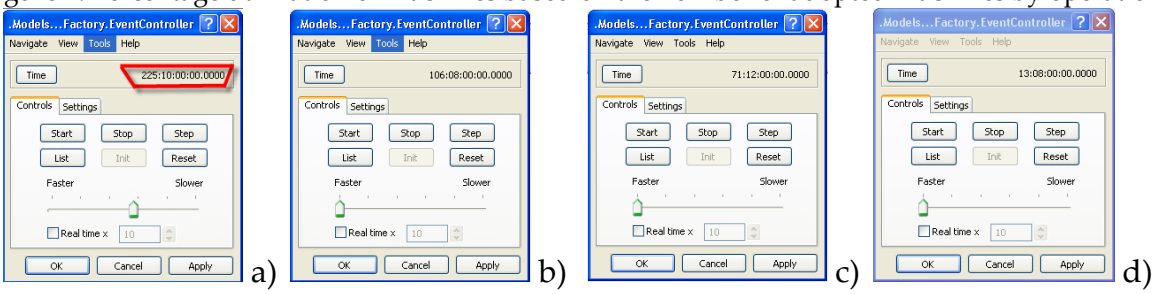



Figure 8. End-times for adopted quantities for lower tools (dies) depending on the number of adopted machines by operations

The results also show a large unbalance of the production process, which is reflected in the emergence of bottlenecks at operations 3 and 5. By adjusting the model of simulation in terms of increasing the number of machines at operation 3 and 5, the following results were obtained as follows:

a) for the case 1-number of machines in operation 3 and 5 (two machines), the results shown in Figures 7.b & 8.b,
b) for the case 2-number of machines in operation 3 and 5 (six machines), the results shown in Figures 7.c & 8.c,
c) for the case 3-number of machines in operation 3 and 5 (twelve machines), the results shown in Figures 7.d & 8.d.

The obtained results clearly show that increasing the number of machines significantly increases utilization of machines and a large decrease of production time in the observed time interval. However, from an economic point the increasing of the number of machines is not justified, because the required quantity of workpieces in that case, can be relatively quickly finished (case 3 - 13 calendar days in mode of 2 work shifts). Other work days during the year, machines would be completely unused.

Thus, taking into account the annual standards of workers, machines, as well as requests for quantities of individual tools for sheet metal bending, it was adopted the case of no.1 - increased the number of machines in operation 3 and 5 on two machines for each operation (Table 4). The initial results of this case indicate that the total amount of the lower tools (dies) can be make for 106 calendar days in the mode of 2 work shifts.

Further improve of the simulation model was based on introduction of the 1 work shift mode, which the end-time of production of all tools increases on the amount of 214 calendar days (Figure 9), it should be borne in mind the savings related to the elimination of the regime with two work shifts.

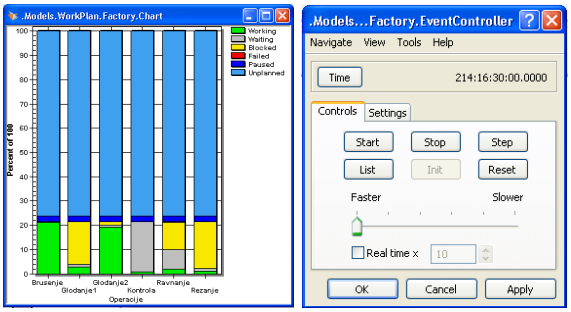



Figure 9. Percent utilize and end-time for production of the tools for an improved simulation model

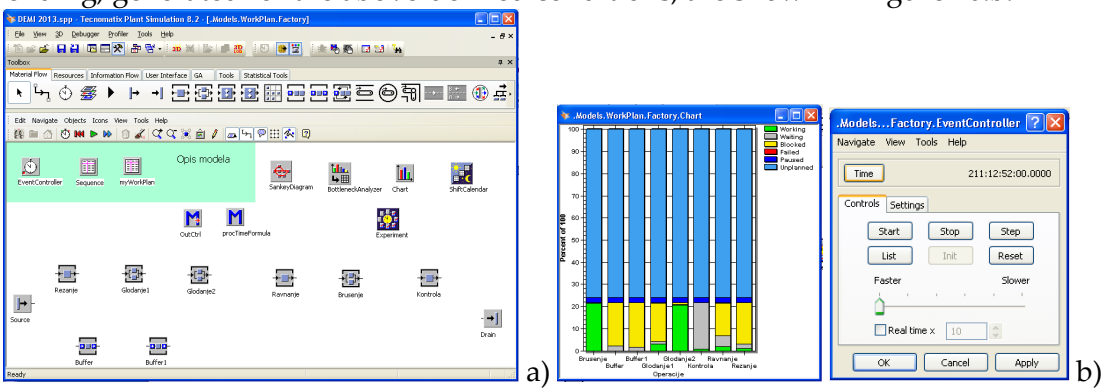
Table 4. Optimal number of machines by the operation for the final simulation model

| No. | Operation/ workplace | Amount of machines |
|---|---|---|
| 1 | Sawing | 1 |
| 2 | Milling 1 | 1 |
| 3 | Milling 2 | 2 |
| 4 | Flattening | 1 |
| 5 | Grinding | 2 |
| 6 | Control | 1 |

Further improve the simulation model was based on introduction of the buffers between all operations (machines). Applying module the Experimental Manager on a designed simulation model, in the framework of this program system, the obtained results indicate the following:

- ✓ total amount of time for production of tools for sheet metal bending will be shortened by 3 calendar days;
- ✓ buffers are only required between operations 1 and 2 and 2 and 3;
- ✓ optimal buffer capacity between operations 1 and 2 (buffer) is 15 workpieces;
- ✓ optimal buffer capacity between operation 2 and 3 (buffer1) is 21 workpiece;

Applying module Experimental Manager on a designed simulation model and with respect to generated results, we get the final model for the simulation of manufacturing systems for the production of the tools for sheet metal bending, which is shown at Figure 10.a. Optimal results of the final model for the simulation of manufacturing systems for the production of tools for sheet metal bending, generated for the above-defined conditions, are shown in Figure 10.b.




a) b)

Figure 10. The final model and the results of the simulation of production systems for the production of the tools for sheet metal bending

## 5. CONCLUSION

This paper provides an analysis of the project of production system for the production of tools for hydraulic press brakes with application of production process simulation. The analysis is based on modeling and simulation of the process planning design for tools for hydraulic press brakes, with application of Experimental Manager module within the program system Tecnomatix Plant Simulation.

By simulation of manufacturing processes there were carried out multiple tests by changing the number of workpieces, number of machines, time norms and material flows in order to increase the efficiency of production system.

The results of the analysis and optimization of the designed production system for the production of tools for sheet metal bending are showed a high degree of consistency of previous design solutions with the solutions derived from this simulation study.

It should be noted that the introduction of simulation and optimization of manufacturing processes using computer systems and software Tecnomatix Plant Simulation largely contributes to high level of project design of production systems, particularly in terms of increasing the efficiency of production systems, in the design phase and prior to the execution and approval of the realization of the production system.

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