ORIGINAL RESEARCH PAPER

Engineering

# EVALUATING THE PROPERTIES OF THE PARALLEL PROCESS ON THE PRODUCTION LINE OF STEEL SURFACE TREATMENT

**KEY WORDS:** Surface Treatment, Alkaline Blackening, Phosphating of zinc, Simulation, Flexibility, Plant Simulation

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**ABSTRACT**

Every organization wants to achieve the highest efficiency of their processes. Improving process efficiency can be achieved by speeding up processes, increasing production, or improving production flexibility. The paper deals with the evaluation of the characteristics of the steel surface treatment line. We have processed simulation models of the production line in its original state. We compared the individual processes and drew up a proposal for their concurrent operation. To assess the design we used a simulation module Tecnomatix Plant Simulation. We proposed extending the handling crane at the next track and the hoist. Each chain hoist ensures the running of the individual processes. By doing so, the processes will be parallel and their fluenced will be maintained. In addition, daily production of processed parts on the production line would increase.

## INTRODUCTION

In the mechanical engineering sector, in addition to direct manufacturing processes such as turning, milling, drilling and the like, existing also finishing processes. These processes often involve customer requirements for the visual and surface properties of the machined parts. One such requirement is often the finish surface of metal components. This service provides several companies offering different types of finishes surface. These finished surface also depend on the type and character of the material. In this paper we describe the production line to finish surface steel parts. These are surface treatments using thermo-chemical processes. With the help of these processes is applied to the surface of parts desired protective treatment. This is alkaline blackening and phosphating of zinc. Among the basic properties of alkaline blackening, which are known in particular to manufacture weapons and gauges, are:

- increase of wear resistance,
- improving corrosion resistance in combination with appropriate impregnation,
- the dimensional stability of the treated parts, the coating being from 0.5 to 2.5 μm,
- long-term life cycle.

The phosphate of zinc, creates anticorrosive coatings, minimizes surface friction, improves abrasion resistance. The benefits are:

- coating acts as an insulator,
- excellent ability to bond additional layers of adhesive,
- dimensional stability of components, coating has a thickness of about 2 μm.

## DESCRIPTION OF THE CURRENT STATE AND POSSIBILITIES ON THE SURFACE TREATMENT LINE

The production line consists of:

- 13 tubs with volume of 180 liters of chemical solutions and waters solutions (Figure. 1,2),
- portal crane for material handling,
- air suction system for chemical vapors elimination,
- preparatory workplace,
- workplaces for finishing and packing

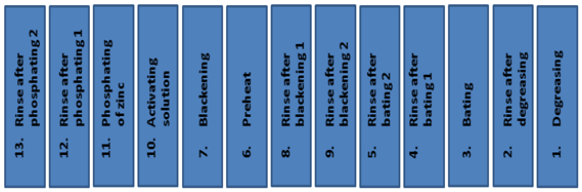


**Figure 1 Schematic representation of tubs on the surface treatment line**

**Figure 2 Production line of surface treatment**

## SEPARATION OF INDIVIDUAL PRODUCTION PROCESSES

1. Alkaline blackening: This production process consists of 9 tubs with chemical solutions and water rinses (Table 1). Some tubs with chemical solutions are heated to temperatures that are necessary for their proper efficiency. It's a tubs number. 1 degreasing, no. 6 with preheating and no. 7 with a blackening chemical solution.

**Table 1 Technological Process Of Alkaline Blackening**

| Odred | Temperature | Time | Production description |
|---|---|---|---|
| | | 10 min. | Input and preparation of input material |
| **Tubs no. 1** | 55-99ºC | 1-6 min. | Degreasing of parts |
| **Tubs no. 2** | ambient temp | 30 sek. | Rinse after degreasing |
| **Tubs no. 3** | 15-30 ºC | 5-15 min. | Bating of the solution 15% HCl, removal of corrosion residues |
| **Tubs no. 4** | ambient temp | 30 sek. | Rinse after bating no.1 |
| **Tubs no. 5** | ambient temp | 30 sek. | Rinse after bating no.2 |
| **Tubs no. 6** | 60-70 ºC | 3-5 min. | Preheat |
| **Tubs no. 7** | 135-142 ºC | 12-20 min | Blackening, time and temperature depends on the material composition of the parts |
| **Tubs no. 8** | ambient temp | 30 sek. | Rinse after blackening no. 1 |
| **Tubs no. 9** | ambient temp | 30 sek. | Rinse after blackening no. 2 |
| | | | Drying and subsequent applying of parts with preservative oil, subsequent packaging of finished products |

2. Phosphating of zinc: this production process also consists of 9 tubs with chemical solutions and water rinses (Table 2). As with the previous process, it is necessary to heat some tubs with chemical solutions to the required temperatures. In addition to degreasing, a tube with a solution for phosphate of zinc is also heated in this process.

**Table 2 Technological Process Of Phosphating For Zinc**

| Order | Temoperature | Time | Production description |
|---|---|---|---|
| | | 10 min. | Input and preparation of input material |
| **Tubs no. 1** | 55-99ºC | 1-6 min. | Degreasing of parts |
| **Tubs no. 2** | ambient temp | 30 sek. | Rinse after degreasing |
| **Tubs no. 3** | 15-30 ºC | 5-15 min. | Bating of the solution 15% HCl, removal of corrosion residues |
| **Tubs no. 4** | ambient temp | 30 sek. | Rinse after bating no.1 |
| **Tubs no. 5** | ambient temp | 30 sek. | Rinse after bating no.2 |
| **Tubs no. 10** | 15-30 ºC | 3-5 min. | Activating solution |
| **Tubs no. 11** | 65-70 ºC | 3-5 min | Phosphating of zinc |
| **Tubs no. 12** | ambient temp | 30 sek. | Rinse after phosphating no. 1 |
| **Tubs no. 13** | ambient temp | 30 sek. | Rinse after phosphating no. 2 |
| | | | Drying and subsequent packaging of finished products |

Tubs, constituting both production processes are part of one common production line (Figure. 2). In the construction of the production line, such a solution was made because of the similarity of both processes and in order to save space in the production hall. On this line, it is currently possible to perform only one of the above-mentioned production processes, without the process being blocked and operating smoothly. According to the volume of orders, production is in alternating mode. This means that one working day is carried out on the alkaline blackening process and the next day is the process of phosphating. Alternatively, the same process is repeated days for several consecutive days, according to customer needs. To a greater extent, the required surface finish is alkaline blackening, which is about 70% of the total production. One worker serving the portal crane is able to operate only one production process. In this manufacturing process, in both cases, one more worker is working to prepare the material. The same worker is also in charge of drying the parts and their subsequent final inspection and packaging of finished products. All production at this line is currently provided by two workers in both production processes.

As can be seen from both the technological procedures (Table 1, 2) and the schematic representation of the production line (Figure.1), both surface treatments are more or less the same. They differ in the main part process that performs the finished effect on the surface of the component. As is evident, process of alkaline blacking is time consuming. The main operation takes 20 minutes. In contrast, the main process of zinc phosphating lasts for 5 minutes. We have created the simulation models of the both manufacturing processes in their original state. Each individually for the duration of one whole working day, that is, two working changes.

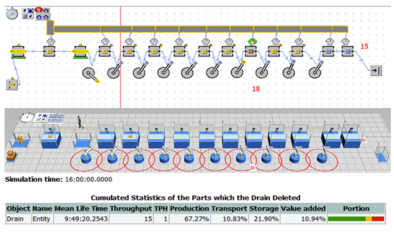


**Figure 3 Simulation model of alkaline blackening in its original state**

As can be seen from the simulation model and the cumulative statistic (Figure 3), the line produces 15 production batches in at alkaline blackening process. On the counter, which is set to the main part of the manufacturing process, for the blackening operation, during the production day, 18 production processes are carried out at this workplace. Value added calculated with help simulation software Tecnomatix Plant Simulation is on the level 10.94%.

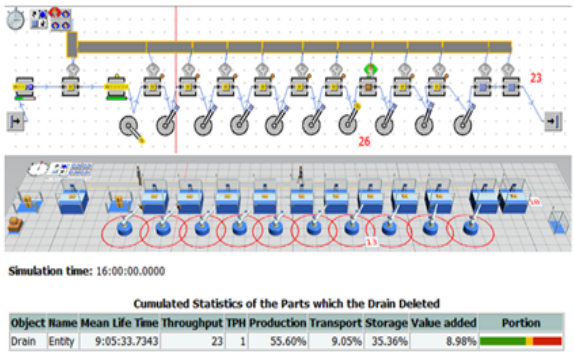


**Figure 4 Simulation model phosphating of zinc in the original state**

In the Figure. 4 is a simulation model of phosphating zinc process. As this process is less time consuming, it is able to perform about 8 production batches more during one working day, than in the process alkaline blackening. It will produce overall 23 production batches. The main operation in this manufacturing process is phosphating. During the whole production day, 26 production batches will pass through this operation. The value of the value added is in the manufacturing process according to statistics Tecnomatix Plant Simulation at level 8.98%.

## PROPOSAL UNIFICATION OF THE TWO PRODUCTION PROCESSES INTO ONE CONCURRENT PRODUCTION PROCESS AND EVALUATE ITS PERFORMANCE.

A problem in the production process is often meeting customer requirements.´ Customers often require time flexibility of the production process and a short time to meet the requirement for the necessary surface treatment. With the current alternate manufacturing mode, it is problematic to meet the frequent customer demand for express surface treatment. This type of surface treatment means that the customer will agree on a specific finish term for the finish, or in the shortest possible time horizon. It is often a requirement to perform both surface treatments as soon as possible. At present, this means that if both alkaline blackening and phosphating of zinc are required at the same time, it takes at least 2 working days to meet this requirement depending on the size of the batch. Using a simulation model in the Tecnomatix Plant Simulation software module, a proposal for the unified both surface treatments into a parallel production process was created. In this proposal, it was necessary the portal crane to extension about of the next track and hoist. In this proposal, has each surface treatment own hoist that manipulates the material during production. For the operation of the second hoist, it was necessary to add another employee to the production process. This will also ensure fluency in the production process. In the simulation of the proposal it was necessary to take into account the fact that the order quantity was 70% alkaline blacking and 30% phosphate of zinc.

The simulation design model (Figure 5) shows that, during two changes per working day, the line produces a total of 28 production batches parallel. Looking at partial results that are indicated to the main manufacturing processes in both process, it is clear that the line processes 19 production batches of alkaline blackening and 23 production batches phosphating of zinc . Total added value of parallel activity in manufacturing process, is according to the simulation at level 11.76%.

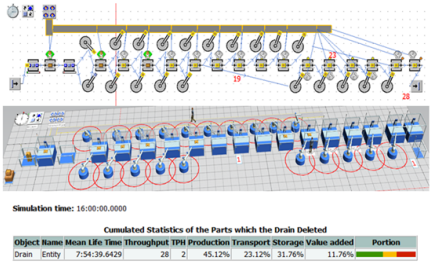


**Figure 5 Simulation model for the proposal of surface treatment unification into a parallel process**

## CONCLUSIONS

From the point of view of the functionality and improvement of the production process flexibility on the line, the idea of streamlining the production process appears to be efficient and acceptable. With the parallel functioning of both surface treatments, alkaline blackening and phosphating of zinc , when looking at the cumulative output statistics, it is clear that when comparing the two previous processes, there was an improvement in efficiency compared to both processes individually. Consideration should also be given to the fact that, when applying the proposal, one workday will provide a service for both available surface treatments and will improve the ability to meet customer.

## ACKNOWLEDGEMENT

This article was created by implementation of the grant project APVV-17-0258 Digital engineering elements application in innovation and optimization of production flows and VEGA 1/0708/16 "Development of a new research methods for simulation, assessment, evaluation and quantification of advanced methods of production".

## REFERENCES:

[1] Bangsow, S. (2015), "Tecnomatix Plant Simulation. Modeling and Programming by means of examples." Springer. 2015, ISBN 978-3-319-19502-5.
[2] Edl, M., Lerher, T., Rosi, B. (2013), „Energy efficiency model for the mini-load automated storage and retrieval systems". International Journal of Advanced Manufacturing Technology, , č. 2013, s. 1-19. ISSN: 0268-3768
[3] Straka, M., Malindzak, D. (2009), "Algorithms of capacity balancing of printing machineries for Alfa Foils, a.s. planning system." Acta Montanistica Slovaca, Volume 14 (1), 98-102.
[4] Bárdy, M., Kudrna, J., Šrámková, B.B., Edl, M. (2014), "Interactive game supporting SMED method." Applied Mechanics and Materials, 474, 141-146.
[5] Saniuk, S., Samolejova, A., Saniuk, A., Lenort, R. (2015), "Benefits and barriers of participation in production networks in a metallurgical cluster - research results.", Metalurgija, 54(3), 567-570.
[6] Rosova, A., Malindzakova, M. (2014), " Material flow - starting point for recovery of inputs in the production company." International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 3(5), 14th International Multidisciplinary Scientific Geoconference and EXPO, SGEM Albena; Bulgaria.
[7] Wicher, P., Staš, D., Karkula, M., Lenort, R., Besta, P. (2015), "A computer simulation-based analysis of supply chains resilience in industrial environment.", Metalurgija, 54(4).
[8] Tecnomatix Plant Simulation Basics, Methods and Strategies Student Guide, 2012, Siemens PLM.
[9] Klos, S., Ptalas-Maliszewska, J.(2014), „Badania kluczowych problemów w zarządzaniu utrzymaniem ruchu", W: Innowacje w zarządzaniu i inżynierii produkcji / red. R. Knosala . T. 2 .- Opole : Oficyna Wydaw. Polskiego Towarzystwa Zarządzania Produkcją, s. 678--687 .- ISBN: 978-83-930399-6-8
[10] Gregor, M., Magvaši, P.: (2014), „Globalizácia a megatrendy", In: ProIN: dvojmesačník CEIT, s. 67-73, Roč. 15, č. 4, ISSN 1339-2271
[11] Straka, M., Lenort, R., Khouri, S., Feliks, J.: (2018) „Design of large-scale logistics systems using computer simulation hierarchic structure", International Journal of Simulation Modelling, Vol. 17, No. 1, pp. 105-118
[12] Straka, M., Khaori, S., Rosova, A., Caganova, D., Culkova, K.: (2018), „Utilization of computer simulation for waste separation design as a logistics system", International Journal of Simulation Modelling, Vol. 17, No. 4, pp. 583-596