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SOFTWARE SIMULATION OF PRODUCTIVITY CHARACTERISTICS FOR EDM PROCESS

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ABSTRACT: The objective of the article is to briefly detail the main aspects that can influence the productvity of a micro-EDM and 3D printing processes for processing an alloy of TiAl6V4. Electrical discharge machining (EDM) is one of the earliest non-conventional machining processes. EDM process use the thermoelectric energy between the the part and tool, which is an electrode manufactured from conductive materials. A pulse discharge occurs in a small gap filled with dielectric liquid between the work piece tool and removes material by melting and vaporising. This paper presents computerized modeling of the plant using Tecnomatix Siemens Plant Simulation.

KEYWORDS: EDM, Sotfware simulation, TiAl6V4, Productivity

1. INTRODUCTION

Micro-EDM process is a further adaptation of the EDM process required to produce micro-scaled components [2]. The main difference between the two non conventional processes is the power supply, which generates nanoseconds pulses.

This process has two very important disadvantages. This is quite slow - the removal rate of the material is relatively low compared to other microprocessing processes [1]. The second disadvantage is the high wear of the tools, which leads to inaccuracies in shape, ie lack of precision machining. This wear is amplified in the case of vanadium aluminum titanium alloys because they have a high hardness (379 HB) and a melting temperature (1604 - 1660 °C). To make titanium alloys possible, ultrasonic vibrations (US) of the tool electrode were successfully applied.

The depth of the micro-holes [4] through the combined effect of EDM with ultrasonic vibration, in the case of titanium, aluminum, vanadium alloys becomes almost twice as high as without ultrasonic vibration and the processing speed has been increased [3].

3D printing of titanium alloys is known as DMLS (direct metal laser sintering) and is an additive manufacturing technology first developed in Germany. This technology is used to create titanium parts but also by 3D printing mechanical parts are made for the domains presented above.

DMLS (Direct metal laser sintering) is an additive manufacturing technique that uses a laser as a power source to sinter the powder material (usually metal), the laser automatically aiming at the points in space defined by a 3D model, binding the material together to create a solid structure. The technique is similar to selective laser sintering (SLS).

The biggest advantage of 3D printing of titanium alloys is the ability to produce parts of complex geometry impossible to achieve by classical processes with good accuracy (± 0.2 mm) and high mechanical properties. On the other hand, 3D printing has disadvantages such as high manufacturing cost (the cost of printing titanium alloys is about 10 times higher than other alloys), very low productivity (a general disadvantage of additive manufacturing technologies) but also wack quality of surface (Ra 20-70μm).

The alloy studied in this paper has very good mechanical properties such as tensile strength, hardness. It also has other characteristics like: possibility of welding and using heat treatments to increase the hardness, corrosion resistance and high thermal resistance.

With those characteristics, TiAl6V4 is especially used in a multitude of components which are part of the body and engine of an aircraft. The main advantage of using this titanium alloy in the aeronautical and military industries is the reduction of aircraft weight.

The physical-mechanical-thermal properties of the titanium alloy TI-6Al-4V are presented in table 1.

Table 1. Properties of the alloy

Property	Value
Hardness, Brinell	334
Hardness, Knoop	363
Hardness, Rockwell C	36
Hardness, Vickers	349
Tensile Strength, Ultimate	950 MPa
Tensile Strength, Yield	880 MPa
Elongation at Break	14 %
Modulus of Elasticity	113.8 GPa
Poisson's Ratio	0.342
Charpy Impact	17 J
Melting Point	1604 - 1660 °C

2. DESCRIPTION OF THE SOFWARE USED FOR SIMULATION

Tecnomatix Plant Simulation software has the possibility to generate event simulation and statistical analysis capabilities to improve process characteristics like, supply and delivery time, machine availability, workers utilisation,

Using stochastic analysis, object programming and 3D modelling capabilities, is possible to optimize manufacturing resources while improving output and overall system performance.

The user can extract after the simulation charts and reporting features, algorithms and trends economic value to evaluate the performance of production and to produce fast with a minimum cost

2.1 Test of Simulation capability

To assess simulation-capability is mandatory to verify:
• Process variables and mathematical models
• Methods and algorithms
• Variation of input characteristics to identify the situation in which the system has the maximum performance.

2.2 Formulation of targets

Before desigs targets like profitability and performance are set up for a system.
The definition of the target system is an important preparatory step. These can be splited in next following KPI (key process input):
• Minimize cycle time
• Maximize the machine availability
• Minimize buffers
• Increase the number of in-time delivery

2.3 Data collection

The data recomanded for the simulation study [1] can be structured as follows:

- Factory structural data
- Manufacturing data
- Resource allocation
- Job data

In table 2 are presented some selection of data to be collected:

Table 2. Data collection

Technical data	
Factory structural data	Layout Means of production Transport functions Transport routes
Manufacturing data	Cycle time Performance data Capacity
Resource allocation	Workers Machines Conveyors
Job data	Production orders Transportation orders Volumes

3. SIMULATE THE NONCONVENTIONAL FACTORY

3.1 Establishing the factory layout

Layout involves adding machines and establishing distances between them.

In this case, for the nonconventional factory is necessary to have Source, EDM Machine, Quality check of EDM process, 3D Printing machine, scrap drain, finish good drain).

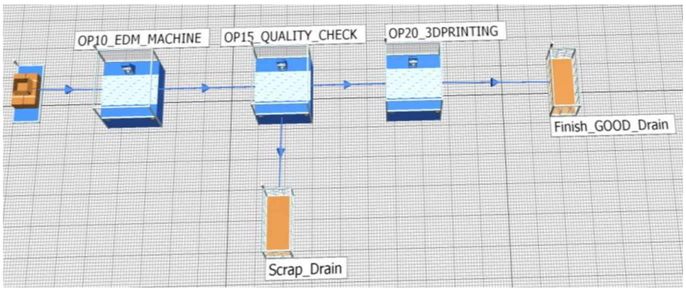

Figure 1 – Factory layout

3.2 Establish the machine parameters

In order to have a reliable simulation, is mandatory to add processing times, availability rate and MTTR (mean time to repair).

Sieamens Plant simulation has the possibility to add this parameter in a table and using a method (write programming code) the user can refer to that table.

The advantage of this set-up is that the parameters are dynamic so can be changed very fast by the user.

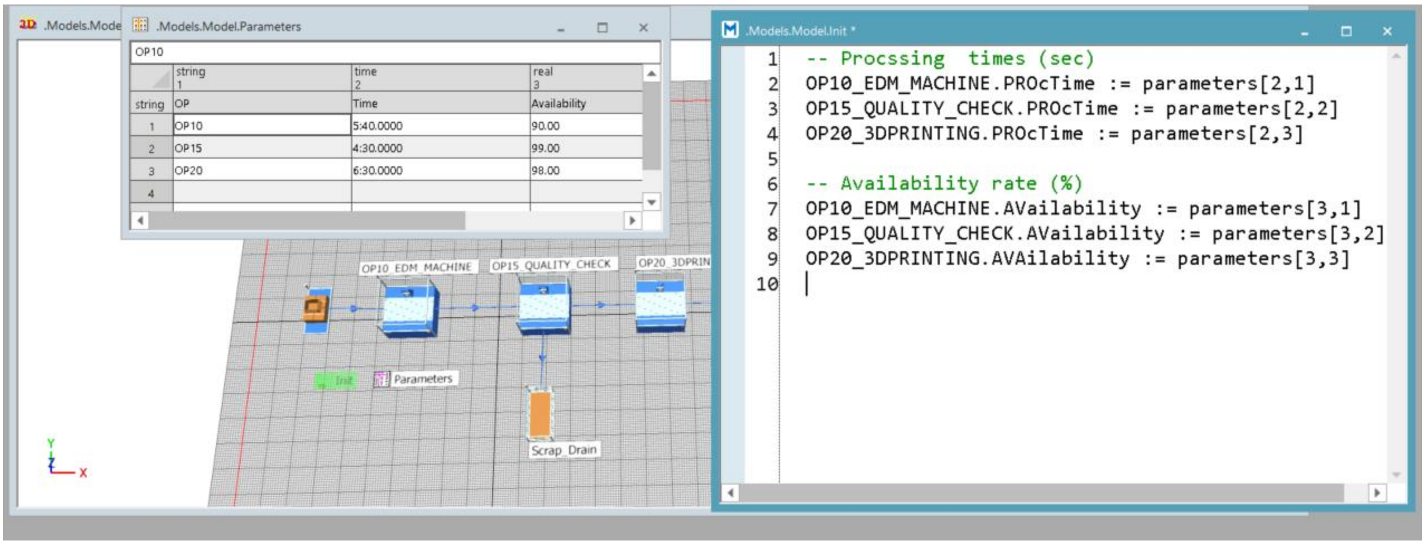

Figure 2 - Dynamic parameters for the process

3.3 Adding workers and workplaces and working times

The next step is to add in the simulation:

Worker_1 for workplace OP 10;

Worker_2 for workplace OP 15 and OP 20.

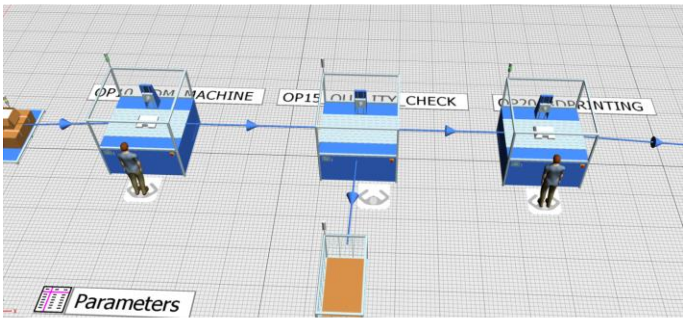

Figure 3 – Workers, Workplace

In table 3, are shown the jobs of a worker but also the cycle times for each.

Table 3. Worker times

Action	Time
Reach workpiece	20 sec
Bring the workpiece	5 sec
Load the workpiece	4
Grip workpiece in the tooling	15 sec
Start the cycle	1
Stop the cycle	1
Unload the workpiece	4
Total	50 sec

4. RESULTS OF THE SIMULATION

After the input parameter had beed added into the software, we are able to run the simulation and check the data generated by the software.

4.1 OP10_EDM_MACHINE

The process was simulated for 8 hours. In this case, for the EDM machine, the software exported the following data presented in the picture 4.

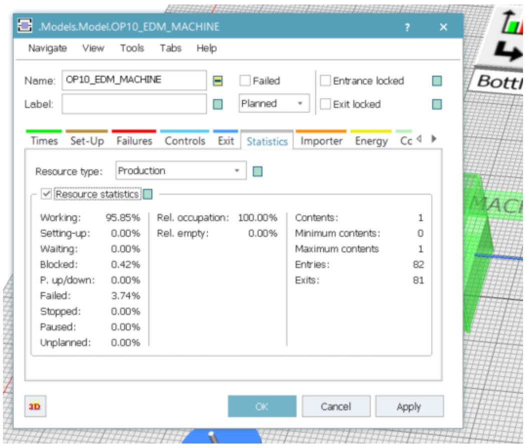

Figure 4 – Data generated for OP10_EDM_MACHINE

We can observe that this station had been worked 95% of the time that happened just because this station has the biggest processing time.
More than that, we have 3.74% line stopped because of the failures.
For this station, we have 3 technical solutions to solve the bottleneck problem:

- Decrease the processing time by increasing the speed of the machine
- Purchase a new EDM machine with better performance
- Assist the EDM process with US to decrease processing time.

4.2 OP15_QULITY_CHECK

OP 15 is called a “Starving Station” because almost 25% percent of the time waited parts from the station 10 (figure 5) . In this case we know that we have a big processing time difference between these two stations

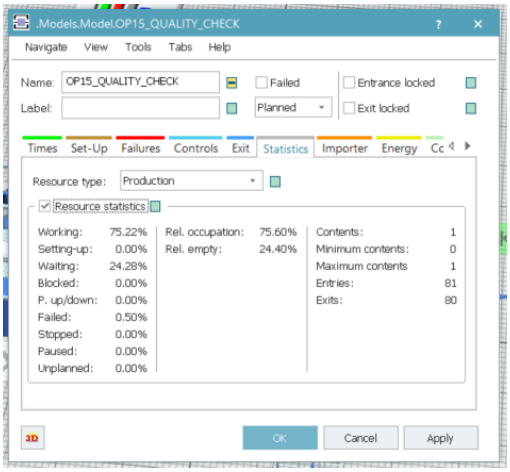

Figure 5 – Data generated for OP15_QUALITY_CHECK

4.3 OP20_3D_PRINTING

The last station, 3d Printing, which have the lowest processing time, we can see that the wainting time is almost double than the OP15. (Figure 6)

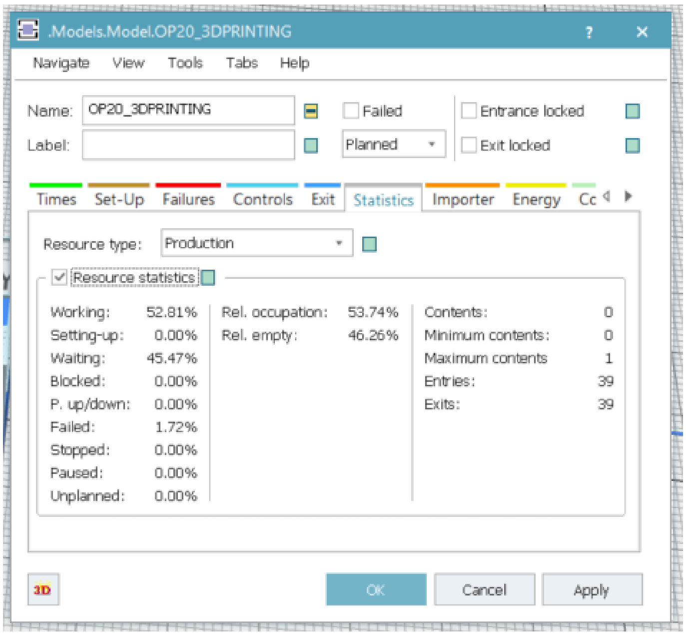

Figure 6 – Data generated for OP20_3D_PRINTING

4.4 FINISH_GOOD_DRAIN

For the final operation of our process, the software generated more data than an ordinary station (figure 7). We can see that in 8 hour of production, we can produce 66 parts with a throughput 8.25 parts/ hour and an average exit interval of 7 minute.

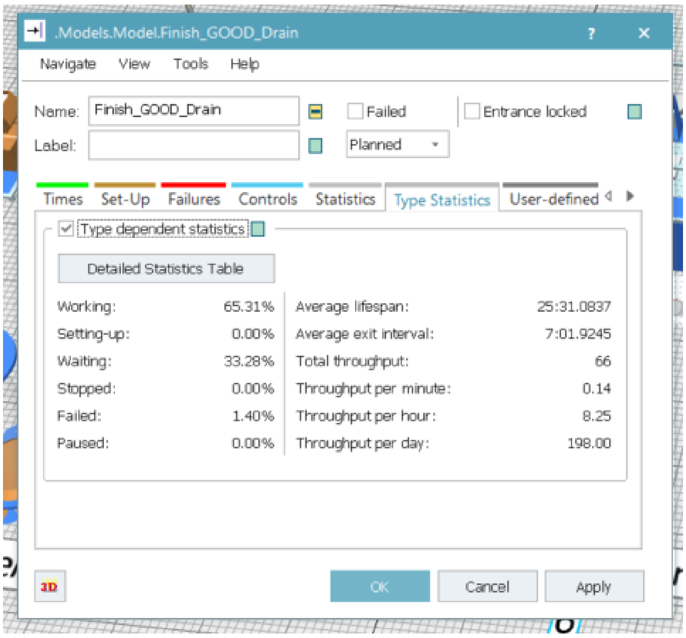

Figure 7 – Data generated for FINISH_GOOD_DRAIN

4.5 WORKERS STATISTICS

For the two workers, we can observe that worker_2, which has two workplaces (OP15 and OP 20) the working time is almost double than worker_1. (fiure 8 and 9)

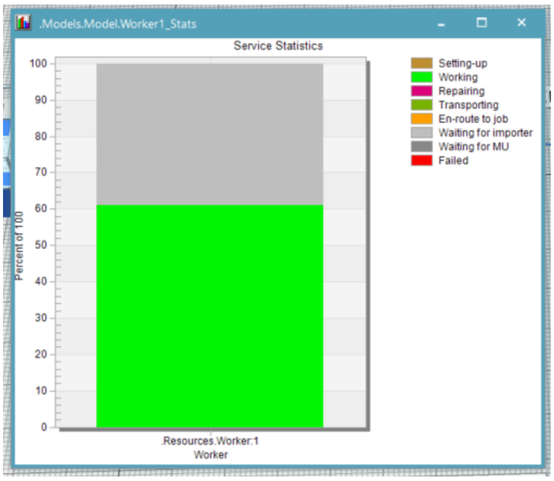

Figure 8 – Worker_1 statistics

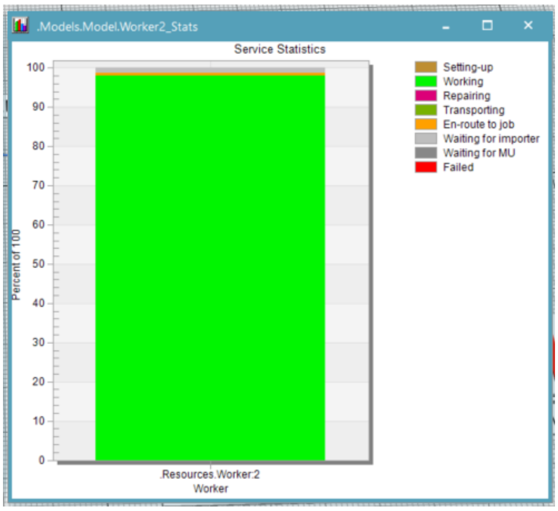

Figure 9 – Worker_2 statistics

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