The use of Tecnomatix software to simulate the manufacturing flows in an industrial enterprise producing hydrostatic components

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Abstract. The analysis performed on manufacturing flows within industrial enterprises producing hydrostatic components was made on a number of factors that influence smooth running of production such as: distance between pieces, waiting time from one surgery to another; time achievement of setups on CNC machines; tool changing in case of a large number of operators and manufacturing complexity of large files [2]. To optimize the manufacturing flow it was used the software Tecnomatix. This software represents a complete portfolio of manufacturing solutions digital manufactured by Siemens. It provides innovation by linking all production methods of a product from process design, process simulation, validation and ending the manufacturing process. Among its many capabilities to create a wide range of simulations, the program offers various demonstrations regarding the behavior manufacturing cycles. This program allows the simulation and optimization of production systems and processes in several areas such as: car suppliers, production of industrial equipment; electronics manufacturing, design and production of aerospace and defense parts.

1. Introduction

Tecnomatix™ is a complete digital manufacturing solutions portfolio realized by Siemens company, that offers innovative solutions by correlating all manufacturing methods for one product – starting from the design process, simulation of the process, validation and ending with the manufacturing process[3]. The simulator helps to create digital models of logistic production systems in order to explore the systems’ characteristics and to optimize their performance [4].

2. Experimental setup

The analysis of the optimization of manufacturing flows was realized within PSAPET PROD COM S.R.L enterprise, in Bacau, that has as main field of activity the manufacturing of hydrostatic assemblies and subassemblies necessary in the aerospace industry.

In order to realize the optimization in terms of times and costs of an assembly’s manufacturing cycle, we started with an initial analysis of the process charts of hydrostatic components.

The analyzed assembly is composed of the following three distinct elements:
- flange 1 pc.
- bushing 1 pc.
- helicoid inserts 9 pcs., 6 pcs M2.5x5 and 3 pcs M3x4, 5, which are supplied by a collaborating company that has the execution of such elements in its activity portfolio.
Each component in the assembly, respectively the flange and bushing are realized on numerical controlled equipment, according to the process charts (table 1, 2, 3, 4, 5, 6 and figures 1 and 2).

2.1. The first simulation
In the optimization analysis of the manufacturing flow using the Tecnomatix program, two series of simulations were realized, the first corresponding to the data in the process chart and the second simulation realized by the attempt to reduce the number of operations, but also the number of operators involved in the assembly’s manufacturing process (tables 7, 8, 9, 10, 11, 12 and figures 3, 4). The two components of the assembly were analysed in parallel.

![Figure 1. Simulation of the flange’s and bushing’s manufacturing cycle.](image)

Table 1. Values registered for the execution time of one flange.

| Operation              | Time | Equipment | Operator |
|------------------------|------|-----------|----------|
| Material acceptance    | 2    | -         | -        |
| Cutting                | -    | 1.30      | 2        |
| Turning setup          | -    | 180       | 180      |
| Turning 1st turn       | -    | 10        | 5        |
| Turning 2nd turn       | -    | 60        | 60       |
| Adjustment             | 2    | -         | -        |
| Wash                   | 1    | -         | -        |
| Final inspection       | 2    | -         | -        |
| Packaging              | 0.25 | -         | -        |
| Storage                | 0.25 | -         | -        |

Starting from the values in this table, registered for the execution of one flange achieving a time for fabrication of 269’80’’. 

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Table 2. Values registered for the execution cost of one flange.

| Operation                  | Cost |
|----------------------------|------|
| Material acceptance [u.m.] | 2    |
| Cutting [u.m.]             | 2    |
| Turning setup 1 [u.m.]     | 360  |
| Turning 1st turn [u.m.]    | 40   |
| Turning setup 2 [u.m.]     | 120  |
| Turning 2nd turn [u.m.]    | 40   |
| Adjustment [u.m.]          | 2    |
| Wash [u.m.]                | 1    |
| Final inspection [u.m.]    | 2    |
| Packanging [u.m.]          | 0.25 |
| Storage [u.m.]             | 0.25 |

Starting from the values in this table, registered for the execution of one flange achieving a cost for fabrication of 789.5 u.m.

Table 3. Values registered for the execution time of one bushing.

| Operation                  | Time | Equipment | Operator |
|----------------------------|------|-----------|----------|
| Material acceptance [min]  | 2    | -         | -        |
| Cutting [min]              | -    | 0.10      | 0.10     |
| Turning setup [min]        | -    | 90        | 90       |
| Turning 1st turn [min]     | -    | 4         | 2.30     |
| Turning setup 2 [min]      | -    | 60        | 60       |
| Turning 2nd turn [min]     | -    | 1         | 1        |
| Adjustment [min]           | 0.50 | -         | -        |
| Wash [min]                 | 0.25 | -         | -        |
| Final inspection [min]     | 0.50 | -         | -        |
| Packanging [min]           | 0.25 | -         | -        |
| Storage [min]              | 0.10 | -         | -        |

Starting from the values in this table, registered for the execution of one bushing achieving a time for fabrication of 162'10".

Table 4. Values registered for the execution cost of one bushing.

| Operation                  | Costs |
|----------------------------|-------|
| Material acceptance [u.m.] | 2     |
| Cutting [u.m.]             | 0.10  |
| Turning setup 1 [u.m.]     | 180   |
| Turning 1st turn [u.m.]    | 13    |
Starting from the values in this table, registered for the execution of one bushing achieving a cost for fabrication of 476.7 u.m.

The values registered following the run of the simulator for the assembling operation, respectively for the final operations, are shown in figure 2 and table 5 and 6.

![Figure 2. Simulation of the assembling operation.](image)

**Table 5.** Values registered over the time for the assembling operation.

| Operation             | Time | Equipment | Operator |
|-----------------------|------|-----------|----------|
| Material acceptance [min] | 2    | -         | -        |
| Assembly [min]        | -    | 0         | 9.50     |
| Turning setup [min]   | -    | 60        | 60       |
| Turning [min]         | -    | 1         | 1        |
| Adjustment [min]      | 6    | -         | -        |
| Wash [min]            | 0.50 | -         | -        |
| Final inspection [min]| 0.50 | -         | -        |
| Packaging [min]       | 0.25 | -         | -        |
| Storage [min]         | 0.10 | -         | -        |

Starting from the values in this table, registered for the execution the assembling achieving a time for fabrication of 80’85”.
Table 6. Values registered over the cost for the assembling operation.

| Operation                  | Costs |
|----------------------------|-------|
| Material acceptance [u.m.] | 2     |
| Assembly [u.m.]            | 35.50 |
| Turning setup 1 [u.m.]     | 60    |
| Turning [u.m.]             | 1     |
| Adjustment [u.m.]          | 6     |
| Wash [u.m.]                | 0.50  |
| Final inspection [u.m.]    | 0.50  |
| Packaging [u.m.]           | 0.25  |
| Storage [u.m.]             | 0.10  |

Starting from the values in this table, registered for the execution the assembling achieving a time for fabrication of 245.85 u.m.

2.2. *The second simulation*

The simulation was realized using the optimized form of the entire manufacturing cycle (the structure of the process chart was modified by cumulating the turning 1 and respectively turning 2 operations in one single operation, one single setting being required, but also by the reduction of the number of operations and personnel. Following these operations, the manufacturing time and costs of the presented assembly were reduced according to tables 7, 8, 9, 10 and 12.

![Simulation of the flange and bushing manufacturing cycle, optimized version.](image)

Table 7. Values registered for the execution of one flange.

| Operation                  | Time | Equipment | Operator |
|----------------------------|------|-----------|----------|
| Material acceptance [min]  | 2    | -         | -        |
| Cutting [min]              | -    | 1.30      | 1        |
| Turning setup [min]        | -    | 200       | 200      |
| Turning 1\(^{st}\)&2\(^{nd}\) turn [min] | -    | 15        | 1        |
Starting from the values in this table, registered for the execution of one flange achieving a time for fabrication of 225'55''.

**Table 8.** Values registered for the execution cost of one flange.

| Operation                | Costs |
|--------------------------|-------|
| Material acceptance [u.m.] | 2     |
| Cutting [u.m.]            | 2     |
| Turning setup 1&2 [u.m.]  | 400   |
| Turning 1\textsuperscript{st} & 2\textsuperscript{nd} turn [u.m.] | 40    |
| Adjustment [u.m.]         | 2     |
| Wash [u.m.]               | 0.5   |
| Final inspection [u.m.]   | 2     |
| Packaging & Storage [u.m.]| 0.25  |

Starting from the values in this table, registered for the execution of one flange achieving a cost for fabrication of 408.75 u.m.

**Table 9.** Values registered for the execution time corresponding to a single bushing.

| Operation                | Time | Equipment | Operator |
|--------------------------|------|-----------|----------|
| Material acceptance [min]| 2    | -         | -        |
| Cutting [min]            | -    | 1         | 0.20     |
| Turning setup [min]      | -    | 90        | 90       |
| Turning 1\textsuperscript{st} & 2\textsuperscript{nd} turn [min]| -    | 5         | 1.50     |
| Adjustment [min]         | 0.50 | -         | -        |
| Wash [min]               | 0.25 | -         | -        |
| Final inspection [min]   | 0.50 | -         | -        |
| Packaging & Storage [min]| 0.10 | -        | -        |

Starting from the values in this table, registered for the execution of a single bushing achieving a time for fabrication of 101'05''.

**Table 10.** Values registered for the execution cost of one bushing.

| Operation                | Costs |
|--------------------------|-------|
| Material acceptance [u.m.] | 2     |
| Cutting [u.m.]            | 0.10  |
| Turning setup 1&2 [u.m.]  | 180   |
| Turning 1\textsuperscript{st} & 2\textsuperscript{nd} turn [u.m.] | 13    |
Adjustment [u.m.] 0.50
Wash [u.m.] 0.25
Final inspection [u.m.] 0.50
Packaging & Storage [u.m.] 0.10

Starting from the values in this table, registered for the execution of a single bushing achieving a cost for fabrication of 266.45 u.m.

Figure 4. Simulation of the assembly operation, optimized version.

| Operation                  | Time | Equipment | Operator |
|----------------------------|------|-----------|----------|
| Material acceptance [min]  | 2    | -         | -        |
| Assembly [min]             | -    | 0         | 9.50     |
| Turning setup [min]        | -    | 60        | 60       |
| Turning [min]              | -    | 1         | 1        |
| Adjustment [min]           | 6    | -         | -        |
| Wash [min]                 | 0.50 | -         | -        |
| Final inspection [min]     | 0.50 | -         | -        |
| Packaging & Storage [min]  | 0.25 | -         | -        |

Starting from the values in this table, registered for the execution of the final operation achieving a time for fabrication of 80’75’’.

| Operation                  | Costs |
|----------------------------|-------|
| Material acceptance [u.m.] | 2     |
| Assembly [u.m.]            | 35.50 |
Turning setup 1 [u.m.]  60
Turning [u.m.]  1
Adjustment [u.m.]  6
Wash [u.m.]  0.50
Final inspection [u.m.]  0.50
Packaging & Storage [u.m.]  0.25

Starting from the values in this table, registered for the execution of the final operation achieving a cost for fabrication of 245.75 u.m.

3. Results
The using new technological documentation with the amendments required in the optimization process, as follows:
- the flange was executed in 4h (initially 5h);
- the bushing was executed in 2h (initially 3h);
- the assembling was conducted in 1.3h, approximately equal to the initial one;
- the entire assembly was realized in 407.35 min /7h (initially 512.75/9h).

4. Conclusions
The optimization of the assembly’s manufacturing flow was realized by the reduction of the number of operations, respectively Turning 1, 2. The Packaging and Storage operations according to the process chart were realized individually, and following the simulation process these operations were cumulated, thus realizing a single adjustment for the turning operation and one single shift for the packaging and storage operation. After completing the simulations, the capability of executing the part in a proportion of 80 % was ascertained, a difference of 20 % remaining for the other related operations such as: adjustment, wash, final inspection, packaging, storage.

For both simulations, the times required for conducting the adjustments to the shifts are taken into account, for manufacturing batches the adjustment is done at the beginning of processing a large number of parts. For the two simulations, one can observe that, the times registered for the assembling operation are approximately equal, since it was only intervened in the amendment of this process by cumulating the packaging and storage operations in one. Comparing the two simulations, one can observe that by using the Tecnomatix program, we managed to optimize the execution time of the entire assembly with a difference of approximately two hours for one single assembly. In case of larger manufacturing batches, this difference is much more visible.

References
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