Research in order to decrease the time manufacturing unit using the combined tools

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\textbf{Abstract.} The work presents the results of the experimental research carried out with the purpose of increasing the productivity of the machining process in the case of a part of the automotive industry. Thus, increasing of volume the parts ordered by the beneficiary, researches have been done for the replacement of simple cutting tools (standards cutting tools) with special cutting tools (combined tools). The use of the combined cutting tools to optimize the productivity of fabrication permitted decrease operative time by reducing the time to change the tools and the machining time. The use of the combined tools allowed machining multiple surfaces. In these circumstances, it was found an improvement in both productivity and quality of the products obtained in the manufacturing process.

1. Introduction
Increasing the productivity, quality of the parts resulting from the cutting operations are important objectives of the modern manufacturing industry. This is emphasized in the specialized literature, thus for machining processes, users should ask the experts, or according experiences, to choose the better CNC machining parameters for different requirements of product. In general, each product has different machining requirement; the milling accuracy and surface quality are usually regarded as performance index of product quality during machining process. This information is also presented in the research paper [1].

The goal of present manufacturing technology is capability to produce parts in a shortest time and most cost effective way [2]. The tool life & tool wear is a major in manufacturing process, is a problem faced by the industry. It has long been recognized that conditions during cutting, should be selected to improve the economics of machining operations, as assessed by productivity, total manufacturing cost per component or some other suitable criterion. These researches are also presented in the paper [3].

In machining processes, it is crucial to ensure good surface finish quality. Improving surface finish has become a major concern especially in mass manufacturing processes where the objective is to achieve final geometry directly.

A major consideration in mass manufacturing processes is that the planning time needs to be substantially reduced so that overall time from design to finished part is also reduced. In traditional computer numerical controlled (CNC) the opposite situation exists, and while machining can be very rapid, the planning process may be complex and time-consuming [4].

2. The process of manufacturing the piece - Disk Limiter. Current state
The Disk Limiter part is made of an aluminum alloy, obtained from a pressure casting process. Figure 1 shows the real model of workpiece Disk Limiter, after the pressure casting process.

![Disk Limiter - real model](image)

**Figure 1.** Disk Limiter – after the pressure casting process a) rear view, b) front view.

An important step in the mass production of this part is mechanical machining operations. The part's execution technology using a CNC machine has been established on the basis of economic criteria, being considered machine tools existing within the company. Taking into account the technical documentation requirements for the CNC processing sequence, this part is performed in three operations, as follows: Operation 10 - OP10 (CNC machining), Assembly (two metal inserts) and Operation 20 - OP20 (CNC machining). Figure 2 shows the drawing of the part, in terms of mechanical machining operations.

![Disc Limiter - drawing](image)

**Figure 2.** Disc Limiter - drawing of the part.
In the execution drawing of the part, we are indicated the deviations of shape and position. The quality of the machined surfaces should be within tolerances inscribed on the drawing, thus the machine surfaces must have a maximum roughness Ra=1.6/0.8 or Ra=0.8/0.8 for each specific surfaces indicated on the drawing. For the shape and positioning of the mechanical machining we have met the requirements, for example: flatness of the machined surfaces of 0.02; the perpendicularity between the machined surfaces of 0.1 or the true position for some surfaces of 0.15.

Operation 10-OP10 and Operation 20-OP20 are machined on the same machine using the same device. In the present stage, the clamping and guiding device is a mechanically actuated device with a position for each operation, as shown in figure 3.

![Figure 3. CNC Mechanical Device.](image3)

![Figure 4. Results of machining time for each tool.](image4)

**Table 1.** Machining operations from the technological machining itinerary

| OP   | Operation                        | Tool   | Machining parameter | Machining time / tool [s] |
|------|----------------------------------|--------|---------------------|--------------------------|
| 10.1 | Roughing the central zone        | T101   | Mill_D20            | 8000/3000                | 5             |
| 10.2 | Rear piece milling               | T7355  | Mill_T Thread-      | 2500/500                 | 9             |
| 10.3 | Thread milling                   | T2410  | mill Dovetail       | 7000/1000                | 11            |
| 10.4 | Chamfer back- thread             | T1645  | cutter Mill_D8      | 7000/1000                | 8             |
| 10.5 | Roughing the hole                | T634   | Reamer_D11.2        | 8000/1500                | 6             |
| 10.6 | Reaming d11.27                   | T7329  | 9 Chamfer_D10       | 1000/2000                | 4             |
| 10.7 | Chamfer hole d11.287             | T7056  | Drill_4.8           | 8000/1500                | 3             |
| **10.8** | Roughing the hole d4.98         | T480   | Reamer_D4.98        | 8000/2500                | 3             |
| **10.9** | Reaming D.4.98                  | T7349  | Drill_D5.5          | 2000/1000                | 3             |
| 20.1 | Drilling D.5.5                   | T526   | Thread_M6           | 10000/3500               | 6             |
| 20.2 | Thread M6                        | T7760  | Mill_D20            | 3000/3000                | 10            |
| **20.3** | External milling D94.8          | T101   | Mill_D8             | 9000/2000                | 22            |
| 20.4 | Milling of metal inserts         | T7338  | Mill_D40            | 4400/560                 | 15            |
| 20.5 | Face milling                     | T1140  | Chamfer_D6          | 12000/4000               | 15            |
| 20.6 | Marking part                     | T6063  |                     | 6000/1500                | 15            |

Machining time [s] 135
Total time /OP10 [s] 52
Total time /OP20 [s] 83
According to the technological flow shown in table 1, comprising a part processing sequence, the total time of these operations is 63 seconds. The total machining time of the piece, including other machining operations, is 135 seconds.

3. The proposed version of the execution parts - CNC mechanical machining

A first way to improve the machining process, in terms of productivity, was to use combined tools specific to this part. The new technological flow has reduced the machining time. For the machining phases: rear milling, prehole for thread milling, roughing hole d11.287, finishing hole d11.287 and chamfering hole d11.287, a combined tool (figure 5) was designed and was made [6]. The new tool, T7481 SpecialToolOP101, is based on a steel body tool and is made of two active cutting edges, both PCD-brazed [8].

The new proposed tool will achieve the finishing of the D11.287 cast hole, this being accomplished by single passage, (see figure 6). After exiting this hole, the tool will position in center and finish the hole D26mm for prehole M27x1, as shown in figure 7, then will do the rear milling along with the chamfer behind the M27X1 thread, as seen in figure 8.

Another improvement from the point of view of the efficiency of the mechanical processing is the realization of the phases: d4.98 hole bore, hole d4.98 drilling and d94.8 external milling with a combined tool. Figure 9 shows the body of the T7449 SpecialToolOP102 tool.
In the mass production, for this part, we replaced the tools: T101-Mill_D20, T480-Drill D4.8 and T7349-Reamer D4.98 with T7449_SpecialToolOP102. In this situation, the machining time and the cost of the tooling are reduced. As can be seen in figure 10, this combined tool makes the D4.98 hole, in one pass, on the front of the piece. Figure 11 shows the T7449 Milling Cutter SpecialToolOP102 performs the outer diameter finishing and chamfering operation with PCD pads mounted mechanically on the two teeth of the special tool.

This special tool, the T7449 SpecialToolOP102, dedicated to this product, consists of the milling cutter assembly on which two PCD Inserts (2 teeths x 2 PCD Inserts = 4PCD Inserts) are radially secured [8]. In the central area of this body of the tool is attached the Reamer-D4.98 in the attachment area on the milling body.

For the new machining sequences, with the new tools proposed (standard and combined tools) and the new cutting regimes for each tool, the CNC machining time was calculated. Table 2 shows the new machining time using the two proposed combined tools to improve surface quality and reduce machining time. This work refers only to the processing time not including the service times of the machine and the times of loading and unloading of the parts. Thus, the new CNC machining time for the operations we used these two combined tools is 45 seconds. The unit time saved using these two combined tools is 47 seconds. Total machining time, including the new combined tools, for this piece is 88 seconds.
Table 2. New machining operations using combined tools

| OP | Operation                   | Tool              | Machining parameter | Machining time / tool [s] |
|----|-----------------------------|-------------------|---------------------|--------------------------|
| 10.1 | Roughing the central zone | T7481 Special tool_op101 | 6000/2000 | 24 |
| 10.2 | Rear piece milling         |                   |                     |                          |
| 10.3 | Chamfer back-thread        |                   |                     |                          |
| 10.4 | Roughing the hole d11.287 |                   |                     |                          |
| 10.5 | Reaming d11.287            |                   |                     |                          |
| 10.6 | Chamfer hole d11.287       |                   |                     |                          |
| 10.7 | Roughing the hole d4.98    |                   |                     |                          |
| 10.8 | Reaming d4.98              | T7449 Special tool_op102 | 6000/1500 | 21 |
| 10.9 | External milling D94.8     |                   |                     |                          |
| 10.11 | Thread milling D5.5        | T2410 Thread-mill | 7000/1000 | 8 |
| 10.12 | Thread M6                 | T7676 Thread_M6   | 3000/3000 | 9 |
| 20.1 | Check part position        | Probe Tool probe  | 0/500               | 3 |
| 20.2 | Milling of metal inserts   | T7338 Mill_D8     | 4400/750            | 8 |
| 20.3 | Face milling               | T1140 Mill_D40    | 12000/3000          | 7 |
| 20.4 | Marking part               | T1116 Tool marking | 5000/1000          | 3 |

Machining time [s] 88
Total time /OP10 [s] 67
Total time /OP20 [s] 21

The new machining times for the two combined tools are determined by simulating and running the new NC program on the numerical control center. Running the new program on the numeric control center provides real time machining time, which is defined by the tools geometry, the length of the machining paths, the machining parameter, the acceleration and deceleration times.

Analyzing the unit processing time obtained with the new tools used (standard tools and combined tools), it was observed that the machining time was reduced.

4. Conclusions

The paper presents the results of the researches carried out in order to increase the productivity and the quality of execution of a part of the automotive industry.

The simplest "improving" procedure is "intuitive improvement", which consists in making models of alternative solutions to the structure and - by repeated attempts - to get an optimal variant of it. The process is empirical and does not necessarily lead to the best possible solution.

In order to design and build the combined tools, the same problems as for any cutting tool are to be solved. Among these problems are: choice of tool types and cutting scheme; choice of load distribution scheme (forces and moments); choosing the material of the active parts and the body; fixation of angles of active parts (cutting); determining the sharpening scheme; calculating the dimensions and shapes of the edges; providing space for chip removal; heat removal from the edges; ensuring shearing; providing mechanical strength and rigidity.

Improving a process is essentially a scientific option and consists of systematically designing and classifying the possible solutions to an engineering problem. The ultimate goal of improving is to select
the solution that, within a reference framework defined by the conditions allowed or initially imposed, leads to the most advantageous use of the resources available to materialize it.

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