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## RESEARCH ON HOLES FINISHING OPERATIONS PERFORMANCE BY CUTTING

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*Abstract:* To finish bores there are several modalities or processing strategies from which the operator can choose one or the other depending on the facilities there. The problem that arises is to choose the optimal variant when existing equipment allows you to choose between two or more possible strategies. This article studies four types of strategies for precise holes finishing and establishes the advantages and disadvantages of each, considering two variables: precise holes quality and the strategy cost.

*Key words:* cutting, finish boring, helical finishing, reaming,

### 1. INTRODUCTION

The precise holes are interior revolution surfaces which are different to holes by being made to a much better accuracy, having small error shape (which are standard) and surface quality is high. The precise holes making process includes two phases. In the first phase a hole is made, then with a final finishing operation, the precise hole is obtained. Basically, this finishing operation consist in improving holes dimensional accuracy, shape error, position error and surface quality.[1]

Precise holes quality is very important in practice because of this depends the functionality and reliability of products that use precise holes as functional surfaces. The precise hole quality relates to four aspects, namely: dimensional accuracy, position accuracy, shape accuracy and surface quality.

The precise holes can be divided by their functional role into two categories: static role bores (used to position and orientation of certain parts of each other) and dynamic role bores (used in mobile assembling in which one or more pieces moves through the precise hole). In the case of static role bores, the dimensional and position accuracy is very important. In the case of dynamic role bores, in addition to

dimensional and precision accuracy, it is also very important the surface quality.

Usually holes are processed in several ways, and choosing the appropriate operation is done taking into account the bore diameter, the surface quality to be obtained, the shape accuracy, the material workability and the existing facilities.

The most used ways of finishing the bores are finishing reamer, head boring finishing, end mill, etc.

In the specialized literature there are a number of papers which conclude that one or other finishing methods as recommended. Thus [2], [3], [4] were obtained using helical milling precision holes are of H7 quality and a surface finish of 0.3 $\mu$ m Ra.

In this article are analyzed, in terms of quality, all three finishing ways listed above and is aimed at determining the optimum processing ways depending on several aspects such as shape accuracy, dimensional accuracy, position accuracy, surface quality, production volume, processing time and cost.

### 2. THEORETICAL CONSIDERATIONS ABOUT USED STRATEGYS OF MANUFACTURING

In this article are presented three precise holes finishing possibilities namely using reamer, the boring barriers and the cutter. For milling finishing are used two processing strategies: conventional milling and helical milling. Figure 1 shows schematically, the kinematic point of view, the working mode that has been used as a strategy for processing the bore.

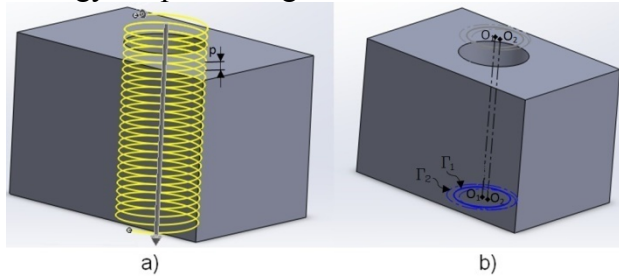


Fig. 1. Finishing strategy use to manufacturing

In figure 1a) is shown the movement of a point on the tool surface with a given pitch  $p$ , along a helix. This processing strategy was used in the processing with head boring, reamer and helical milling hole.

Figure 1b) shows the processing mode using milling profile strategy. This strategy is most commonly used in the industry. Processing consists of positioning the end mill on  $O1-O1$  axis, that moves on  $O2-O2$  axis such that  $\Gamma_1$  curve, materialized by cutter diameter, to move on  $\Gamma_2$  curve materialized by the end of the bore diameter. The two curves are tangent to each other.

### 3. EXPERIMENTAL RESEARCH

#### 3.1 Experimental design

The experiment consisted of two parts processing of AW7075 (aluminum alloy) whose drawings are shown in Figure 2.

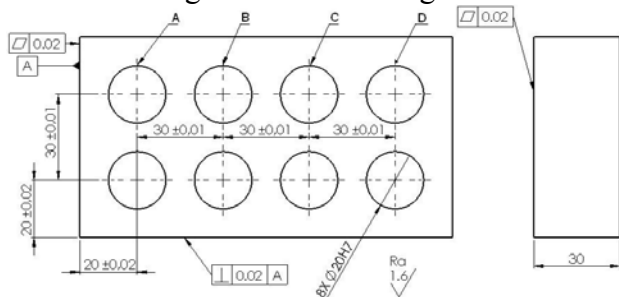


Fig. 2. Drawing of the test part

On each piece, the holes pairs A-D were processed as follows:

- A - helical milling hole strategy;
- B – profile milling strategy;
- C – with head boring;
- D – with reamer.

First part finishing was processed after drilling at  $\text{Ø}19.8$  mm followed by getting  $\text{Ø}20\text{H}7$  dimension with a single pass of the tool.

Finishing the second part was processed after drilling to  $\text{Ø}19.8$  mm followed by getting the dimensions of  $\text{Ø}20\text{H}7$  with two passes. These two parts were processed to determine the influence of passes number over the bores quality.

#### 3.2 Equipment

For conducting experiments and measuring the quality of machined surfaces we have used these equipment:

- Vertical machining center (VMC);
- Milling machine FUS 25;
- AW7075 aluminum alloy;
- TRM50/50 Boring head Testarossa D’Andrea;
- HSS Reamer for  $\text{Ø}20\text{H}7$ ;
- Rough mill,  $\text{Ø}16$ ,  $z=2$  mm;
- Drill  $\text{Ø}16.5$  mm;
- Solid carbide end mill,  $\text{Ø}16$ ,  $z=4$  mm;

¶ As working regime were used the values that are presented in Table 1:

Table 1

Parameters of cutting bores.

| Method          | Feed     | Spin      | Tooling allowance |
|-----------------|----------|-----------|-------------------|
|                 | [mm/min] | [rev/min] | [mm]              |
| Helical milling | 1000     | 2500      | 0.02              |
| Contour milling | 400      | 2500      | 0.02              |
| Head boring     | 120      | 2800      | 0.02              |
| Reaming         | 160      | 80        | 0.02              |

#### 3.3 Measurement strategy

The measurements were done using a Zeiss Prismo CMM equipped with a VAST Gold sensor and a 5 mm sphere tipped ruby stylus.

Two different measurement strategies were used for the each work piece. Firstly three planes were measured (one at the top, one at the middle and one at the bottom) of each hole. For each hole the diameter, circularity and position

were measured. After that, the cylindricity was measured using a spiral path. The holes were numbered A through D from left to right and 1 and two from bottom up.

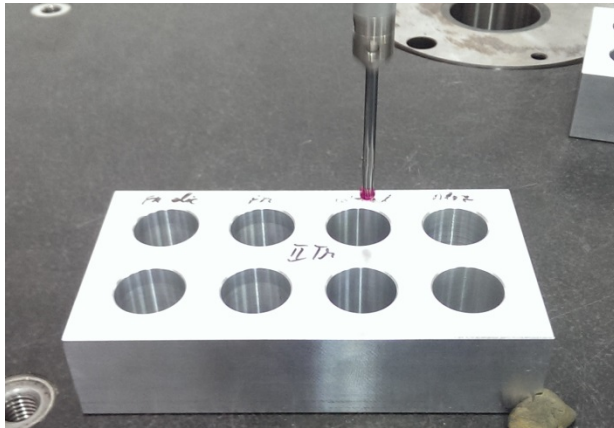


Fig. 3. The measurement process

The difference in diameter for each method used can be seen on the graph in Figure 4.

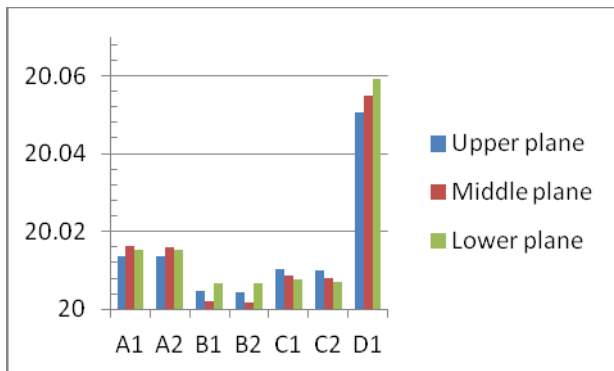


Fig. 4. The different diameter values

The circularity on the three planes varies in accordance with the graph in Figure 5.

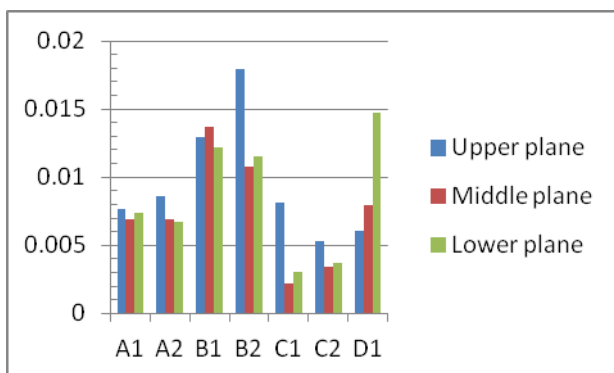


Fig. 5. The circularity for each hole

The cylindricity was measured with a spiral path and the results for each hole are shown in Figure 6.

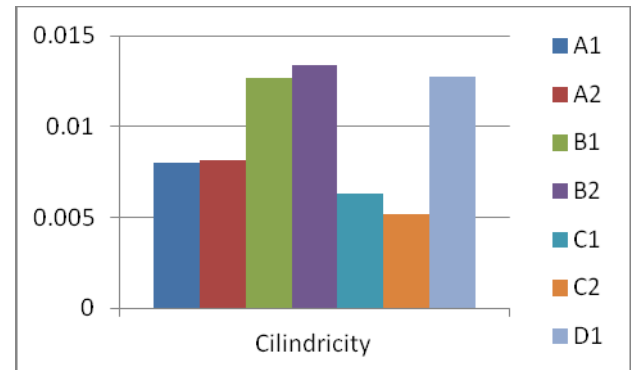


Fig. 6. The cylindricity for each hole

#### 4. DISCUSSION OF THE RESULTS

Seeing that the set machining value was of 20,01 mm the best dimensional result is obtained using the boring bar. As seen in the graph, the precision decreases slightly as the bar progresses through the hole. Similarly good results can be obtained with either standard or helical milling. The biggest deviation was obtained by using a reamer.

The best circularity and cylindricity were also obtained by using the boring bar. But in this case we can see that the circularity improves as the tool progresses through the work piece.

The first three set of holes were machined on the VMC and the last set on a FUS 25. Because of that the last set is excluded as it might introduce too many variables.

#### 5. CONCLUSIONS

This paper analyzed four finishing methods for holes in order to establish which of them provides the best results.

From the obtained results the following conclusions can be drawn:

- The most precise method of machining from a dimensional point of view is with the boring bar;
- Still, while using the boring bar, the dimensional precision worsens as the hole gets deeper;

- To be able to machine holes in a H7 class of precision, helical and contour milling can also be used;
- The milling finishing method is recommended in the case of deep holes because the form precision is better than the one obtained with a boring bar;
- When machining holes with a diameter larger than Ø10 mm, machining with a boring bar or milling is recommended because CNC machines can correct radii which allows an additional adjustment of the tool edge on the machined surface;
- Because of the reamers rigidity, it's use is recommended for holes with a diameter less than Ø10 mm, where better results are obtained.

From an economic point of view, when there is no boring bar available it is recommended that machining be done with a mill. If minimal time is required, the reamer can also be used for surface finishing instead of milling.

Considering the conclusions presented above, it can be said that the optimal machining method can be chosen taking into account the dimension of the machined hole, the tools that are available and the time necessary for the operation.

## 6. ACKNOWLEDGEMENTS

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### Cercetari privind performantele strategiilor de finisare a alezajelor prin aschiere

**Abstract:** Pentru finisarea alezajelor exista mai multe modalitati sau strategii de prelucrare dintre care operatorul poate sa aleaga una sau alta in functie de dotariile care exista. Problema care se pune este de a alege varianta optima atunci cand dotarea existent iti permite sa alegi dintre doua sau mai multe strategii posibile. Acest articol studiaza patru tipuri de strategii de finisare a alezajelor si stabileste avantajele si dezavantajele fiecareia, tinand cont de doua variabile: calitatea alezajelor si pretul de cost al strategiei.

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