Modeling of deviations on machined surfaces

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ABSTRACT

To obtain imposed dimensional and geometrical specifications for any mechanical piece, production tolerances must be calculated. So a simulation of workpiece behavior, when it is machined, has permitted to calculate deviations on machined surfaces.
The method of deviation calculation is based on a comparison between imposed functional tolerance and the tolerance calculated in relation to deviations on two machined surfaces or between a machined surface and the operational datum.
The one direction modeling of deviations inquires practical inputs such as the planning process, the operational datum and deviations on surface datum for any stage of machining.
The developed method allows to determine the deviations on machined surfaces. Then, tolerances on production dimensions were calculated in three directions. These results have permitted to define average production dimensions, which may be used for NC machine programming and to prepare an optimal rough piece configuration.
The developed method has been applied for the machining of an axis.

***Keywords**: manufacturing, machining, deviation modeling, dimensions, tolerances.*

1. Introduction

Improving quality and reducing cycle time and cost are the main objective for competitive manufacturing. These objectives can be achieved partially by the optimisation of rough dimensions. This latter depends on the manufacturing tolerances which are a result of the deviations on machined surfaces.
To calculate deviations on machined surfaces, researches have developed different methods. Some researches /1/ proposed a state space model which describes the dimensional variation propagation of multistage machining process. To represent the geometric deviation of the workpiece, they use the differential motion vector which is a concept from the robotic field.
An other analysis method is proposed by Musa and Huang /2/. It is based on Monte Carlo simulation. The idea of this simulation is to represent the features of interest by samples points. The part is then virtually machined and inspected according to the standard CMM (coordinate measuring machine) inspection procedures by tracking the spatial changes of the features.
Tolerance results from both process tolerance and the tolerance stack up /3/. The latter is the accumulation of error in a dimension between features resulting from taking operational datum that are different from the ones indicated in the design specifications /4/. Indeed, in practice, due to economic reasons, design datum are not always used as

Stage 1: Figure 9.

$$MD_{19} = 161^{+0.17}_{-0.83}\ mm$$

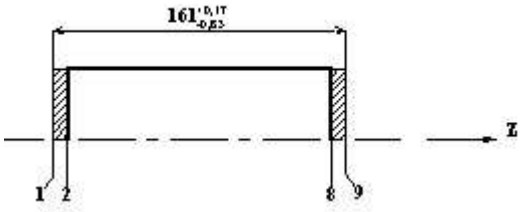

Figure 8. *Manufacturing dimensions Stage 1*

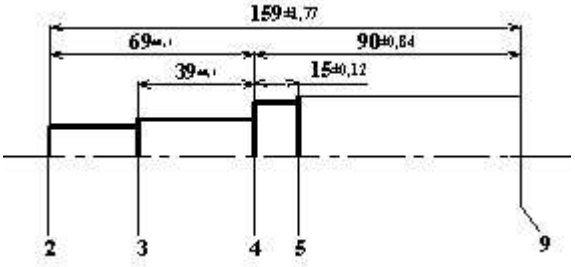

Figure 9. *Manufacturing dimensions Stage 2*

Stage 2: Figure 10.

$$MD_{24} = 69^{\pm 1}\ mm$$

$$MD_{34} = 39^{\pm 1}\ mm$$

$$MD_{45} = 15^{\pm 0.12}\ mm$$

$$MD_{29} = 159^{\pm 1.77}\ mm$$

$$MD_{49} = 90^{\pm 0.84}\ mm$$

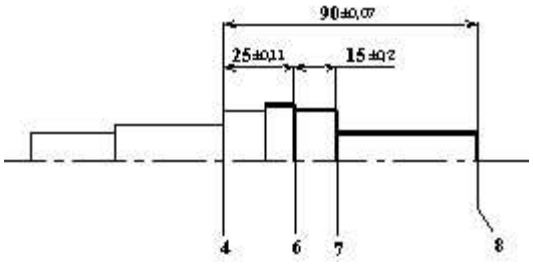

Figure 10. *Manufacturing dimensions Stage 3*

Stage 3: Figure 11.

$$MD_{48} = 90^{\pm 0.07}\ mm$$

$$MD_{46} = 25^{\pm 0.11}\ mm$$

$$MD_{67} = 15^{\pm 0.2}\ mm$$

6. Conclusions

The calculation method of deviations leads to the optimisation of the deviations on machined surfaces and then to minimisation of the rough dimensions. Then, for serial production, the use of this method allows to minimise the cost of the pieces, which is one of the most important objectives for manufacturing industries. So, from this study, the following conclusions can be drawn:

- The calculation of deviations or errors on machined surfaces.
- The calculation of average cutting width.
- The determination of manufacturing dimensions, which will be used for NC machine programming.
- The calculation of 3D rough piece dimensions.

Also, all these results, may lead to minimise the number of rejected pieces and so to reduce the machining cost.

References

1. S. Zhou, Q. Huang, and J. Shi, “State space modeling of dimensional variation propagation in multistage machining process using differential motion vectors”, IEEE