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Thermal Deformation Study of a Main Spindle System for a CNC Lathe Machine

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Abstract: The objective of this paper is to reveal the possibility of new technologies in FEA, to optimize the manufacturing process – in this case the turning process. In this study we considered that only the gear box of the main spindle system is loaded from the temperature of 20ºC to 65ºC or more during the working process. All the rest factors (like heat generation in moving parts, heat generation in electrical motors, heat generation in cutting process, external heat generation) we considered are constant. In this case, we study the effect of the temperature to conduct the design for a new CNC lathe machine.

1. Introduction

Modern machine tools must provide high precision machining capability and also high productivity. The entire machine tool is affected by the thermal deformation during the work time, but in particular the main spindle system is the mainly important component in the machine structure [22]. The main spindle system direct affect machining accuracy and – most important – the productivity of the production system. The thermal deformation of the main spindle system can influence also the speed rotation, so, controlling and measuring the thermal deformation is the most important theme to solve for the machine tool designer and also for the industrial engineer who use this equipment on the workshop.

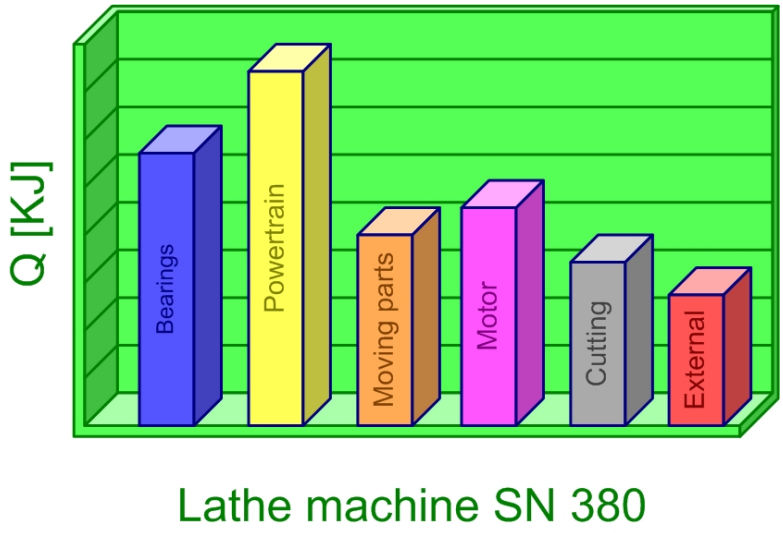

Figure 1

The thermal deformation of the main spindle system depends on the spindle itself and also of the thermal deformation for each component of the machine tool. These deformations depend on internal heat sources in a machine tool. Temperature distribution in the structures and the resulting heat flow will affect each component. These complex thermal behaviors are sources of heat generation [2]:

- heat generation in bearings
- heat generation in power train
- heat generation in moving parts
- heat generation in electrical motors
- heat generation in cutting process

- external heat generation

Figure 1 show these sources of heat generation in the case of a conventional (manual) lathe machine SN 380 made in Romania. For this machine tool we have done the FEA study, and after the calibration process we will apply the results for a new CNC lathe machine.

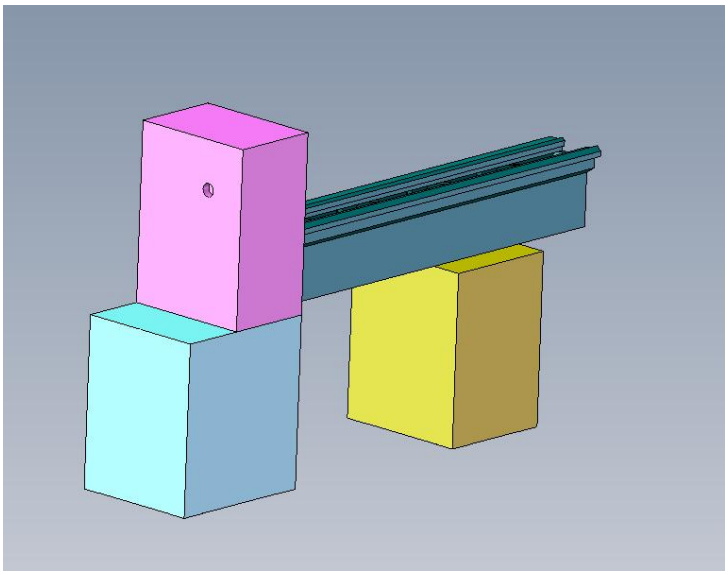

Figure 2

2. FEA thermal study for the main spindle system of a lathe machine tool

At the moment, the most software applications available in Finite Element Method (FEM) domain are capable to resolve thermal studies to find geometrical differences between the theoretical machine tool (at workshop temperature of 20ºC) and the shape of machine tool during the turning process.

The starting lathe machine was created as a 3D model in SolidWorks® 2007. In figure number 2 we show only the main assembly components – like the lathe bed, gear box, and the rest of the structure components.

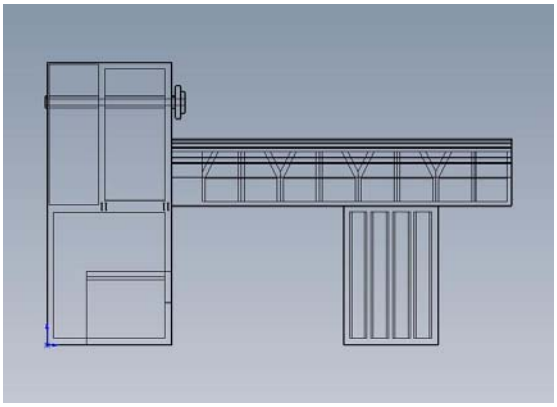

Figure 3

In figure number 3 we can show in wireframe the entire model prepared for thermal study in CosmosWorks® 2007.

As is presented in Table 1, we divided the machine tool in three large parts and assumed that all parts are made from gray cast iron.

We consider that we can base our design decisions solely on the data presented in this study, because we use this information in conjunction with experimental data and our practical experience. Therefore, field testing is mandatory to validate your final design. COSMOSWorks helps only to reduce the time-to-market by reducing but not eliminating field tests.

Table 1

No.	Part Name	Material	Mass	Volume
1	Strung	Gray Cast Iron (SN)	1645.97 kg	0.228607 m^3
2	Strung	Gray Cast Iron (SN)	1645.97 kg	0.228607 m^3
3	Strung	Gray Cast Iron (SN)	1645.97 kg	0.228607 m^3

As a Load & Restraint information, we considered Restraint on 8 faces) fixed, load temperature on 6 faces with temperature 65º Celsius. As a Study Property, the Mesh Type = Solid mesh, Mesher Used = Standard, Automatic Transition = Off, Smooth Surface = On,

Jacobian Check = 4 Points, Element Size = 45.097 mm, Tolerance = 2.2548 mm, Quality = High, Number of elements = 41142, Number of nodes = 75139.

Also, the solver information Quality = High, Solver Type = FFEPlus, Option = Include Thermal Effects, Thermal Option = Input Temperature, Thermal Option = Reference Temperature at zero strain: 298 Kelvin, Contact state = Touching faces - Bonded

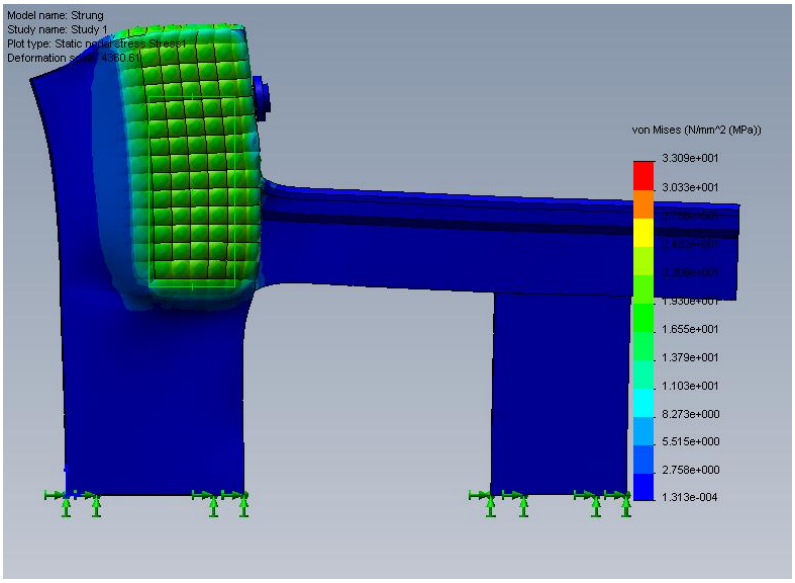

Figure 4

3. Conclusions

The results of this study are presented in figures number 4 and 5. Figure 4 shows the stress of the entire machine tool caused by the thermal deformation of the gear box which includes the main spindle system. . Figure 5 shows the displacement of the entire machine tool caused also by the thermal deformation of the gear box which includes the main spindle system. Using these results we can develop a new machine tool with CNC. The deformation main spindle system direct affect machining accuracy and – most important – the productivity of the production system can be minimized if the study is accurate and calibrated with correct measurements.

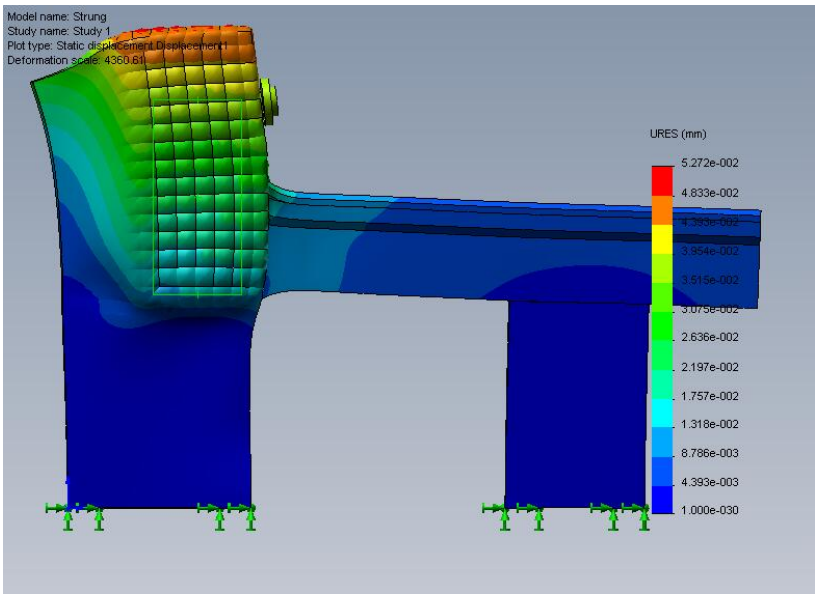

Figure 5

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