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STRESSTECH BULLETIN 8

Material removal process during residual stress depth profile measurement

Machining Residual Stresses

Residual stresses are induced during the machining due to mechanical, thermal or chemical factors. They may lead to lower fatigue life hence they should be analyzed and controlled.

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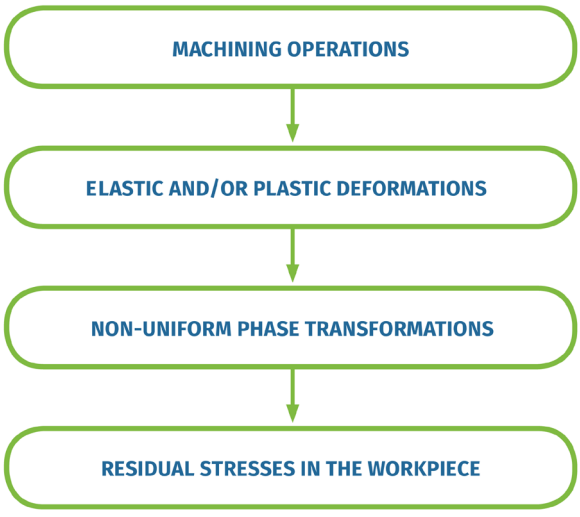
Machining is the general term for turning, milling, drilling, planing and grinding. The common point of these applications is the cutting process that heats the surface of the material due to the friction and forms chips. The figure on the right shows the process steps in machining operations that form residual stresses.

The existing residual stress state of the component may be changed due to mechanical, thermal, or chemical factors. The mechanical factor is the material removal process itself, the thermal factor is the work done by friction, and the chemical factor is the possible reactions caused by cutting fluids.

Mechanical effects of the machining processes change the surface finish and microstructure. Plastic deformations are observed as well.



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Thermal effects are created by the process causing a change in the dislocation density and distribution as well as surface integrity. In addition, pressure and the temperature of the cooling are important effects which contribute to formation of residual stresses.

The combination of these effects together with other parameters of the machining may form cracks on the surface of the component. The cracks are the consequence of residual stresses which are formed because of plastic deformation and possible phase changes. Phase changes are caused by local heating. Local heat increases due to friction and other abrasive effects of the machining. Tensile residual stresses are formed partially because of local heating. Machining residual stresses affect the reliability and lifetime of the component.

Machining residual stresses are affected by thermal and mechanical factors. Usually, surface and near-surface layers of the component are affected by both thermal, and mechanical factors, and subsurface layers are affected by mechanical factors only.

Milling is another common chip-forming machining process which induces residual stresses on the workpiece. It's known that when a plain carbon steel milled in different ways, the resultant residual stress depth profiles could be different, depending on the way of milling.

It is also known that the changes in cutting speeds would change the residual stress depth profiles. Usually, the lowest cutting speed also produces the lowest residual stress and the highest cutting speed which causes a temperature increase between the tool and workpiece produces the highest residual stress on workpiece.

Residual stresses induced during the machining operations can lead to lower fatigue life hence they should be analyzed and controlled. It should be also noted that in practice, various machining operations could be used together. Even though different processes will induce their own residual stress profiles on the workpieces, it is common that the very last machining operation's residual stress profile will be dominant.

Stresstech is a research-oriented company with 34 years' experience in residual stress engineering. Feel free to contact us to learn more about residual stresses and their measurements.

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Sources

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