Craftsman's Cribsheet

NUMBER 15

Miles Free – Director of Technology and Research

☒ Technical ☐ Regulatory ☐ Quality ☐ Management

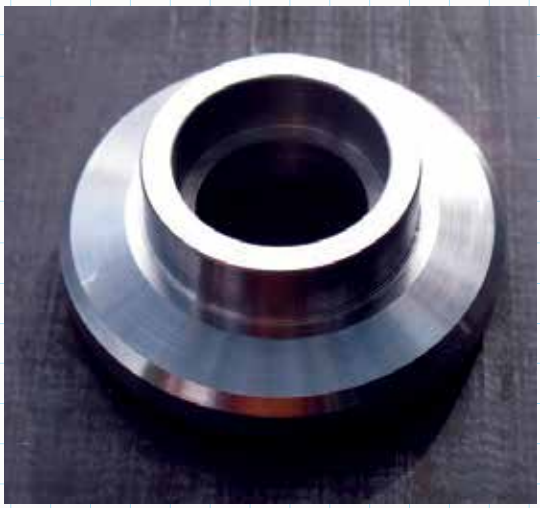
DISTORTION IN HEAT TREATMENT

There are two kinds of distortion that can result from a heat-treating process in steel: dimensional distortion and shape distortion.

Dimensional Distortion can take place upon heating when steel parts change volume as they change crystal structure. When heated parts are quenched, their internal crystal structure changes again. When the quenched parts are tempered, the resulting volume change may not be sufficient to offset the changes from the prior heating and transformations. This change of volume can cause dimensional distortion.

The rule of thumb that I have used for medium carbon alloy steels is to expect a change in linear dimensions of about 0.125% maximum. That is, one eighth of a percent of the linear dimensions could be the change encountered from heat treatment and quench. It generally is less, but 0.125% gives me a rule of thumb to evaluate capability to hold dimensions after heat treat.

Shape Distortion (warpage) as a result of heat treatment is a result of processing or design issues rather than the expected phase changes of the material.



8 reasons steel parts can warp upon quench and tempering:

1. Rapid heating
2. Overheating
3. Non-uniform heating
4. Non-uniform cooling
5. Non-uniform agitation
6. Water contamination in oil
7. Large changes of mass and section
8. Asymmetric features

Rapid heating can cause stresses to develop in parts due to excessive temperature gradients. **Overheating** similarly lowers mechanical properties, potentially leading to parts sagging or creeping depending on orientation in the furnace. **Non-uniform heating** also creates differences in properties within the parts as well as leading to incomplete transformation products or hybrid structures upon quenching. **Non-uniform cooling** allows unbalanced stresses to develop during the quench, as does **non-uniform agitation** of quench medium. Often non-uniform heating or cooling result from the way parts are stacked or piled in the basket or on the belt such that gradients of temperature are created. **Water contamination in oil** is difficult to figure out, but in addition to warped parts, inconsistent hardness readings between parts or on the same part are a sign of this. Parts with **large section changes** or that have **asymmetric features** are also more likely to warp than parts with balanced and uniformly distributed mass, regardless of process control.

Choosing steels with higher hardenability (alloys rather than plain carbon steels), finer grain size and paying attention to the details of loading, time at temperature and quenchant delivery are all steps that can minimize shape distortion, even when part design is less than optimum.