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The Importance of Normalizing

"Why bother normalizing?" is a question frequently asked of The Doctor. Why indeed? Let's learn more.

Why Normalize?

Normalizing imparts both hardness and strength to iron and steel components. In addition, normalizing helps reduce internal stresses (Fig. 1) induced by such operations as forging, casting, machining, forming or welding. Normalizing also improves microstructural homogeneity and response to heat treatment

(e.g. annealing or hardening) and enhances stability by imparting a "thermal memory" for subsequent lower-temperature processes. Parts that require maximum toughness and those subjected to impact are often normalized. When large cross sections are normalized, they are also tempered to further reduce stress and more closely control mechanical properties.

Normalizing is typically performed in order to:

- Improve machinability
- Improve dimensional stability
- Modify and/or refine the grain structure
- Produce a homogeneous microstructure
- Reduce banding
- Improve ductility
- Provide a more consistent response when hardening or case hardening

By way of example, many gear blanks are normalized prior to machining so that during subsequent hardening or case hardening dimensional changes such as growth, shrinkage or warpage will be better controlled.

Soak periods for normalizing are typically one hour per inch of cross-sectional area but not less than two hours at temperature. It is important to remember that the mass of the part or the workload can have a significant influence on the cooling rate and thus on the resulting microstructure. Thin pieces cool faster and are harder after normalizing than thicker ones. By contrast, after furnace cooling in an annealing process, the hardness of the thin and thicker sections are about the same.

Low-carbon steels typically do not require normalizing. If these steels are normalized, however, no harmful effects result. Castings with relatively uniform wall thickness and section sizes are usually annealed rather than normalized. Other castings, especially those having a complex shape or interconnected thick and thin sections and are thus prone to high levels of residual stresses, benefit from normalizing. The microstructure obtained by normalizing depends on the composition of the castings (which dictates its hardenability) and the cooling rate.

How it Works

The normalizing of steel (Fig. 2) is carried out by heating approximately 100°F (38°F) above the upper critical temperature (Ac_3 or Acm) followed by cooling in air to room temperature, or at no greater than one-bar pressure using nitrogen if the process is being run in a vacuum furnace.

Normalizing is often considered from both a thermal and a microstructural standpoint. In the thermal sense, normalizing is austenitizing followed by a relatively slow cool. In the microstructural sense, the areas of the microstructure that contain about 0.80% carbon are pearlitic, while areas of low carbon are ferritic.

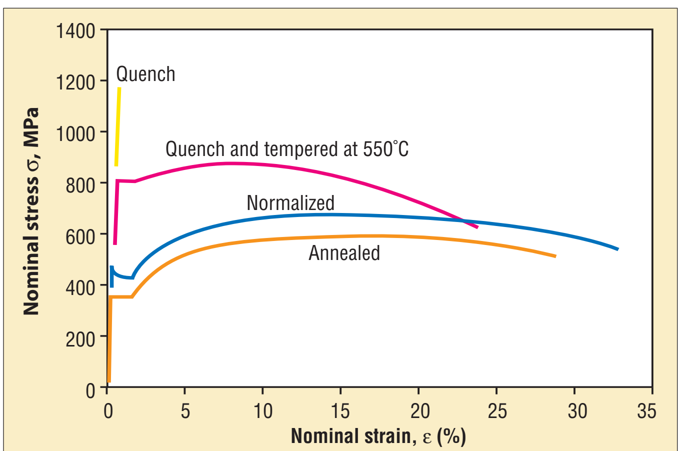

Fig. 1. Stresses induced by heat treatment (SAE 1045)[1]

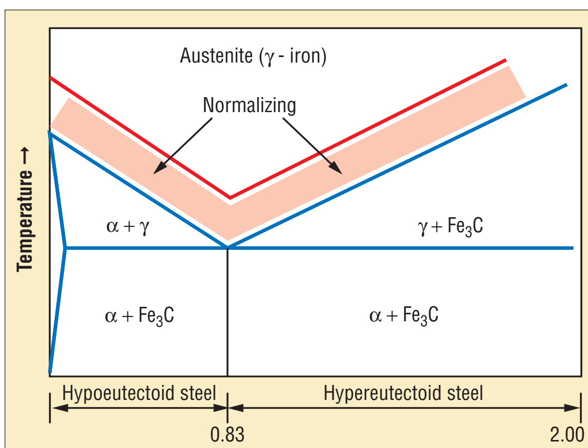

Fig. 2. The normalizing process[2]

Normalizing vs. Annealing

Normalizing differs from annealing in that the metal is heated to a higher temperature and then removed from the furnace for air cooling rather than furnace cooling. For many manufacturing engineers there is often a great deal of confusion as to when to specify normalizing and when to call out annealing. There is a logical reason for this because, in many instances, the procedure for normalizing and that of annealing are one and the same. For example, very-low-carbon steel can be almost fully annealed by heating above the transformation range and cooling in air.

In normalizing, the cooling rate is slower than that of a quench-and-temper operation but faster than that used in annealing. As a result of this intermediate cooling rate, the parts will possess a hardness and strength somewhat greater than if annealed but somewhat less than if quenched and tempered. The slower cooling rate means normalized sections will not be as highly stressed as quenched sections. Thus, normalizing is a treatment where a moderate increase in strength is achieved without undue increase in stress.

Effect of Normalizing on Physical Properties

Annealing and normalizing do not present a significant difference on the ductility of low-carbon steels. As the carbon content increases, however, annealing levels off, with respect to a property such as elongation, around 20%. On the other hand, the ductility of the normalized high-carbon steels continues to drop to the 1–2% level (Fig. 3).

The tensile strength (Fig. 4) and the yield point (Fig. 5) of the normalized steels are higher than the annealed steels. Normalizing and annealing do not show a significant difference on the tensile strength and yield point of the low-carbon steels. Normalized high-carbon steels, however, exhibit much higher tensile strength and yield point than those that are annealed.

Low- and medium-carbon steels produce similar hardness levels when normalized or annealed. However, when high-carbon steels are normalized, they maintain higher levels of hardness than those that are annealed (Fig. 6).

In Conclusion

Normalizing is a process that improves part quality and plays an important role in controlling dimensional variation in hardening and case hardening. Normalizing should be done whenever dimensional stability is important or when manufacturing operations are expected to impart significant amounts of stress into the material. Normalizing helps avoid many heat-treating problems. **IH**

References

1. Rapid Product Deployment Research Centre (http: rpdrc.ic.polyu.edu.hk)
2. School of Engineering Technologies, Farmingdale State College (www.lu.farmingdale.edu)

Additional related information may be found by searching for these (and other) key words/terms via BNP Media SEARCH at www.industrialheating.com: normalizing, austenitizing, pearlitic, ferritic, annealing, quenched

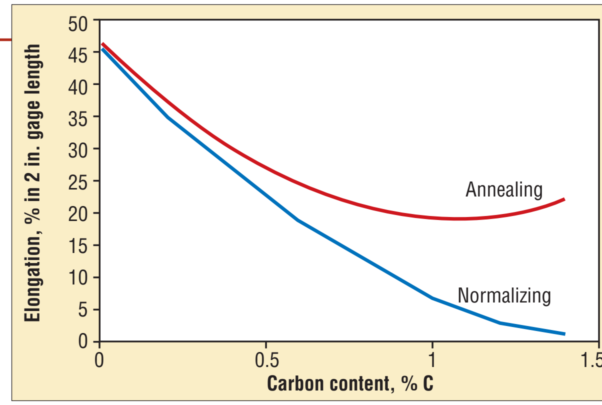

Fig. 3. Normalizing and ductility[2]

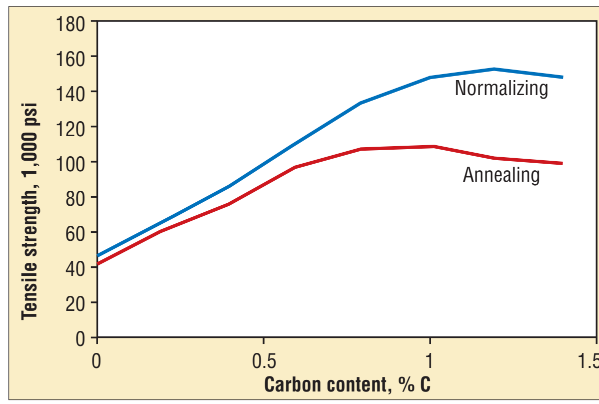

Fig. 4. Normalizing and tensile strength[1]

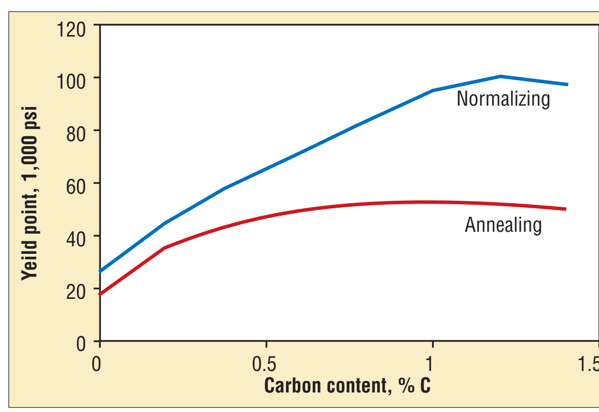

Fig. 5. Normalizing and yield strength[1]

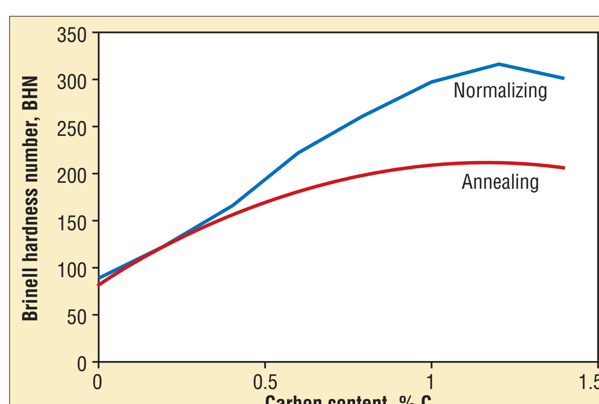

Fig. 6. Normalizing and hardness[1]