OPTIMA
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OVER VIEW

- Heat treatment can improve refiner plate materials.
- Material performance can be improved by applying the proper heat treatment cycle and controlling the cycle to tight tolerances.
- Heat treatment is a very important variable and can lead to increased refiner plate performance when done properly.

Heat Treating Refiner Plates

Developed by the Technical Group, J&L Fiber Services

Improvements in refining technology have created the need for refiner plate materials with advanced properties. Heat treatment is one method of achieving improved material properties.

Heat treatment and material microstructure

Heat treatment and chemical composition are the two main variables responsible for developing material properties. Together, they determine the microstructure of the material, which represents the atomic arrangement of alloying elements in the material. Exposure to heat for an extended period of time can change the microstructure, which can either be beneficial or detrimental to performance, depending upon the process and the desired results.

Changes that occur in the microstructure due to heat treatment are referred to as “transformations.” The typical microstructure of a refiner plate material has two components: 1) carbide and 2) the matrix. Carbide is a very hard and stable structure formed by combining carbon with another alloying element, such as chromium, titanium, molybdenum or vanadium. Generally, this structure does not transform during subsequent heat treatment. The second component – the matrix – fills the voids between carbides.

The matrix microstructure is a solid solution of the remaining alloying elements in iron. Initially, the matrix microstructure is a mixture of ferrite plus carbide. Heat treatment can transform this structure by rearranging element distribution. High temperatures form a new matrix microstructure called austenite. Rapid cooling, or quenching, creates a final microstructure called martensite.

Many property combinations can be obtained from the same material by simply modifying the heat treatment. The key is to match the heat treatment to the desired properties, and control the process so that the results will be consistent.

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Heat treatment objectives

Heat treatment is a separate production step that occurs immediately before the refiner plates are finished to their final dimensions. It is a controlled process that utilizes time and temperature as variables (*Fig. 1*). There are many combinations of heat treatment cycles, and each one affects the material in a different way.

Typically, heat treatment processes are designed to accomplish one of the following objectives:

- Relieve stresses that were introduced during the production process. This is normally done with a low temperature treatment (400 to 600F/204 to 316C). It is often referred to as tempering.
- Homogenize the structure at high temperatures (1600 to 2000F/540 to 1090C) to achieve a consistent microstructure. This may also cause material softening because of the formation of austenite.
- Transform the structure by heating it at high temperatures (1600 to 2000F/540 to 1090C) and cooling it rapidly to increase hardness through the formation of martensite.

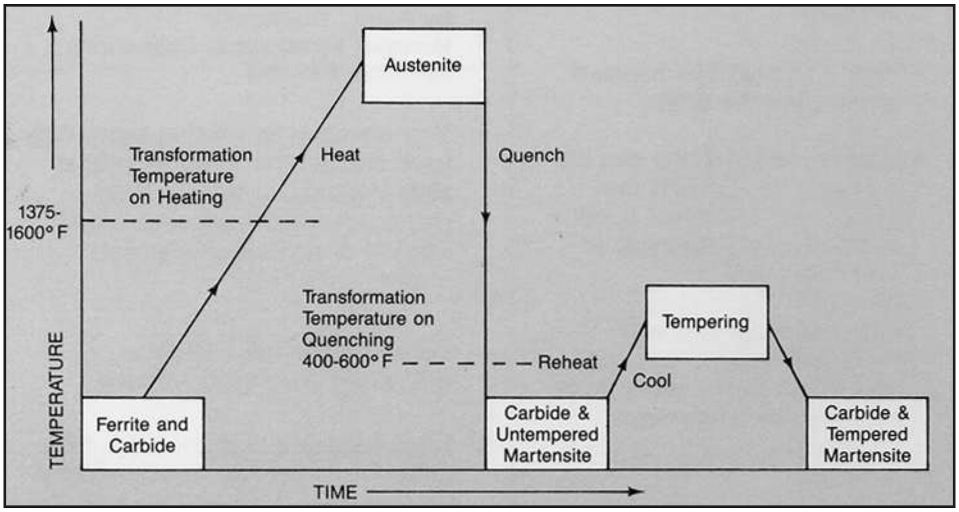
The goal of heat treatment is to improve refiner plate material properties for better performance. Improved performance is often exhibited by better bar edge retention, reduced cavitation defects or the resistance to serration. Refiner plate material performance has been correlated to laboratory test results, which means that the effect of heat treatment can be verified outside of the refining environment. The results of some of these tests highlight the potent effect heat treatment has on refiner plate material properties.

Heat treatment and white irons

Heat treatment can enhance the properties of most refiner-plate materials. White iron materials, while conventionally non-heat treated, are one example. The white irons depend on hard carbides, which encompass 20 to 40% of the structure, for wear-resistance properties. The balance of the structure is the matrix, which provides support against breakage. However, when it is not heat treated, the austenite matrix is much softer and often the site of preferential wear.

Heat treatment provides tremendous opportunities for white iron material

Fig. 1: Schematic drawing of the heat-treatment cycle.



property improvements through matrix transformation to martensite. As shown in *Fig. 2*, heat treatment increases the hardness, wear resistance, cavitation resistance, and impact strength of a 2.8% carbon, high chromium white iron. Similar gains are seen in other white iron compositions where carbon and chrome vary. In addition to the measurable properties, proper heat treatment of the white irons has proven to be an effective way of reducing or eliminating the serration grooving caused by plate clashing. Examples are shown in *Fig. 3*, where the non-heat treated plate serrated while the heat treated plate did not.

Fig. 2: 2.8% carbon white iron material properties – heat treated versus non-heat treated (NOTE: Lower weight-loss figures indicate better resistance).

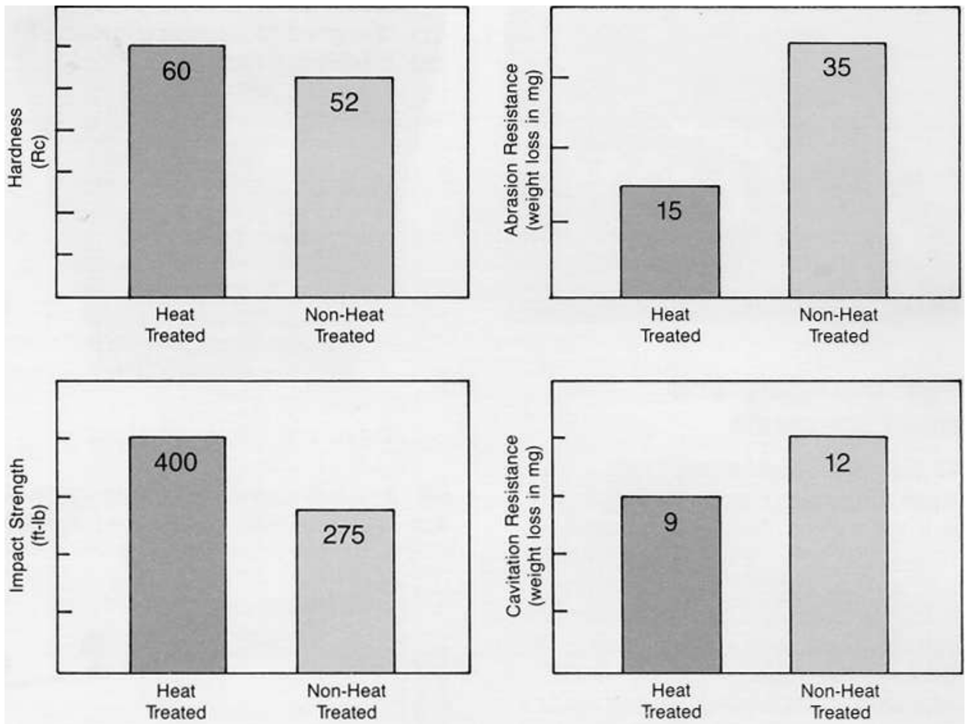
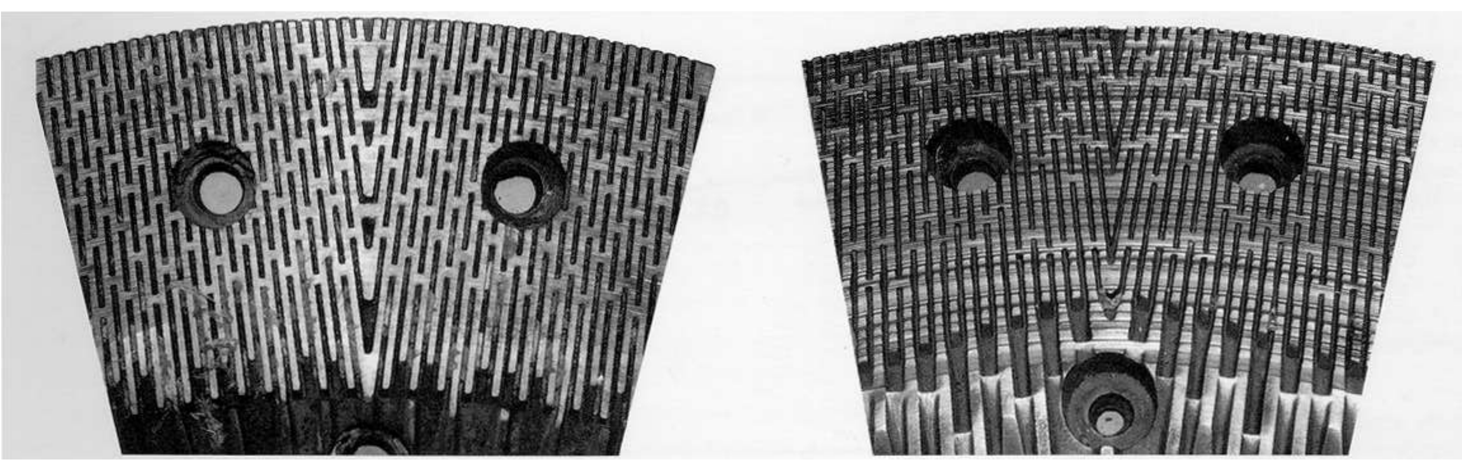


Fig. 3: Heat treated white iron (left) versus non-heat treated white iron (right).



Heat treatment and stainless steels

All stainless steel refiner plate materials require heat treatment. Since the microstructure is now 90% matrix and only 10% carbide, the matrix must contribute the majority of the properties. The major concern with stainless steels is the quality of the heat treatment. Improper heat treatment can often result in inferior wear resistance, corrosion resistance or cavitation resistance. *Fig. 4* shows the different responses to cavitation in a properly heat treated 1.0% carbon stainless steel versus an improperly heat treated plate. Heat treatment quality is often quantified by the amount of transformation taking place. *Fig. 5* shows the effect of changing the heat treatment cycle for a 1.0% carbon, high chromium stainless steel. As the amount of transformation increases, the wear resistance, corrosion resistance and cavitation resistance also increase.

Similar results have been seen with other stainless steels. The same relationship also holds true for heat treated white iron materials.

In summary, refiner plate material properties and their performance can be improved by applying the proper heat treatment cycle and controlling the cycle to tight tolerances. Heat treatment is a very important variable, and can lead to increased refiner plate performance when done properly.

Fig. 4: Properly heat treated stainless steel (left) versus improperly heat treated stainless steel (right). Note the gross cavitation defects in the breaker-bar area for the improperly heat-treated plate.

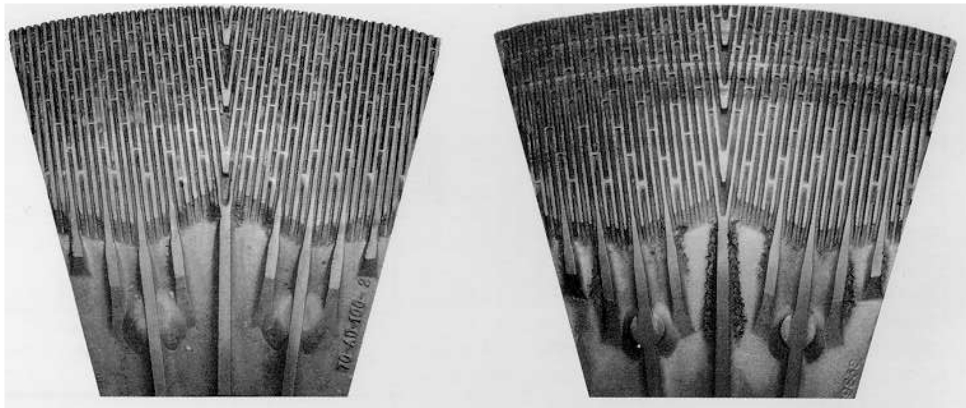
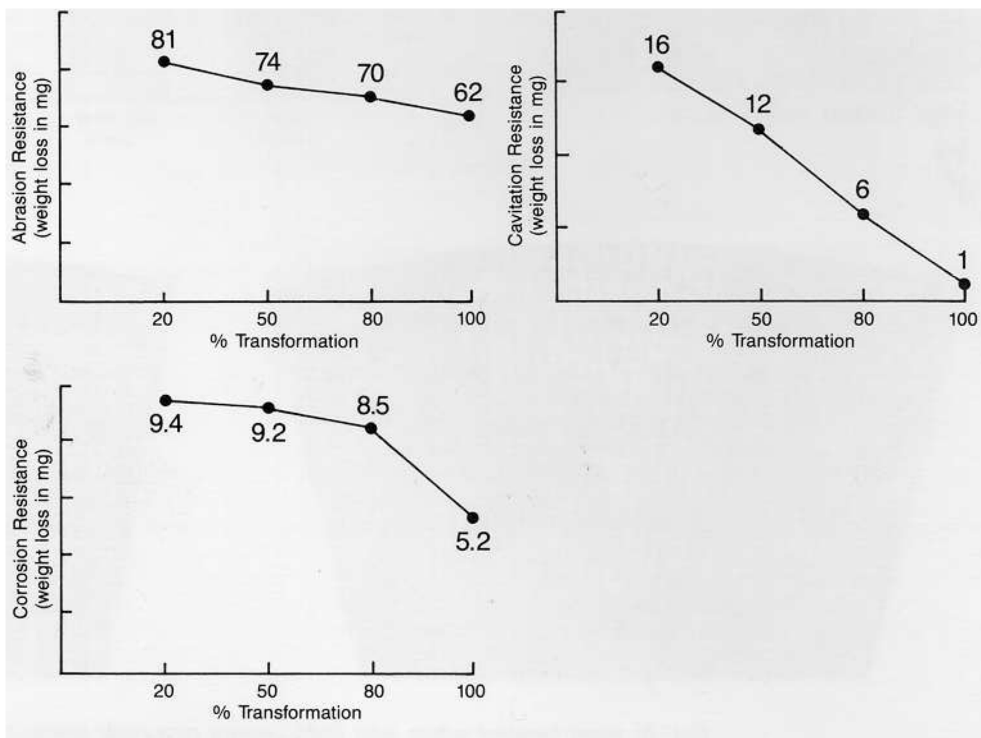


Fig. 5: 1.0% carbon stainless-steel material properties versus % transformation (NOTE: Lower weight-loss figures indicate better resistance).



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