OPTIMA
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OVER VIEW

- Refiner plate material can affect refiner operation and fiber quality.
- Material properties are controlled by an alloy's chemistry and heat treatment.
- Breakage resistance is inversely related to the carbide content of a material, while wear resistance is directly related to it.
- Corrosion resistance is directly related to the Cr/C ratio of a material.
- Heat treatment can improve cavitation resistance, wear resistance and breakage resistance of a material.

Optimizing High Consistency Refiner Plate Performance Through Material Selection

Developed by the Technical Group, J&L Fiber Services

In high consistency applications, the refiner plate material used greatly affects the operation of the refiner and the quality of the fiber produced. First and foremost, the design of the plate must be suitable for the operating parameters of the system. But system optimization does not occur unless both design and material are properly chosen. With an acceptable plate design, plate material alone can be responsible for better refiner stability and fiber quality over a longer period of time.

Therefore, choosing the right blend of alloying elements that make up the plate is a very important part of the refiner plate selection process. Refiner plate alloy combinations greatly affect both operating efficiency and the quality of the end product. It is important to understand this effect when choosing the right plate to optimize your refining process.

In a high consistency operation, the leading edge of each refiner plate bar must be maintained for effective fiber processing. As the edge deteriorates, closing pressures increase, fiber quality decreases and more energy is required to maintain desired properties. This loss of edge is caused by five major deterioration processes: Rounding, serration, cavitation, breakage and corrosion.

The type of refiner plate alloy used is directly related to the plate's resistance to these factors. Since each refining application has its own distinct operating conditions, a variety of alloy materials is needed to satisfy all refining requirements.

To help optimize the alloy material selection process, a number of laboratory experiments have been devised to test refiner plate materials under controlled conditions. All tests simulate actual refining conditions, and measure a plate alloy's resistance to specific deterioration processes.

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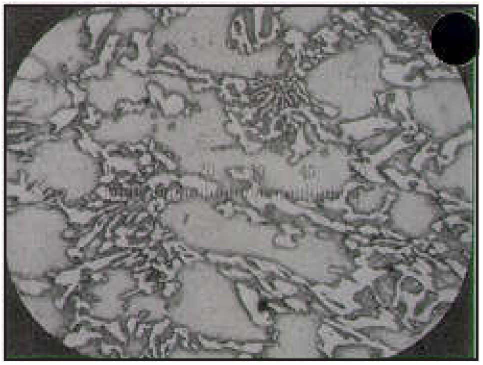


Figure 1. Typical microstructure of a high chromium white iron refiner plate. (400x magnification.)

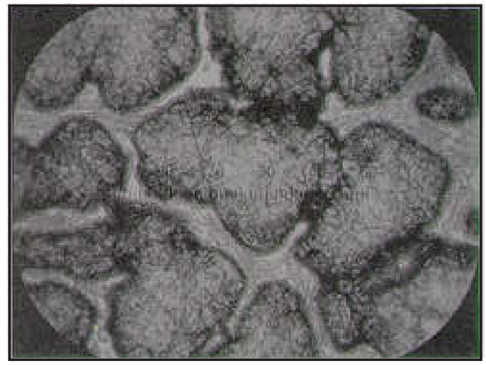


Figure 2. Microstructure of a stainless steel plate. (400x magnification.)

Experiments were conducted to test four of the five processes: Abrasive wear resistance, breakage resistance, cavitation resistance, and corrosion resistance. The ability to measure serration resistance has not been achieved under laboratory conditions; therefore, results have not been recorded. Using this controlled environment, test results are far more accurate, a greater number of plate materials can be tested, recorded data is much more credible, and new alloys created as a result of testing have a much better chance of success.

Key Refiner Plate Alloys

Refiner plate materials are defined by the combination of varying degrees of chemistry and heat treatment. There are two general categories of refiner plate alloys: *white iron and stainless steel.*

White irons contain high levels of carbon and chromium. These two elements form a compound chromium carbide, which is surrounded in the microstructure by a matrix of martensite (when the *white iron* refiner plate is heat-treated), or austenite (when it is not).

Stainless steels also contain chromium carbide but in a much lower percentage. The chromium carbide is always surrounded by a matrix microstructure of martensite, since *stainless steel* plates are always heat-treated.

These carbides, present in both alloys, are very hard and very brittle. They provide most of the plate material's wear resistance. The refiner plate's matrix microstructure (martensite or austenite) is very strong, and acts as a support for the brittle carbides to help prevent breakage.

Keeping these inherent properties of *stainless steel* and *white iron* alloys in mind, we can better understand their measured resistance to the deterioration processes simulated in the experiments.

Wear Resistance

White irons have a very high carbide content. The carbide is a very hard compound in the plate microstructure. The result: Excellent wear resistance. *Stainless steel* alloys contain a much lower carbide content, and are less wear-resistant. These results are graphically depicted in *Figure 3.*

Breakage Resistance

The opposite is true when measuring breakage resistance. As illustrated in *Figure 4*, the lower carbide content of the stainless steel alloy, which lowers its wear-resistance, *increases* its impact strength. The strong martensite microstructure also acts as a support and helps prevent breakage.

White irons have a higher carbide content. This factor lowers its breakage-resistance, since carbides, while hard, are also exceptionally brittle.

Corrosion Resistance

Chromium content in the microstructure increases corrosion

TABLE 1. CHEMICAL ANALYSES OF STANDARD HIGH CONSISTENCY REFINER PLATE ALLOYS

Material	C	Mn	Si	Cr	Ni	Mo	Cu
28% Cr White Iron	2.8	1.0	.8	28	1.0	.5	-
20-2-1 White Iron	3.0	1.0	.8	20	1.0	2.0	1.0
1% Carbon Stainless Steel	1.0	1.0	.8	17	1.5	.5	
1.5% Carbon Stainless Steel	1.5	1.0	.8	17	1.0	.5	

Fig. 3 *Wear Resistance vs. Carbide Volume*

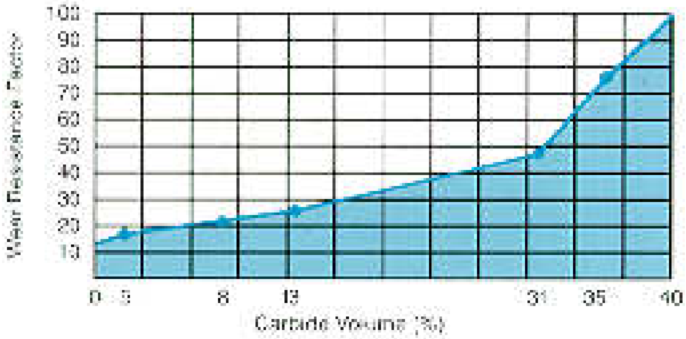


Fig. 4 *Breakage Resistance vs. Carbide Volume*

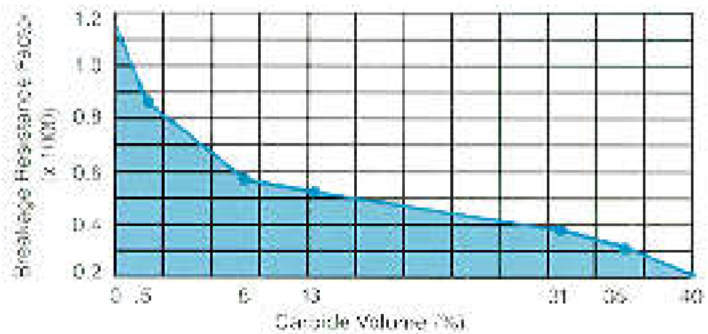


Fig. 5 *Corrosion Resistance vs. Chrome/Carbon Ratio*

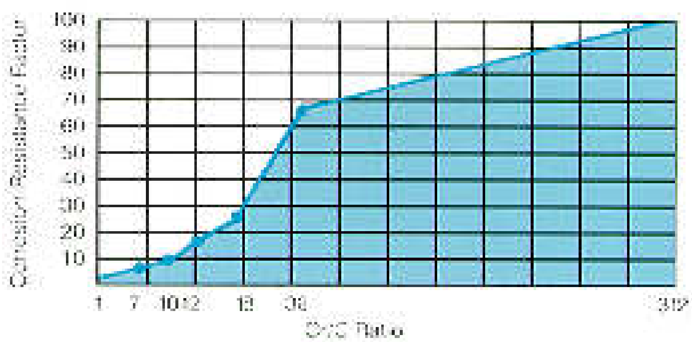
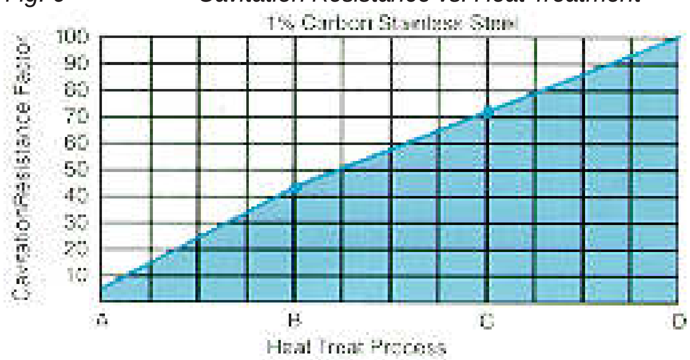


Fig. 6 *Cavitation Resistance vs. Heat Treatment*



resistance. If an alloy has a lower carbide content, there is more free chromium available. *Stainless steels*, because of their high "free" chromium content, provide better corrosion resistance than *white irons*. The relationship of chromium content to corrosion resistance is shown in *Figure 5*.

As is the case with corrosion resistance, cavitation resistance also depends upon the composition of the microstructure. A high presence of carbides tends to disrupt the uniformity of the microstructure matrix. These "disruptive areas" are very vulnerable to an erosive attack. Because the *stainless steels* have a lower level of carbides, and therefore have a more uniform surface, they are more resistant to cavitation than *white irons*.

The Positive Effects of Heat Treatment

One way of creating a more uniform microstructure is through heat treatment. Heat treatment changes the structure of the non-carbide matrix areas in the refiner plate's microstructure. This process hardens the microstructure, making it more resistant to several deterioration processes. As shown in *Figure 6*, heat treatment does improve the cavitation resistance factor. Various degrees of cavitation resistance can be obtained, depending on the type of heat treatment given to a specific alloy.

TABLE 2. MATERIAL PROPERTIES OF HIGH CONSISTENCY REFINER PLATE ALLOYS

Material	Carbide Volume	Cr/C Ratio	Breakage Resistance	Wear Resistance	Cavitation Resistance	Corrosion Resistance
26% Cr WI	31%	10.0	390	45.0	49	9.7
20-2-1 WI	35%	7.0	310	75.0	27	7.2
1% C SS	5%	18.0	570	20.8	98	24.4
1.5% C SS	13%	12.0	520	25.0	84	19.8

Note: Higher values relate to better resistance to the failure mode

As seen in Figures 7, 8, and 9, heat treatment is also effective in slowing other deterioration processes. Heat treatment can be responsible for improved wear resistance or breakage resistance in both *stainless steel* plates and *white irons*.

Final Analysis

The metallurgy of refiner plate alloys is a complex issue. However, with proper knowledge of operating requirements for a given application, the correct alloy with the best mix of properties can be produced to optimize your refiner plate performance.

Summary

One of the keys to optimizing process performance is the careful selection of refiner plate material. Along with plate design, no other factor plays so important a role in refiner operation and fiber quality. Material properties, defined by material chemistry and heat treatment, must be chosen with regard to an alloy's suitability for a particular application, as well as the material alloy's ability to maintain the integrity of its leading edge. Breakage resistance is inversely related to the carbide content, while resistance to wear is directly related to it. Proper selection of material content ultimately improves the cavitation resistance, wear resistance and breakage resistance of a material.

Fig. 7

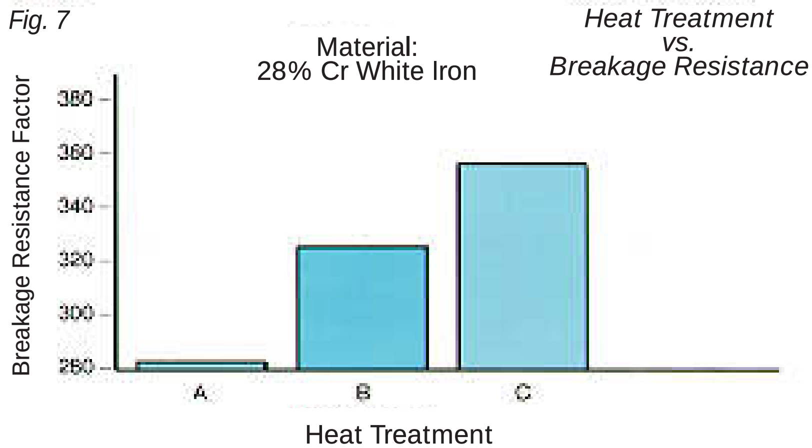


Fig. 8

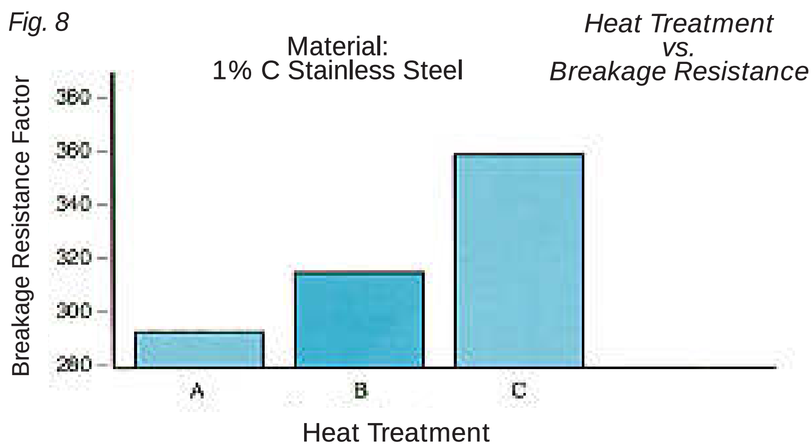
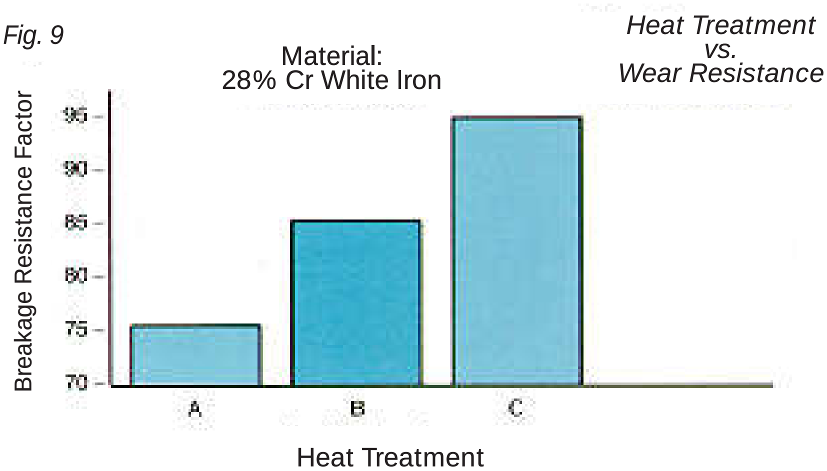


Fig. 9



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J&L FIBER SERVICES, INC.

J&L Fiber Services, Inc. • 809 Philip Drive • Waukesha, WI 53186 USA • Phone 414-544-1890 • Fax 414-547-8166