Revolutionary C90 Alloy for Low Consistency Refiner Plates – In a Class by Itself.

Developed by the Technical Group, J & L Fiber Services

Extremely Resistance To Breakage And Abrasion – In One High-Performance Alloy

Historically, choosing the right refiner plate alloy for low consistency applications has been a matter of compromise. It was not possible to have both abrasion-resistance and breakage-resistance.

In the ideal refining situation, the primary concern would be to minimize plate wear by selecting an abrasion-resistant plate material, such as the high carbon nihards, white irons, or the medium carbon cast 440 grade stainless steels. However, virtually no mill operates under “ideal” conditions. Such problems as process upsets, tramp materials and plate-to-plate contact can – and routinely do – cause refiner plates made from these materials to fracture.

The results: disruption of the refining operation and the risk of damage to refiners and downstream equipment caused by bar fragments.

Plate fracture can be eliminated with the virtually unbreakable 17-4PH alloy, a low-carbon stainless steel. However, it is also the least effective of all the alloys when it comes to wear-resistance.

So what to do? Opt for maximum wear and risk damaging breakage? Or the reverse? Until now, there has not been a satisfactory answer.

Fortunately, compromise is no longer necessary with the introduction of the revolutionary J & L C90 alloy. Not only does it match the fracture-resistance of the 17-4PH alloy, it also offers much more wear-resistance, comparing favorably with cast 440 grade stainless steel (which, however, provides significantly lower breakage resistance). Only the high carbon alloys are more wear-resistant.

C90 also exhibits superior performance in two other areas of concern: corrosion- and cavitation-resistance.

The following are test results comparing the C90 alloy with the most commonly used alloys (nihards, high chromium white irons, cast 440 grade stainless steels and 17-4PH):
Fracture Toughness
Specimens of all five alloys were subjected to the impact of a gravity-driven weight in an instrumented drop tower. Because of the intrinsic resistance to crack propagation of the C90 alloy, testing was performed on specimens without pre-crack conditioning. This permitted direct testing and comparison of the brittleness of each alloy. Computer monitoring measured the energy absorbed prior to the fracture of each material, thus providing data on their relative “fracture toughness.” As Fig. 1 shows, the C90 alloy demonstrated a fracture-toughness ratio nearly three times that of 440 grade cast stainless and almost six times that of the nihard alloy.

Abrasive Wear Resistance
Samples of each material, taken directly from refiner plates, were abraded under controlled load on a continuously renewed garnet-clad abrasive cloth. (Garnet most closely simulates abrasive conditions in a refining operation.) Weight loss was used to measure abrasion resistance.

Corrosion Resistance
A polarization test was conducted on samples of each material taken from refiner plates. Each sample was used as an electrode immersed in an electrolyte solution of chlorides with a pH of three (similar to an actual refiner environment). A potential was passed through the wetted surface of the sample to stimulate corrosion. The corrosion rate was then measured.

Cavitation Resistance
Test samples of each material were extracted from refiner plates and mounted to the base of an acoustic system. Oscillation of the acoustic tip caused liquid displacement, resulting in cavitation and subsequent weight loss of each sample. This method of testing closely simulates the actual refining conditions that cause cavitation. The weight loss was used to measure and compare the cavitation-resistance of the alloys.

Results: J&L’s C90 alloy matched 17-4PH in corrosion resistance and was vastly superior to all other alloys tested.

Results: J&L’s C90 alloy exceeded the cavitation-resistance of 17-4PH alloy and was far superior to the nihards and 28% chromium white irons. It closely matched cast 440 grade stainless steel, the alloy most commonly used to combat this failure mode.
Innovative Metallurgical Techniques Used to Develop New C90 Alloy

The C90 alloy offers the best of all worlds: an extreme toughness to resist brittle failure and a self-sharpening cutting edge for optimum fiber development. These remarkable performance characteristics are the result of an innovative process developed by J & L metallurgists.

The matrix of the highly corrosion-resistant alloy CB-7CU was modified extensively to create a duplex microstructure that afforded an extraordinary resistance to premature failure:

- Careful control of the austenite and ferrite-forming elements, based on a Schaeffler diagram, to produce a hard, wear-resistant martensitic structure and to avoid the formation of brittle sigma phase.
- Careful control of the martensite’s carbon content toward the upper limit of its alloy class. (There is a direct, positive relationship between martensite’s abrasion-resistance and toughness and its carbon content.)
- Control of the nitrogen content to a strict maximum to obtain desired wear resistance and fracture toughness. (This is extremely important since nitrogen causes brittleness.)
- Careful selection of secondary hardening techniques to develop the critical size and distribution of the precipitation phase. The result is a hard precipitate which greatly enhances edge retention.
- Development of new test techniques to assure optimum performance for refiner plate applications.

Fig. 5

Schaeffler Diagram showing the optimum balance of alloys, trace elements and gases that is necessary to provide the C90 alloy's unique microstructure.
The C90 Alloy: Created For The Real World of Low Consistency Disc Refining

As mentioned earlier, low consistency refining does not occur in a closed environment, where undesirable events leading to plate failure can be 100% avoided. Every mill must face these realities:

• Plate gaps on the order of two to three fiber diameters
• Floating rotor disks on refiners
• Fluctuations in stock pressure, consistency, flow rate and specific energy
• Tramp material

With the new C90 alloy and plate designs tailored to the precise and unique refining needs of each mill, these major causes of plate failure can be diminished significantly.

The C90 alloy offers the highest possible level of toughness and resistance to abrasion, corrosion and cavitation available in a single low consistency refiner plate alloy today. It has now established new, higher standards for optimum fiber processing performance.
**Overview**

- C90 has become the premium alloy for low consistency refining operations.
- Recent field studies, comparing C90 to 17-4PH, support this assessment.

In 1989, J&L Fiber Services introduced the revolutionary C90 alloy to the pulp and paper industry. Since then, C90 has gained widespread acceptance as the premium alloy for low consistency refining applications, where breakage and abrasive bar wear are the major causes of refiner plate failure.

The benefits of C90 have become even more evident through the industry’s increased utilization of the alloy. The following case study describes C90 applications in the field and the results obtained. This study demonstrates the typical benefits of using C90 and is just one of many examples of the alloy’s success.

**Case Study Details**

This study provides a visual comparison between a C90 plate and a 17-4PH plate in a 42” double disc refiner running top sheet at a mill producing linerboard at a rate of 450 tons per day, a consistency of 4.0%, and a pH of 7.5. Both plates described in this study had a bar code of 2.7-2.7-4.8, and performed under virtually identical conditions. These conditions included plate-to-plate contact, tramp materials, as well as the abrasive forces of stock flow.

**Life expectancy.** The normal life expectancy of the 17-4PH alloy was four months, while the C90 alloy ran for over nine months.

**Abrasive wear resistance.** The following four graphic examples compare the C90 alloy to the 17-4PH.

![Figure 1](image)

Figure one shows the entire refining surfaces of the C90 plate (left) and the 17-4PH plate (right).
Conclusion
This case study clearly shows that the C90 alloy lives up to its reputation under high-stress conditions in the field. C90 stands up to the real-life situations of low consistency refining; it provides the highest possible resistance to abrasive wear, breakage and bar deformation available in single refiner plate alloy; and has established new and higher standards for optimal fiber-processing performance.

Figure two is a close-up of the ID section of each plate. It is clear that plate clashing and abrasion has occurred; however, the response of the C90 plate (left) to these common refining conditions is quite different from that of the 17-4PH plate (right). The bar surfaces and bar edges of the 17-4PH plate are deformed and smeared, resulting in blockage or complete closing of the groove area and limited throughput. The C90 material, under the same conditions, remains open at the ID (and OD, as seen in figure one) of the plate because bar deformation has been eliminated. Bar height is also maintained for greater flow capacity.

Figure three shows an even closer view of the ID of each plate. The amount of deformation and plugging of the grooves occurring in the 17-4PH material (right) is quite obvious. A 4mm groove width has been completely blocked, causing restricted stock flow. It is evident that plate clashing did occur with the C90 plate (left), but the grooves remain clear even after nine months.

Figure four depicts the edge wear of both materials. The leading edge of the 17-4PH plate (right) has blunted, even though the top of the bar is flat from plate clashing. The trailing edge has developed burrs from material deformation. On the other hand, the C90 plate (left) maintains a sharp leading edge, creating a 90° angle, and a distinct trailing edge to provide optimum refining conditions.