Controlled Shot Peening to Increase the Fatigue Properties of Crankshafts

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ABSTRACT

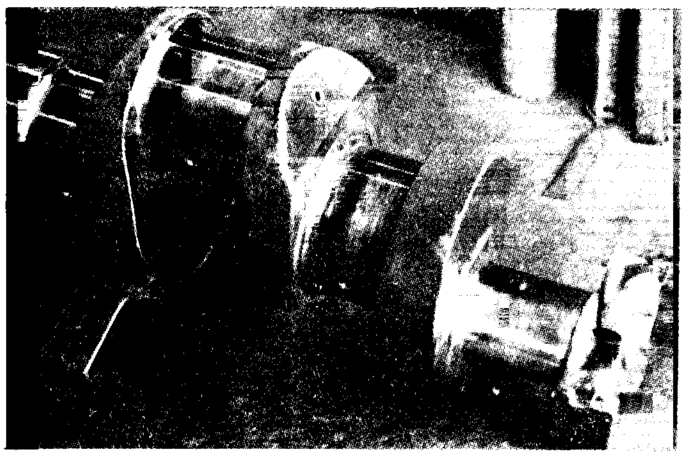
Shot peening has become a common production method of increasing the fatigue life of crankshafts. In each of the cases cited below, the Metal Improvement Co. performed the shop peening and the manufacturer performed the fatigue tests and reported the results. Also, in each case, the tests resulted in shot peening being used as a production process.

KEY WORDS

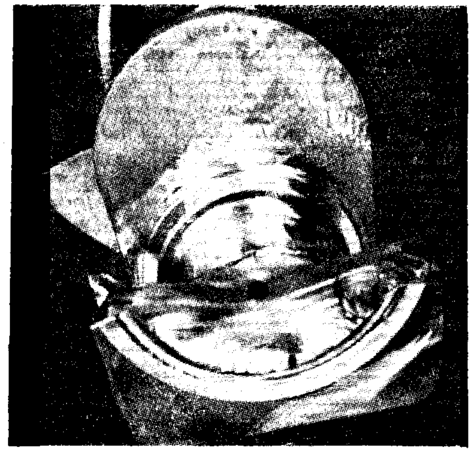
SHOT PEENING CRANKSHAFTS FATIGUE LIFE

Many manufacturers of internal combustion engines have been faced with the necessity of increasing the output of these engines and have accomplished this by turbocharging and after-cooling. As a result, the internal components have been subjected to higher stress levels. One of the most critical components, and the most difficult to redesign, is the crankshaft. A number of these manufacturers have elected to use the controlled shot peening process as a means to increase the fatigue life of the crankshaft, therefore allowing them to operate the engine at the higher horsepower and achieve acceptable life on the crankshaft.

Shop peening has been used successfully as a production tool on many sizes of crankshafts manufactured from many materials. The sizes range from very small single cylinder crankshafts, to small high power, high speed crankshafts, to intermediate sizes such as used for moving heavy vehicles, and very large crankshafts up to 20 cylinder, for use in high horsepower, show speed applications. Data dealing with some of these applications will be introduced.



Photograph No. 1



Photograph No. 2

The most highly stressed area of a crankshaft is the journal bearing fillet. The high stress point is the bottom side of the fillet when the journal is in the top dead center position during the firing cycle. Photograph No. 1 is that of a failed crankshaft and the failure is characteristic in that it occurred in the area as described. Photograph No. 2 is a closer view of the fracture face, which indicates the initiation site of the fatigue crack to be in the journal bearing fillet with the crack propogating across the cheek to the adjacent main bearing fillet. Photograph No. 3 illustrates a crankshaft on which the journal bearing fillets have been peened and the journal bearings have been masked against impingement by the shot.

Photograph No. 3

Many fatigue tests have been performed on crankshafts, typically on single journal bearings. This is accomplished by sectioning the shaft at the center of each main bearing adjacent to the journal to be tested. A high frequency load is applied in a bending mode with the load being constantly monitored by strain gages mounted in the fillets.

The following data represents fatigue testing performed by various engine manufacturing companies.

Case No. 1 - 6 Cylinder Diesel Engine Crankshaft

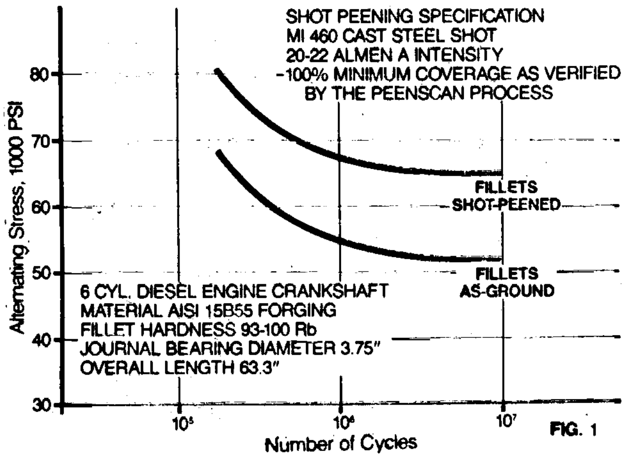


FIG. 1

As can be seen in figure 1, the unpeened crankshaft had a fatigue strength of 52,000 psi. In the peened condition the fatigue strength was increased to 65,000 psi or an increase of 25%.

Case No. 2 - 6 Cylinder Diesel Engine Crankshaft

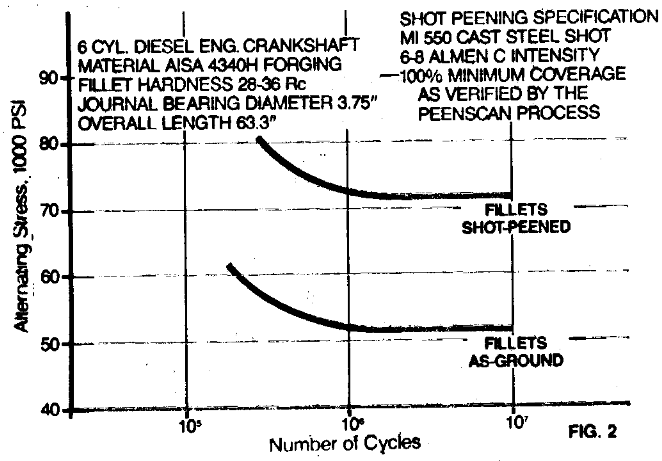


FIG. 2

In Figure 2 the increase was more dramatic in that the increase in fatigue strength was approximately 40%. This is probably explained by the fact that the material had a higher tensile strength and therefore the magnitude of compressive stress from the shot peening operation was higher. The crankshafts in Case No. 1 and 2 were of identical design, but of different material.

Case No. 3 - 6 Cylinder Diesel Engine Crankshaft

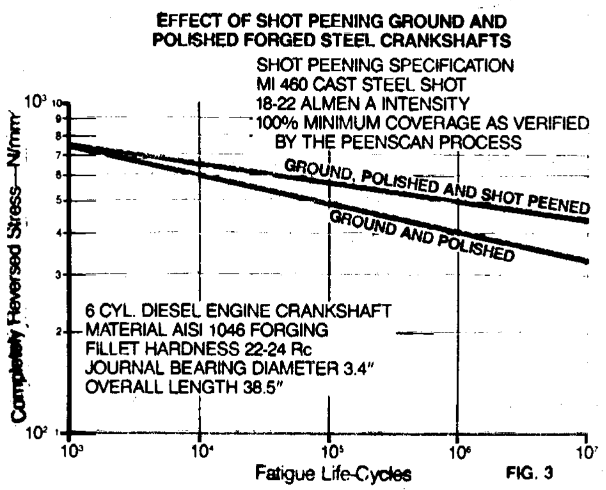


FIG. 3

In Figure 3, the increase in fatigue strength was from 320 N/mm^2 to 420 N/mm^2, or 31%.

Case No. 4 - 6 Cylinder Diesel Engine Crankshaft

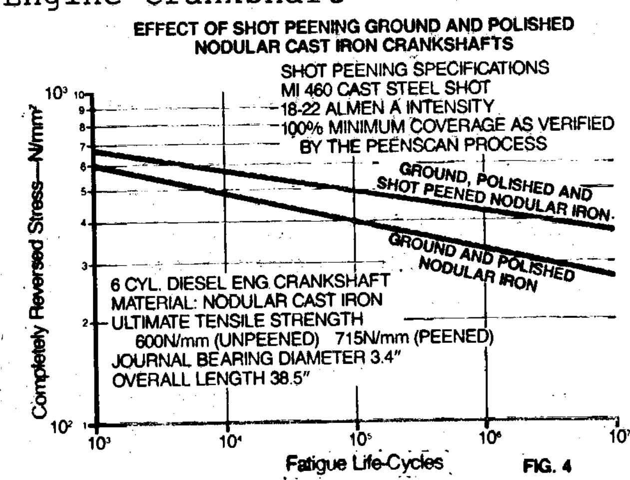


FIG. 4

In Figure 4 the raw data yields an increase in fatigue strength of 38% which is not totally valid because of the difference in the ultimate tensile strength of the peened and unpeened specimens. However, the significance of the data is the fact that the crankshafts in cases 3 and 4 are of the same design. The fatigue strength of the forged but unpeened shaft was 320 N/mm^2 whereas the fatigue strength of the cast and shot peened shaft was 360 N/mm^2, an increase of 12.5%. This data suggests that there are cases where a shot peened nodular cast iron part can be substituted for a forged steel part.

Case No. 5 - 2 Cylinder 4 Cycle Gasoline Engine Crankshaft

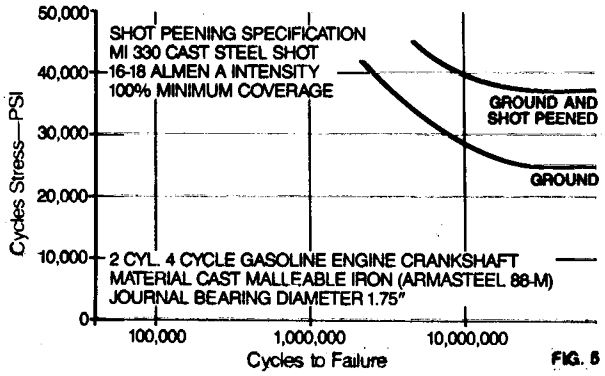


FIG. 5

Figure 5 is another example of a cast crankshaft, cast from alleable iron. In this case the fatigue strength increased from 25,000 psi in the unpeened condition to 37,000 psi after shot peening, or an increase of 48%.

Case No. 6 - 16 Cylinder Diesel Engine Crankshaft

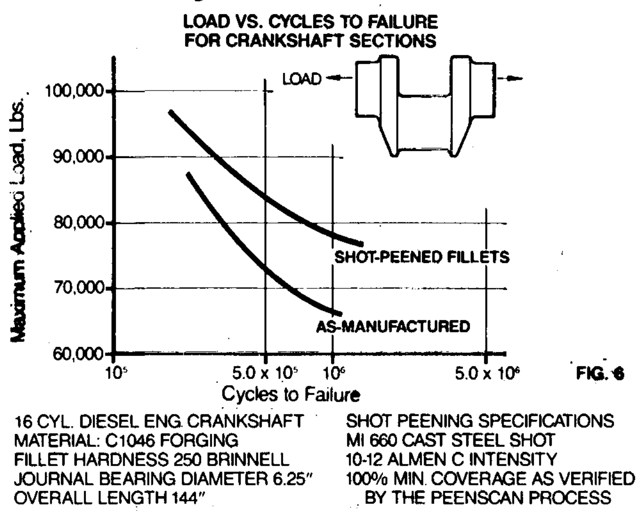


FIG. 6

In Figure 6 the fatigue strength increased from an applied load of 67,000 lb. to 77,500 lb. of applied load, or an increase of 17.2%.

SUMMARY

The above data indicates that crankshafts used in internal combustion engines, gasoline or diesel, high or low RPM, forged or cast, over a wide range of material and sizes, all show a significant increase in fatigue strength when shot peened under controlled conditions, compared with the same part in the unpeened condition.

It is also significant in the one case cited above, that in certain applications, it perhaps, would be possible to substitute a shot peened cast crankshaft for an unpeened forged crankshaft at considerable cost savings.

While this paper has been limited to crankshafts utilized in internal combustion engines, similar improvements have been noticed on crankshafts used in other applications.