The Use of Shot Peening to Delay Stress Crack Initiation on Axles for Coal Mine Duty Use

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ABSTRACT

This paper describes the application of shot peening to delay stress crack initiation on coal mine personnel carrier axles made of 4140 L/50 heat treated bar stock. A description of typical working conditions and operating environment of the axles is given. Using S-230 cast steel shot the axles were peened and subsequently installed in equipment used in actual operating conditions. Results of empirical data collection are given. It is concluded that shot peening enhances fatigue life and delays stress crack initiation.

KEY WORDS

Crack Nucleation

Fatigue Fracture

Shock Loading

The subject components are axles for coal mine vehicles which have a gross weight of 16,000 pounds and are used in transporting mine personnel. Axles are machined from 4140 L/50 heat treated bar stock with a Brinell hardness of 269-321.

Mine track sections are laid on ballast as thin as possible due to mine-shaft height restrictions, resulting over a period of use in typical track joints having horizontal and vertical mating variances ± .5 inch. The shock loading resulting from vehicles traveling at 12 miles per hour was, at some mines, causing a 50% axle failure rate within 60 days of installation in radii marked (A) and (B) in Fig. 1. ((A) being the primary failure mode with (B) and (C) secondary). Fracture analysis suggested crack nucleation occured at surface scratches or toolmarks as small as .0005 inch in depth and .250 inch in length.

The radius of .0132 inch was changed to .015 inch in area (A) and similarly the .1562 inch radius in area (B) to .1875 inch.This resulted in a failure rate of 10% in a period similar to above. A program of shot peening these axles was commenced at this point.

Utilizing data accumulated in past applications, Airtech chose a peening intensity of 16 to 20A using 54-60 Rc, S-230 cast steel shot as the most promising parameters. Since time constraints would not allow an exhaustive destructive testing program, it was necessary to use empirical results from field application to conclude whether further test work to optimize peening parameters would be necessary. A total of 200 axles were peened from January 15, 1982 to September 1, 1982.

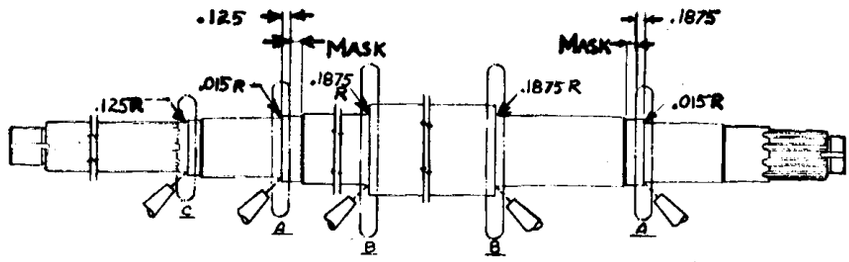

FIGURE 1. Coal Mine Car Axle and Peening Nozzle Placement and Orientation

RESULTS

Results from 19 months of field operation of shot peened axles showed no failures occuring in peened axles during this period.

To date there have been no reported failures on axles peened during this period. This represents an 850% increase in the low limit fatigue life of axles tested.

CONCLUSION

Shot peening of the subject radii at the intensity and peening parameters chosen has apparently raised the fatigue limit of these areas above the load they undergo.

Further test work with varying intensity variables might yield a greater increase in the fatigue limit than the estimated optimum used.

This leaves open the possibility of using smaller sectional dimension components or lower cost material to achieve the same design life.