TOM BERTONE CONSULTING
14113 REIS STREET
WHITTIER, CA 90604
A METALLURGICAL CONSULTING CORPORATION
(562) 941-2911 Office (562) 944-8891 FAX
www.metallurgy.com

Metallurgical Evaluation of Broken Tow Truck Extendable Boom

Observations

An extendable boom on a tow truck fractured without forewarning directly behind the welded top plate and aft of the hydraulic lift rams. The truck was driven to the Tom Bertone Consulting laboratory in Whittier, CA., where the fractured boom was examined; see Figures 1 through 12. The fracture location is aft of the hydraulic lift rams and about an inch away from the point weld made on the top strengthening plate. The observed crack appears to have propagated transversely across the top surface of the boom, from the center area weld bead (the boom seam weld), progressing in a brittle manner down both sides of the boom. The interesting feature of this fracture is the lack of ductility exhibited throughout, especially on the top surface and along the first half of the side fractures where fast fracture changes to shear mode.

Discussion

A brittle appearing crack which propagates transverse to grain flow can be an indicator of a fatigue fracture mode. Fractures of this type often originate due to manufacturing problems with the fabrication process when making the tube, along with the boom fabrication and assembly procedures; i.e. it would be preferred to have the weld seam oriented to the bottom of the boom rather than at the top where the bending and fatigue stresses are always in tension.

There are numerous recorded cause(s) for brittle metal fracture, propagating perpendicular to grain flow. Heavy wall tubing used for booms are manufactured by folding soft metal plate into shape and welding the edges together to make a tube. Particular attention is given to the cooling of the weld metal so as not to allow formation of any hard microstructure compounds. Welds are usually allowed to cool slowly rather than by rapid quenching. The weld microstructure is columnar in crystal formation and lacks tension strength compared to the longitudinal microstructure of the tube base metal. Upon bending and or when loaded; lifting / towing with the boom, the top surface of the boom and the welded seam is stretched in tension. Under this type of loading conditions (tension fatigue stress), the weld metal tends to fail by transverse splitting in a brittle manner as is evident in this failure

The decision to allow the tube weld seam to be oriented on the top surface of the boom is a poor choice, since bending and fatigue stresses combine during normal operation of the vehicle and equipment and at times can be excessive. Any welding defect either in the tube and or as a result of the welding attachment of the strengthening pointed plate, by the manufacturer to the top surface of the boom, can cause weakening and seriously reduce fatigue strength. Another significant observation in support of this failure scenario is the way the boom weld fractured; there is no evidence of longitudinal splitting. I believe the heat-affected zone at the termination of the pointed strengthening plate weld seriously weakened the boom weld seam, causing loss of fatigue strength and resulted in the initiation of fracture. Orienting the tube weld seam to the bottom of the beam keeps the weld seam loaded in compression and will prevent a tension / fatigue type failure.

Conclusions

In the opinion of this metallurgist, the conditions causing the boom fracture are most likely the result of the boom manufacturer's option to place the longitudinal weld seam oriented to the top boom surface. The manufacturer's welding procedure used to attach the pointed strengthening plate caused serious loss of fatigue strength which resulting in a premature fast fracture of the boom.

The immediate corrective action recommended is to notify the manufacturer and have the boom section replaced. A second choice would be to weld repair the fracture and enclose the entire area with a sleeve welded to the boom.

Respectfully Submitted,

Thomas J. Bertone, CPC,SDS
Metallurgy Professor

Figure 1.

Figure 2.

Figure 3.

Figure 4.

Figure 5.

Figure 6.

Figure 7.

Figure 8.

Figure 9.

Figure 10.

Figure 11.

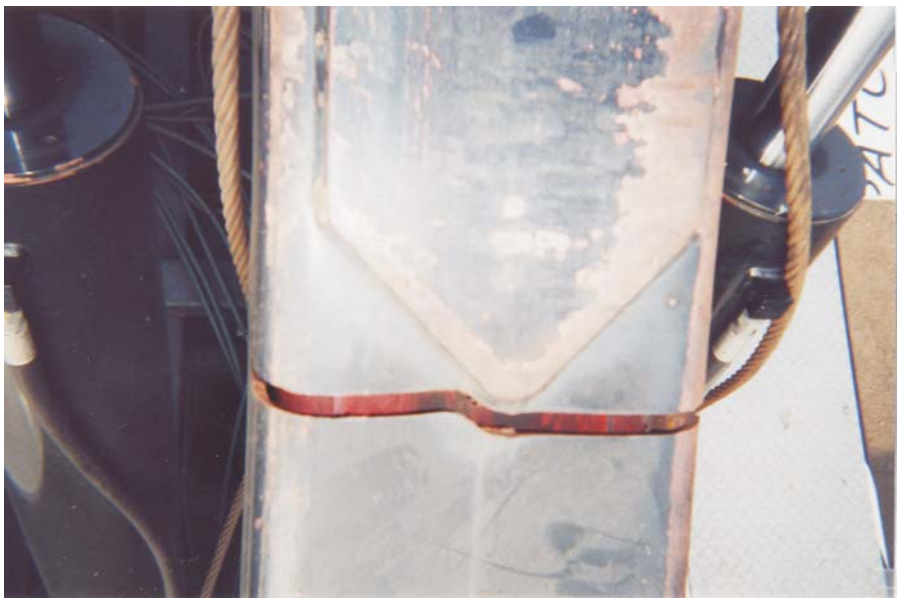

Figure 12.

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