CASE STUDY OF CARBAMIDE PUMP CRANKSHAFT FAILURE

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Crankshaft fracture by fatigue in corrosive environment is presented. The recommendation for ultrasonic in-service inspection of growing crack up to practically defined size is proposed.

INTRODUCTION

Two carbamide pumps are included in production of carbamide in HIP-AZOTARA company in Pančevo: one is in service and the second is a reserve. These are Triplex piston pumps URACA type KD-515. Piston diameter is 80 mm and it's stroke 220 mm. Inlet pressure is 20 bar, outlet pressure 247 bar, capacity 246 lit/min at 76 rpm. Required input power of 107 kW is supplied by steam turbine. Working media is carbamide with inlet temperature of 90.6°C.

In April 1992 crankshaft of pump No 202-A fractured, followed by fracture of other vital pump components. Programme of investigation of this failure is proposed with the aim not only to discover the fracture cause but also to prescribe requirements for inspection and testing of crankshaft on the second carbamide pump.

INVESTIGATION RESULTS

The crankshaft of carbamide pump had been produced by forging in 1967 of MR St.60-2 steel, heat M 123093, with chemical composition as follow (wt %): 0.44 C, 0.27 Si, 0.62 Mn, 0.022 P, 0.03 S.

Visual inspection revealed that fracture surface is slant to longitudinal shaft axis. Larger part of fractured surface has smooth "shell" view, covered by corrosion products, and smaller part is rough with typical surface view (Fig.1). Fractured surface appearance corresponds to fatigue fracture. Smooth surface portion corresponds to fatigue crack propagation, since during successive openings and closures due to variable loadings separated surface faces are in successive contacts, causing friction and wear of highest surface parts and consequent flatness. Final brittle fracture is a consequence of reduced load carrying cross-section area.

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Corrosion reduces fatigue strength by environment aggressive effect. Larger portion of surface, fractured by corrosion fatigue, is covered by corrosion products, deposited during fatigue fracture process, and only on final rough fracture surface no corrosion products can be found. It is to be mentioned that the presence of corrosion products on surface does not confirm corrosion fatigue effect in all circumstances, since they also can be deposited in service on surface fractured by mechanical fatigue only.

Both fractured surfaces can be seen in Fig.1. Typical smooth "shell" fracture surface is divided in two clearly visible zones.

Operating time for fatigue crack initiation cannot be exactly determined, but it is clear that crack initiation process is long enough having in mind low revolution speed and fatigue crack initiation mechanism.

Ultrasonic and metallographic testings had revealed structural inhomogeneity and coarse grain microstructure in close vicinity of cracked area. Basic microstructure corresponds to tempered grained eutectoid with net of carbides (cementite) on grain boundaries. Additional microcracks, parallel to main crack, had also been found, at 2-3 mm distance of fracture surface. In fracture area non-metallic sulfide inclusions were detected. Microhardness values were measured between 93.8-301 HV. The scatter in microhardness value confirmed the evidence of structural inhomogeneity.

CONCLUSION

Carbamide pump crankshaft was fractured in transition radius between shaft and wheel on wheel side by fatigue, initiated in two locations in long time period.

Factors contributing to fatigue crack initiation and propagation can include operational hours, number of start-ups (with possible low-cycle fatigue effect), cavitation (that can increase stresses) and misalignment between power and working pump parts due to foundation denivelation.

With exposed experience in mind, a technique of ultrasonic testing is defined for early fatigue crack detection. By preventive periodic control, once or twice a year during long time stoppage or maintenance it is possible to detect crack indication in an early stage and follow its propagation up to the critical size, when replacement or repair can be required. In considered case, critical crack size can be defined by lubrification hole position (Fig.1) and when crack tip reaches this position repairing actions have to be undertaken.

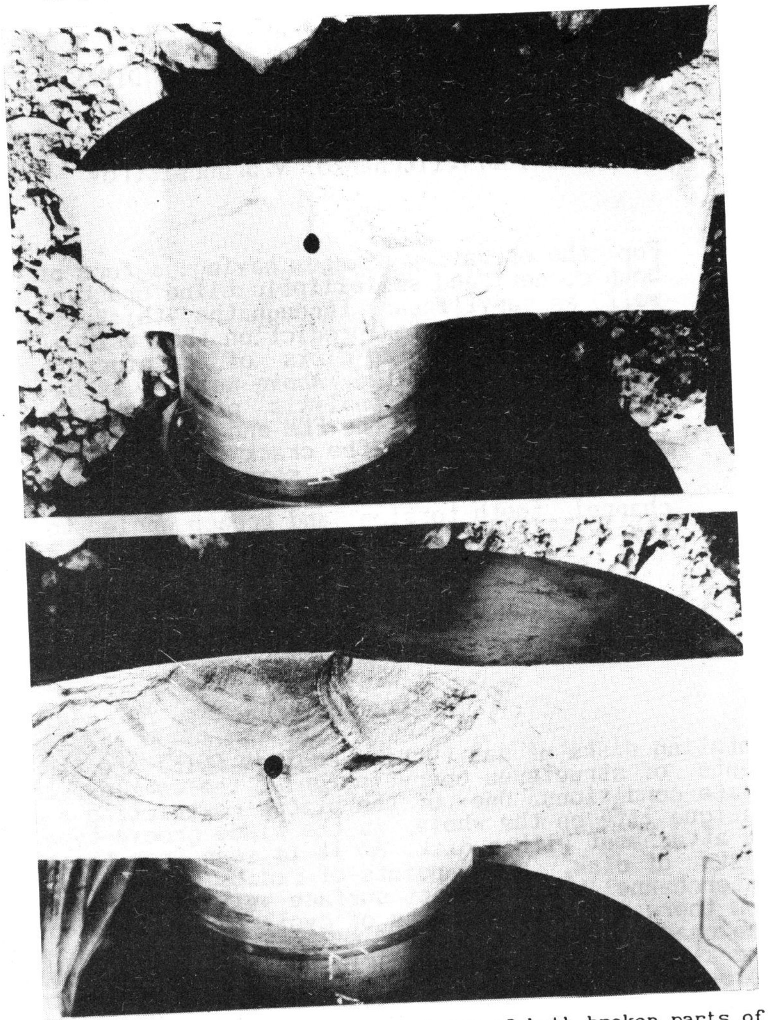

Figure 1 The view of fracture surfaces of both broken parts of a crakshaft.