Maintenance Minders: Extending the Life of Pump Bearings

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How to extend pump bearing life with advanced bearing technology and bearing application engineering.

The initial cost of a pump is a small component of the pump's total life cycle cost. Progressive, proactive maintenance practices are vital to maximize pump life, minimize downtime and avoid costly repairs and lost production.

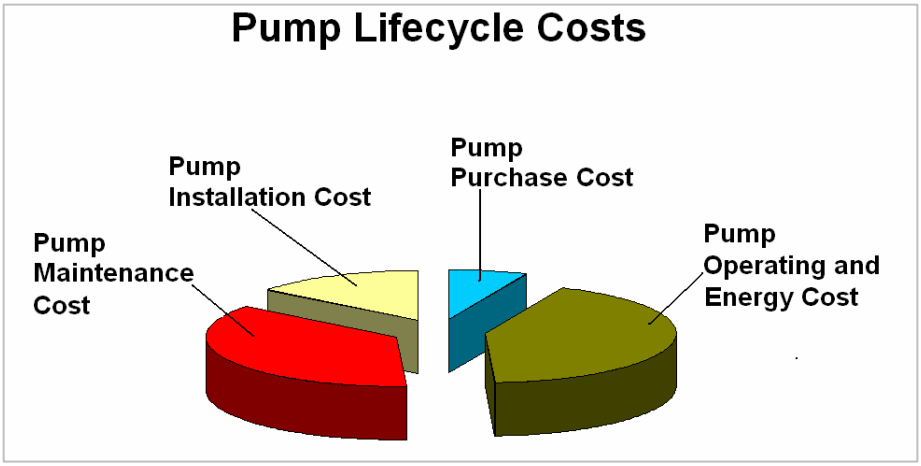

Figure 1. Typical centrifugal pump life cycle costs

Rolling element bearings are also an important component for extending a pump's life. Proper bearing selection in designing, servicing or retrofitting pumps can significantly reduce maintenance costs and elevate product value for end users. Pump bearings should meet and ideally exceed pump standards (such as ANSI/API 610, ISO 13709:2003 and Hydraulic Institute standards)

Pump bearing life can be extended without modifying the pump. Retrofitting rotating shaft systems in the field with new advanced rolling bearings increases reliability and safety and can be achieved without changing the bearing size or modifying the pump.

Advanced bearing technologies such as highly pure steels, advanced heat treatments, optimized contact angles and geometric features can extend bearing fatigue life up to five times that of conventional bearing fatigue life without changing the bearing size to reduce warranty, maintenance intervals and cost per service..

Advanced Bearing Technologies

High Purity 52100 Steel for Centrifugal Pump Bearings

Typical rolling element bearings used for centrifugal pumps are radial ball bearings, angular contact bearings, double row ball bearings and cylindrical roller bearings in various arrangements. Apart from more expensive and exotic bearing materials for unique pump applications, centrifugal pump bearings primarily use bearings made of SAE 52100 steel.

The steel's physical and mechanical properties are critical to developing long life in rolling element bearings. Variation and processing of SAE 52100 bearing material significantly affect the empirical data compared to actual application bearing life (see Figures 2 through 4).

Carbon	0.98
Chromium	1.3 - 1.6
Iron	Balance
Manganese	0.25
Phosphorus	0.025 max
Silicon	0.15 - 0.35
Sulphur	0.025 max

Figure 2. Chemical Composition of 52100 Bearing Steel

Density (lb / cu. In.)	0.283
Specific Gravity	7.83
Specific Heat (Btu / lb / Deg F - [32 - 212 Deg F])	0.114
Melting Point (Deg F)	2595
Thermal Conductivity	240
Mean Coeff Thermal Expansion	6.5
Modulus of Elasticity Tension	29

Figure 3. Physical Properties of 52100 Bearing Steel

	Temperature (C° / F°)		
	21°C / 70°F	200°C / 390°F	400°C / 750°F
Yield Strength (Mpa)	1,400	1,675	920
Tensile Strength (Mpa)	1,410	2,485	1,225
Fracture Strength (Mpa)	1,870	2,730	1,345
Youngs Modulus (Gpa)	200	180	163
Poisson's Ratio	0.28	0.27	0.26

Figure 4. Typical Mechanical Properties of 52100 Bearing Steel

Rolling fatigue life of bearing steel is significantly affected by non-metallic inclusions. The inclusions found in steel are oxides of silicon, aluminum and sulfur. These inclusions are detrimental to bearing fatigue life. Life testing shows that non-metallic inclusions negatively affect rolling fatigue life in 52100 bearing steel, while high purity, homogenous 52100 steel significantly increases bearing life and reliability compared with conventional 52100 steels (see Figure 5).

A 52100 steel image analysis system employed in steel making monitors and controls purity, reduces non-metallic inclusions and improves steel quality.

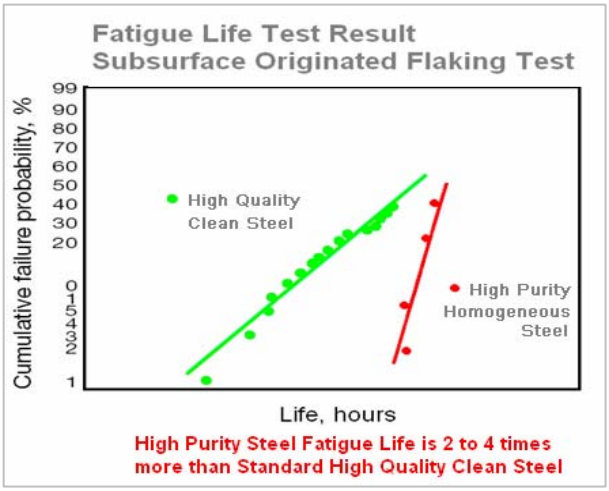

Figure 5. Increased bearing life of highly pure 52100 steel

Heat Treating Technologies

Heat treating increases steel's resistance to wear, providing greater bearing life. This wear resistance helps prolong bearing life under adverse conditions. Advanced heat treatment technologies can significantly extend surface fatigue characteristics beyond industry standard conventional heat treating methods, particularly in harshly contaminated environments (see Figure 6).

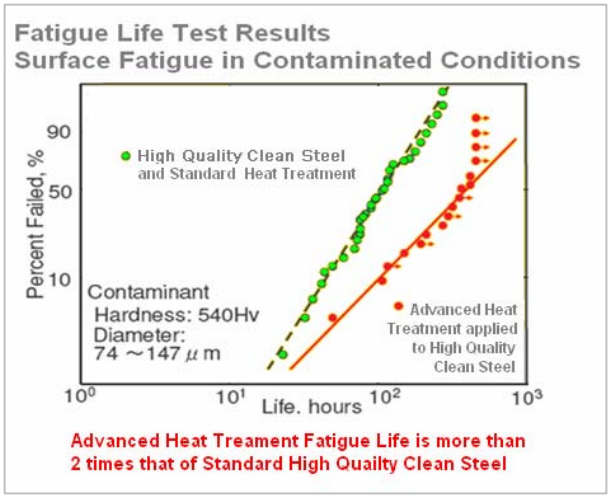

Figure 6. SAE 52100 advanced heat treating doubles life

High purity homogeneous steel coupled with advanced heat treatment creates a material foundation for wear resistance and rolling fatigue life far beyond conventional calculated life. Figure 7 shows the enhanced durability and performance that high wear resistant bearings can provide.

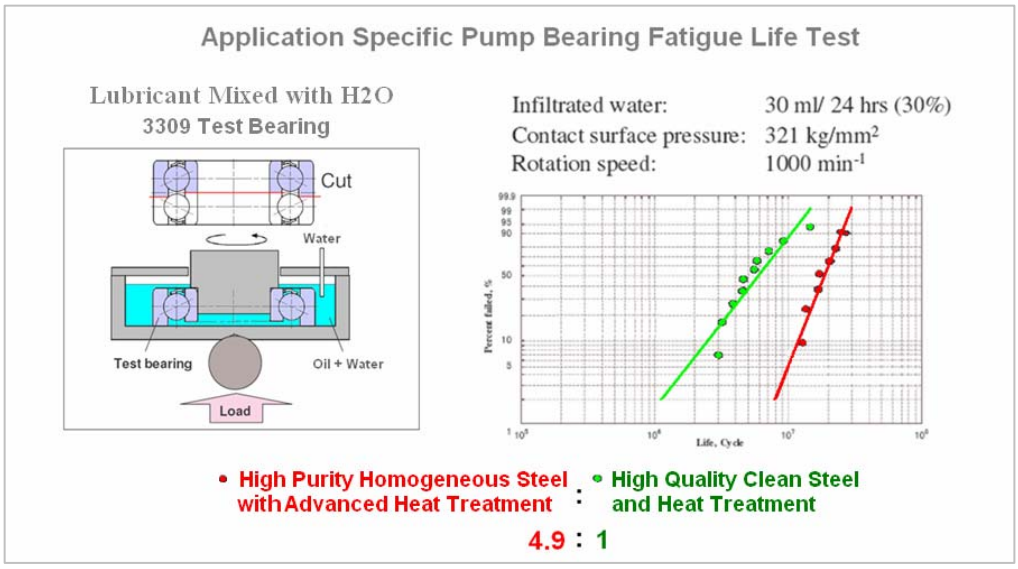

Figure 7. Pump bearing wear resistance in H_20 and oil conditions

Advanced Geometry

Advanced geometric ring and rolling element designs deliver stable, smooth operation; minimize potential for ball skidding under transient/alternating or no load conditions; and provide axial stiffness and strength. External geometric features can improve bearing installation and mounted bearing stability.

Figure 8. Typical angular contact ball bearing and double row ball bearing

Bearing Surface Finishes

Rolling element bearing surface finishes and precision reduce friction and extend life while providing, smooth operation. Newly developed processes improve the topography of bearing raceways and balls, increase the load bearing area of the surfaces separated by the oil film and reduce the micro hertzian pressures in the contact area.

Advanced Cage Design for Improved Lubrication and Strength

Machined Brass

The mechanical construction of advanced machined brass cage designs provides the rigidity and strength to handle heavy and transient load conditions. Improved lubrication under thin oil film conditions and superior load distribution is realized with machined brass cage ball pockets designed to deliver contact interface through precise pocket contour.

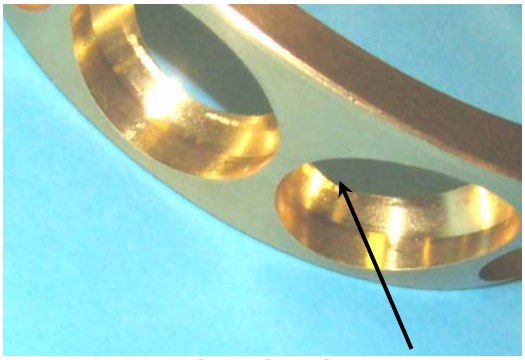

Figure 9. Typical Machined Brass Cage Design

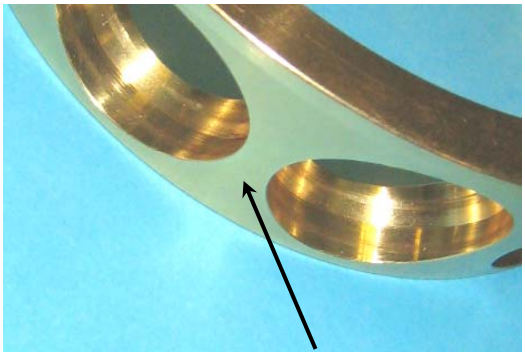

Figure 10. Robust Machined Brass Design

Precision Formed Steel

Improved lubrication is realized with contoured ball pockets. Cage manufacturing and forming lends itself to increased rigidity and strength. An advanced cage design will handle harsh and adverse conditions, heavy alternating loads and contaminated or thin film lubrication conditions.

Figure 11. Typical formed cage design

Figure 12. Superior formed cage design

Conclusion

Bearing application engineers can review an application beyond typical means of bearing life and fit calculations by providing advice on bearing configuration optimization, using finite element modeling and simulation analysis techniques when needed. They can also support pump design enhancements to ensure bearings perform as intended for motion and control of a pump's rotating assembly. Effective bearing application support provides a full array of services and technologies to increase pump bearing life and improve reliability.

Technical collaboration with a bearing partner that can provide solutions and troubleshooting, advanced bearing technologies, services, application understanding and bearing service recommendations is valuable.

As maintenance and reliability techniques improve, bearing material technology will provide improved reliability for difficult applications, extend pump life dramatically and ensure confidence for mission critical applications.

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