Centrifugal Pump Retrofit with Non-metallic Wear Parts

Rotating Equipment Energy Conservation Program

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***Abstract*— as an ongoing effort to improve centrifugal pump reliability and efficiency, Saudi Aramco Riyadh Refinery has developed a program that utilizes non-metallic materials as replacement wear components in place of commonly used metals (such as wear rings, throat bushing etc.). The use of non-metallic material can improve pump efficiency and reliability through utilization of reduced running clearances and by taking advantage low friction. Lower running clearances can reduce vibration and limit the repair cost in the event of a failure. These improvements could help to achieve lower maintenance cost, increased mean time between failure, and reduced equipment downtime. The centrifugal pump improvement would also result in reduced energy cost too. An internally developed program provides guidelines in selecting candidate pumps, procedures, material information needed to retrofit existing centrifugal pumps with high performance composite materials. The program has identified suitable candidates at Riyadh Refinery Units. As a pilot project, Crude Unit De-salter water Pump (Z05-P3B) stationary wear rings were recently upgraded to PEEK based WR-525 non-metallic material. For Z05-P3B metal wear rings, API 610 recommends minimum diametric clearance of 0.48 mm; however with use of non-metallic material, clearance was reduced by 55% to 0.21 mm. As a result of this upgrade, there is a significant reduction of 52% in vibration levels from previous baseline (3.057 to 1.477 mm/sec rms). Also, there is a noticeable increase in pump hydraulic efficiency by 5% over design.**

Keywords—Non-metallic; Centrifugal Pumps; Wear parts; Wear rings; throat bushings

I. Introduction

In centrifugal pumps, wear materials are used as a buffer between rotating and stationary parts. Historically, these components have been metallic in nature. To avoid galling and possible seizure of equipment, dynamic metal clearances are set at a generous minimum. The American Petroleum Institute published Standard which addresses these clearance recommendations. Since January 2003, composite based materials have also been recognized by API STD 610 as suitable wear materials for such applications. In addition, API STD 610 11th edition recognized reinforced composite and Carbon Graphite Composite based components can be installed with a smaller dynamic clearance than metallic components. A smaller dynamic clearance has two distinct advantages. First, the reduced clearance restricts recirculation of process media resulting in a more efficient system. Secondly, the reduced clearance generates increased fluid pressure around the shaft. This has a centering effect that stabilizes the shaft and reduces system vibration. Non-metallic wearing materials are composites that are usually made out of PEEK, PTFE or PFA as the base resin and carbon in continuous or chopped fiber form. Although composite materials are not generally recommended for dry bearing applications, significant speed or loading, they have excellent friction and wear properties and can tolerate short term dry run conditions.

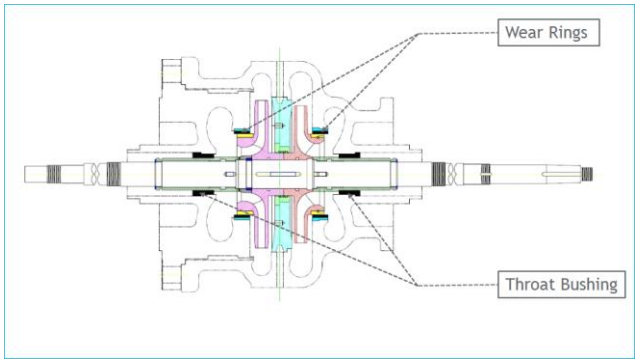

Fig. 1. Centrifugal Pump Wear Parts

For extreme situations, the non-galling nature of composite materials dramatically decreases damage repair costs.

II. Program & Selection of Candidate Pumps

A. Program & Selection of Candidate Pumps

Program provides reasons, procedures, material information needed to retrofit existing centrifugal pumps with high performance composite materials. General guidelines in selecting candidate pumps and how these pumps can be fitted is illustrated. The program has identified suitable candidates at Riyadh Refinery Units.

General Guideline followed in selection of centrifugal pumps are as follows:

1. Pumps with specific speed ≤800 Ns
2. Pumps having service fluid with low lubricity, such as clean hydrocarbons with specific gravity <0.70 and BFW pumps (Aramco Standard 031-SAMSS-004).

Additionally the application should meet following listed criteria:

1. TSS (Total Suspended Solids) <300 PPM
2. Compatibility of service fluid and operating temperature (<180ºC) within the material design.

Based on above criteria, pumps are grouped in 3 groups as follows:

Group 1 (29 Pumps) -

a. Pumps in water service with specific speed ≤ 800 Ns

b. BFW pumps

Group 2 (24 Pumps) - Hydrocarbon pumps with specific speed ≤ 800 Ns AND Specific gravity < 0.70

Group 3 (18 Pumps) - Hydrocarbon pumps with specific gravity < 0.70

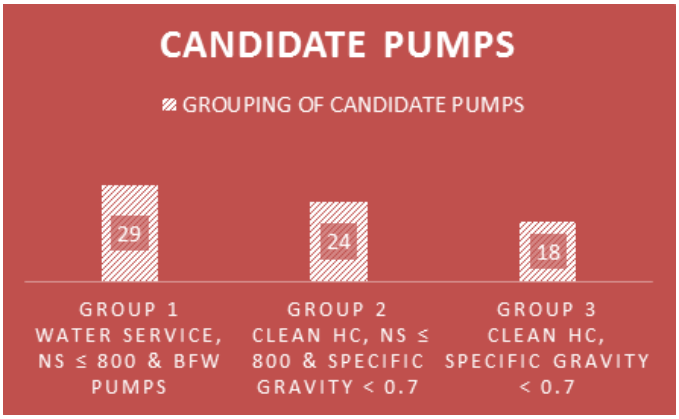

Fig. 2. Grouping of Candidate Pumps.

III. Pilot Implementation

Base on above guidelines, Crude unit de-salter water pump (Z05-P3B) was selected as a candidate for pilot retrofit. Taking into account pump service condition, Greene Tweed WR-525 was chosen as suitable material for the retrofit. Pump casing (stationary) wear rings were changed to non-metallic and impeller wear rings were left unchanged (metallic). Existing case wear rings were machined and used as metal carrier for non-metallic lining.

Design: Saudi Aramco best practice "SABP-G-021 Pumps Retrofit with Non-Metallic Components" and Material supplier document "Greene Tweed WR Design Guide" guidelines were referred for design, machining and installation of WR-525 wear rings. Figure 3, 4 & 5 shows the design of non-metallic wear ring and metal carrier with applied fits and tolerances.

WEAR RING CLEARANCES	
Metallic (API 610 Recommended)	Non-metallic
0.48 mm	0.21 mm (-55%)⬇

Fig. 3. Non-metallic Wear Ring Clearances

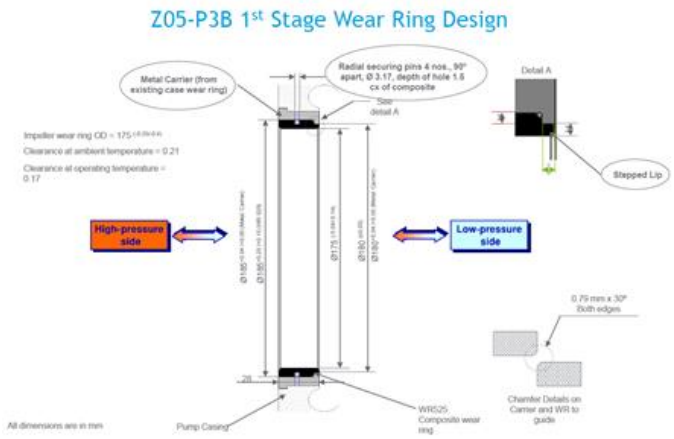

Fig. 4. Wear Ring Design

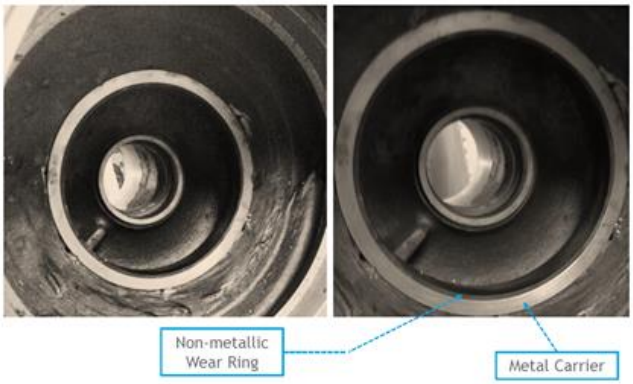

Fig. 5. Non-metallic installed in metal carrier

A. *Machining and Installation Tips*

1. Use diamond film tools
2. Alternate Tooling: Carbide tip tools.
3. Use separate tools for rough cuts and finish cuts.
4. Finish machine dynamic surface after installation
5. Mechanically secure for added precaution.
6. Use exiting case wear rings for carriers.
7. Provide shoulder for high diff. pressure applications.
8. Use thermal fitting for high interference fit.

B. *Pump Performance Post Retrofit*

- Performance trial was conducted for measuring the improvement and results of performance trial are tabulated as under.

Upgraded Pump (Non-metallic Wear Rings)				
HYD. EFF. (η_h) as per curve	Measured Hyd. Efficiency	Power Saving	Motor Amps	Annual Cost Saving
40%	45% (+5%)⬆	~10 KW	134⬇	$1,718

Vibration Improvements (mm/sec rms)			
Base Line	Before O/H	After Upgrade	% Change
3.057	4.288	1.477	-52%

IV. Conclusion

Not every pump is a candidate to be upgraded. There are application where use of non-metallic materials can solve difficult problems. Trial implementation in de-salter pump under the program has resulted in significant gains in centrifugal pump performance, vibration levels and efficiency. These upgrades can help in improving mean time between repairs. In addition, significant energy savings can be realized. This program can help refinery to increase machinery reliability and save money.

References

[1] Greene Tweed & Co., "WR/AR External Design Guide, RevD, May 2013".

[2] Saudi Aramco, Best Practice, SABP-G-021, Pump Retrofit with Non-metallic Components.