CHALLENGES FOR PUMPS HANDLING HOT REFINERY RESIDUUM

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BACKGROUND

- Visbreaker Unit was commissioned in September 1997.
- Two (2) Pumps are in Feed service.Two (2) Pumps are in Fractionator Bottoms Service.
- All pumps are handling hot Crude Oil Residuum with Coke particles.

PROBLEM STATEMENT

- Initially MTBF was low, Year 2000 - 0.4 months.
- Seal failures were predominant (about 80%).
- 10% failures were bearing related.
- High production losses due to plant shutdowns.
- Two (2) fires on the Bottoms Pumps with extensive damage to the pumps.

PUMP DUTY

	Feed	Fract. Botts.
Normal capacity (USGPM)	1050	2042
Differential Head (ft)	1405	982
Pump Speed (rpm)	3550	3550
Pumping temperature (F)	520	662
Viscosity at PT (cp)	24.0	1.8

PUMP DUTY

	Feed Service	Fract. Botts. Service
Seal Design	API 682 Type C – Tandem arrangement 2	API 682 Type C – Tandem arrangement 2
Seal Plans	Plans 32/52.	Plans 32/52.
Pump Size	6x8x13.5 4x6x15	8x10x16
Pump Design	**API Code BB2**	**API Code BB2**

Steps To Solve The Problem

- Checked with Visbreaker Licenser and other Users. Feedback was similar to our experience.
- A significant effort including several Root Cause Analyses (RCA's) from 2000 to present was expended.

Steps To Solve The Problem – Low Cost Initiatives

- **First approach was to address low cost initiatives e.g. Improve seal design, Q.A. repair.**

OBSERVATIONS	CONCLUSIONS / ACTIONS
■The Hastelloy Bellows subject to shearing and temperature set. ■Plan 52 buffer pot not vented .	■ Hastelloy is not suited for high temp. Changed to Inconel 718 with drive lugs. ■See "other future action plans"

Steps To Solve The Problem – Low Cost Initiatives

OBSERVATIONS	CONCLUSIONS / ACTIONS
■Seal faces being scored and residuum solidifying in the outer seals. ■Cooling water inadequate due to header plugging.	■External Seal Oil Flush (Plan 32) was unreliable. A flow meter, valve and pressure gauge added. ■Buffer pot cooling water - project is underway to improve.

Low Cost Initiatives

OBSERVATIONS	CONCLUSIONS / ACTIONS
■ Pressure builds in the buffer tank causing reverse pressurization and at times dislodging inner seal stationary seat.	■ Plan 32 Flush unreliable. Instrumentation added. ■ Better seat retainer required. ■ Tangential ports used instead of radial ports. Buffer fluid changed to synthetic oil (5 to 8 cs @ 104 F).

Low Cost Initiatives

OBSERVATIONS	CONCLUSIONS / ACTIONS
■Different bearings running at different temperatures - some would exceed 250 F (Bearing housing skin) and run to failure. Others would stabilize at 230 F max.	■Slight variances in the bearings were deciding whether "go" or a "no-go". ■Dual oil mist re-classifiers installed and jets directed at the bearing balls.
■Shaft lockup caused by thermal growth.	■Ensured adequate axial clrs (.072" min.) at radial bearing.

Low Cost Initiatives

OBSERVATIONS	CONCLUSIONS / ACTIONS
■Bearing to steel shaft(2.5 – 3”) fit for most pumps require an interference (.0000 - .0005” – k5 or k6 or j6).	■ For these particular pumps, bearing to alloy steel (416SS) shaft require a loose fit (.0000 - .0003” – j5).
■Bearing to housing fit for most pumps require a loose fit (.0000 - .0005”).	■For these pumps, bearing to housing fit require a looser fit (.001 - .002” – j5).

Low Cost Initiatives

OBSERVATIONS	CONCLUSIONS / ACTIONS
■The preceding general guidelines are wrong for these particular pumps.	■Detailed QA/QC sheet developed and used to support shop repair.
■Bottoms Pumps experienced cavitation due to hole size on the suction strainer (1/8”).	■Changed to screens with 5/8” holes.

Steps To Solve The Problem – High Cost Initiatives

- Our second approach was to research the problem further, seek advice from consultants, then to engineer carefully the more expensive measures necessary

High Cost Initiatives

OBSERVATIONS	CONCLUSIONS / ACTIONS
■Seal faces being scored and residuum solidifying in the outer seals.	■To improve the Plan 32, a Booster system for flushing installed. It consisted of dual pumps, dual filters, surge tank and instrumentation. Installed cost – US$ 120,000. Completed mid 2003.

High Cost Initiatives

OBSERVATIONS	CONCLUSIONS / ACTIONS
■Pumps were oversized and Nss was high, about 13,000. ■Bottoms Pumps sometimes run at 32 – 46% of BEP whereas the minimum flow should be 50% of BEP. Flow could drop to as low as 5%.	■Need to buy pumps with a better hydraulic fit. ■Commissioned one new feed pump in 2004, cost – US$ 200,000. For one new bottoms pump, order placed Sept. 2007.

High Cost Initiatives

OBSERVATIONS	CONCLUSIONS / ACTIONS
■ Different bearings would run at different temperatures - some would surpass 250 F and run to failure. ■ By design, sleeve bearings would be insensitive to thermal expansion effects.	■ Bearing housing skin temperature < 180F are desired: - - For new feed pump, fan cooled ball bearings used. - - For bottoms service, sleeve bearings are now specified.

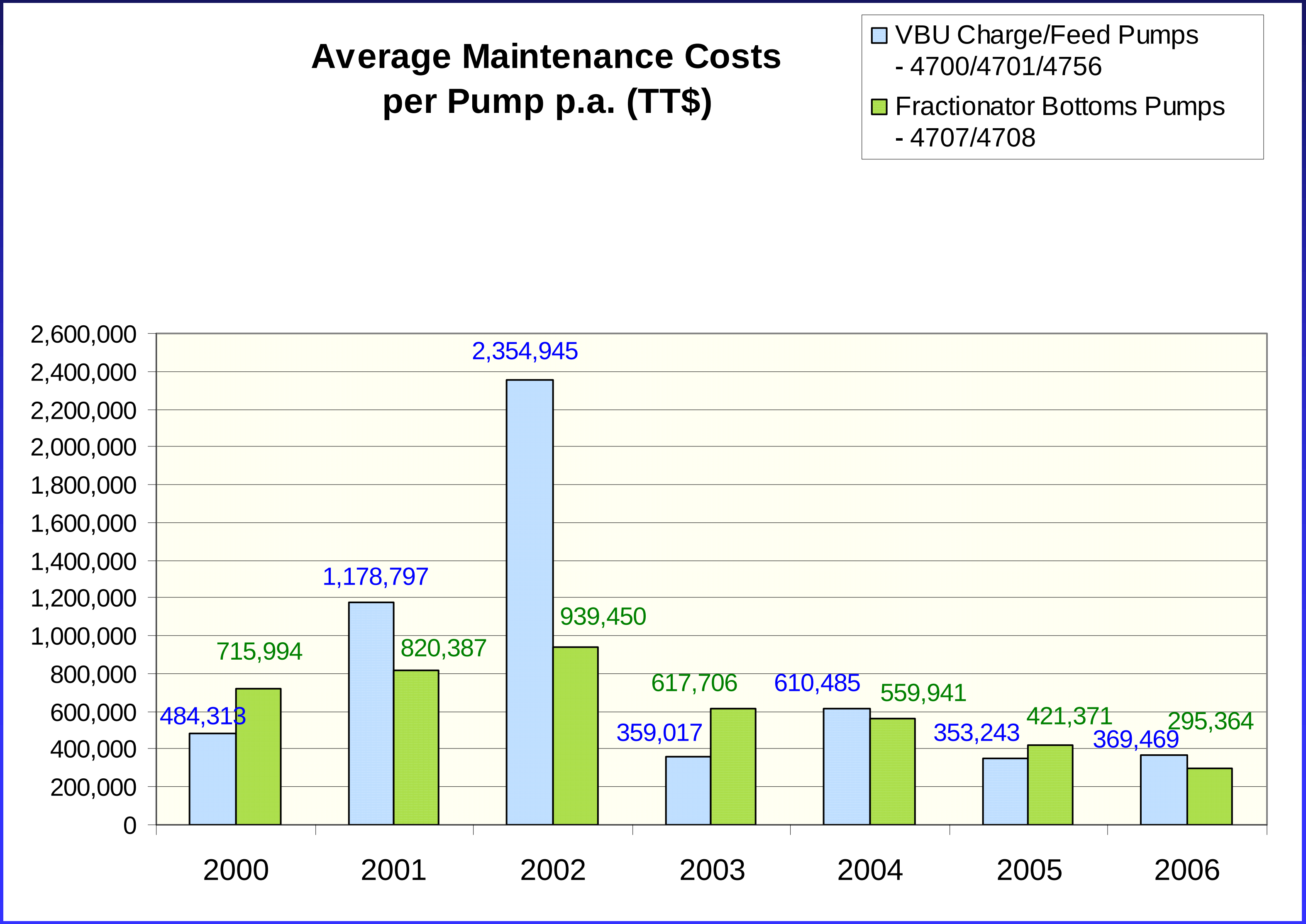
High Cost Initiatives

OBSERVATIONS	CONCLUSIONS / ACTIONS
▪ For the feed pump (2 Stage), the inter-stage seal cavity was subject to high pressures (160 to 200 psig). This was causing overheating at the seal faces.	▪ For the new pump, the inter-stage end seal cavity was fitted with Colmonoy and Graphalloy throat bushings on either side of the leak-off to reduce the pressure to 120 to 150 psig .

RESULTS REALIZED

- MTBF has been improved from 0.4 months (in Year 2000) to 12 months (in Year 2006).
- Occasional Bearing housing skin temp of 250 F on the old pumps have reduced to 230 F max.
- Maintenance cost per pump p.a. has reduced US $ 158,000. in year 2001 to US $ 53,000. in 2006.
- Production losses substantially reduced.

RESULTS REALIZED



LESSONS LEARNED

- Even properly installed API-52 &53 plans with barrier fluid pots are unsuitable for these services.
- If ball bearings are used, the design should limit bearing housing temp to 180 F max.
- Plan 32 flushes need to be properly designed with controls to maintain product isolation.
- Follow a specific repair procedure.

OTHER FUTURE ACTION PLANS

- To address the ultra-low bottoms flows (5% BEP) during plant startups and shutdowns :
  - Modify operating procedures.
  - Investigate control changes to enable more stable temperature and level control.
  - Install a minimum flow recycle loop.

OTHER FUTURE ACTION PLANS

- Install new dual mechanical seal arrangements (alternates) :
  - API 682 2CW-CS with steam as the buffer fluid.
  - API 682 3CW-BB (or FB) with plan 54 external barrier fluid circulator system.
- Upgrade the second pump in both services.

Picture 1: *East Pump Interstage End – Inner Seal Face (Rotating)*

Picture 2: *West Feed Pump Interstage End – Inner Seal Face (Stationary)*

Picture 3: *West Feed Pump Interstage End – Inner Seal Bellows (Rotating)*

Coke stuck
on face

Picture 4: *West Feed Pump Suction End – Inner Seal Face (Stationary)*