Rotating Equipment Energy Conservation Initiatives

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***Abstract*—Riyadh refinery has developed separate comprehensive program for each of the following categories: Compressor re-rates, Fin Fan Blade Upgrade, Hydraulic Re-rates & Non-metallic Wear Parts. This paper aims to highlight comprehensive energy assessment carried out on different types rotating equipment to identify energy saving opportunities and candidate equipment under each category-ry. Successful cases histories are also shared in brief to highlight the benefits realized in terms of energy saving and improvement in equipment reliability.**

Keywords—Rotating Machines, Energy Efficiency, Energy Conservation.

I. INTRODUCTION

With the surge in local demand for energy and higher capital cost of new energy generation projects, energy conservation has become an area of high importance for the industry as a whole and the Oil and Gas processing industry in particular. In refineries, energy cost may reach up to 50% of the total plant operating cost. There is an ever growing need to find out on constant basis where the energy dollars are going and how to save it as much as possible. Rotating equipment are the largest consumers of the energy in a Refinery and studies have shown that over 20% of the energy consumed by these systems could be saved through equipment or control system changes. At Saudi Aramco Riyadh Refinery, Reliability Unit has embarked on a drive to improve rotating equipment reliability and efficiency as a part of ongoing efforts by refinery to improve its Energy Intensity index (EII).

Rotating equipment energy conservation initiatives are broadly categorized as under: (1) Compressor re-rates, (2) Fin-fan Upgrades, (3) Hydraulic re-rates of pumps, (4) Use of non-metallic wear parts in pumps.

Those initiatives came after the data collection and analysis of plant energy consumption, which reduces the power at each type of rotating equipment. Then, prioritizing the available solutions based on the cost, efficiency and reliability.

II. COMPRESSOR RE-RATES

This program is basically focusing on compressors potential saving by surveying the plant compressors and analyzing the power consumption.

It was evaluated to select the proper technique based on the study outcomes in case of potential improvement of power consumption.

Case Study: Wet Gas Compressor

This is a case study of rerating one of the compressors in RRD which is Wet Gas Compressor.

The compressor was significantly over sized due to the change of crude specification. The crude stabilization was processed in CSF in RRD where the compressor is handling the rated flow, but since the crude source changed, it became stabilized before feeding the refinery, hence the gases reduced as shown in Table 1.

Max. Flow	48,000 Nm3/h
Min. Flow	24,000 Nm3/h
Normal Flow	12,000 Nm3/h
Recycled Flow	12,000 Nm3/h
Power Consumption	3.1 MW
Suction Pressure	0.9 Kg/cm2
Discharge Pressure	5.0 Kg/cm2

Table 1 Previous Parameters

Reverse engineering was carried out for the compressor, and as a result rotor & diaphragms were changed along with the inter-stage seals. As a result of the modification, the recycled flow reduced 12000 to 4000 m3/h. Power consumption reduced by 45% to be 1.7 MW instead of 3.1 MW. Total power saving is 1.4 MW equivalent to 0.5mm $ annual cost saving. Another Benefits:

- Avoid surge problems.
- Avoid flaring in summer. $200M/Y
- Total Project Cost: $2.5 MM
- The project payback period is 2.5 years

III. FIN FAN UPGRADE

This initiative aims to reduce energy consumption in fin fans by improving the aerodynamic performance. This would be done by upgrading the fan blades from aluminum to curved fiber plastic

Case Study: Upgrade fan blades of R215-E24 M5

Upgrade has been implemented for R215-E24 M5 in the refinery. This fan has a number of 12 blades with 14 ft diameter and speed of 195 rpm. The air flow measured at 12 locations with 3x readings and it’s approximately 230000 ACFM. Amps was also collected which’s 74. The readings was taken before and after upgrade the blades from aluminum to curved fiber plastic.

As a result of the upgrade the power consumption reduced by 25% from 43.5 to 33.1 KW. This equivalent to $3645 annual cost saving.

IV. Hydraulic Re-rates & Power Optimization

The main objective of this initiative is to go over all plant's pumps and evaluate for energy losses such as recycled flow or throttling or even possibility of optimization. Based on the study outcomes, the proper technique will be selected either trim, upgrade or replace if needed. There are five pumps were upgraded form 27 potential pumps.

Case Study: Re-rate of Hydrocracker Debutanizer Feed Pump

This is a case study of Debutanizer feed pump, in Hydrocracker unit. The pump was oversized and suspected high recirculation and vibration. Table 2 shows the pump specification. It's centrifugal, between bearings. It is pumping hydrocarbon with capacity of 350 m3/h, and bhp is about 214 KW.

Type	Centrifugal, b/w Bearing
Capacity	319.3/350.9 m3/hr
TDH	218.9 m
Sp. Gr.	0.727
Pressure Suc./Disch	7.1/23 kg/cm2
Liquid	Hydrocarbon
Driver	Motor, 3560 RPM
BHP	214.2 KW

Table 2 Pump specification

An outside engineering company was contacted to proceed with reverse engineering, hence new impeller & shaft were manufactured along with wear rings. Table 3 shows the old & new material of the manufactured parts.

#	Description	Original material	Upgraded material
1	Shaft	Carbon Steel SCM4	AISI 4140 HT
2	Impeller	Cast iron FC25	CA6NM
3	Impeller wear ring	SUS420 J2 HT	SUS420 J2 HT
4	Casing wear ring	SUS420 J2 HT	SUS420 J2 HT

Table 3 The old & new materials

As a result of the re-rate, the flow reduced from 350 to 150 m3/h, which is less than 50% reduction of original flow, with minor reduction in the head as shown in Table 4. The change in parameters, result in power consumption, where it reduced by 55% from 200 to 90 KW. Annual cost saving is $16,000.

Performance Data	Before	After
Flow m3/h	350	150
Head m	219	200
Impeller OD mm	362	360
NPSHr m	4.6	4
*Consumed power KW	200	90

Table 4 results after reverse engineering

Non-metallic Wear Parts

As an ongoing effort to improve centrifugal pump reliability and efficiency, Reliability Unit 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 of significantly reduced friction. The unique properties of the material can reduce vibration and significantly decrease repair cost when a failure does occur. 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.

There are 71 candidate pumps where they're grouped into three groups, based on S.G & the specific speed.

Case Study: Crude De-salter Water Pump

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 diametral 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 which corresponds to ~10 KW of power saving. On comparison with sister pump (w/ metallic wear rings), P3B pump is drawing 17% lower current than P3A (134 Amp as against 161 Amp in P3A).

Conclusion

Table 5 shows the overall summary of the program for each mentioned category. The total power saved is 1800 KW with the target is to reach more than 3 MW.

Initiatives	Power Saving KW		Progress %
	Completed	Plan	
Compressor Re-rates & Power Optimization	1400	-	100%
Fin Fan Upgrade	215	212.5	45%
Hydraulic Re-rates & Power Optimization	176	950	25%
Non-metallic Wear Parts	12	303	25%

Table 5 Overall summary

The compressor re-rating has been implemented for one compressor, and there are few are under evaluation to capture the potential energy saving. The upgrade is ongoing for the fin fans where it reaches 45% of the target saving (427.5 KW). Most of power that could be saved is thru pumps, as it's targeting almost 1 MW. Currently, the 25% completed for several equipment, and the rest is under planning as well as the non-metallic upgrade initiative.

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