Technique to Assess and Improve Refinery Performance

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BACKGROUND & INTRODUCTION

Starting with the first refinery built in Margherata in 1883 and subsequently relocated in Digboi in 1901, India today has refineries at 14 locations with a totoal refining capacity of 60.55 million tonnes per annum (MMTPA). While several revamps/energy efficiency measures have been carried out in each of these refineries, it is worth noting that most of the refineries in India were designed in the 1970's or earlier when there was no energy crisis.

In order to meet the continuously increasing demand of petroleum products which grew at an average of 7% during 8th five year plan period, additional refining capacity of 70 MMTPA has been approved for implementation by the financial year 2001 -2002. This will augment indigenous refining capacity to about 130 MMTPA which will turn India from net importer to exporter of petroleum products. As the administered pricing Mechanism (APM) is being dismantled in phased manner, the refining sector will witness intense competition. Energy consumption in refineries, as in any process plant constitute a major operating cost component. Cosequently, refineries have been making concerted efforts to reduce energy consumption.

Energy in refineries is consumed in the following ways: As direct fuel in process heaters.

As indirect fuel for raising steam or generating power.

As power for drivers.

Further, there are hydrocarbon losses during processing, handling, storage besides normal flare losses and leakages. The total energy consumption in terms of oil equivalent (FOE) and hydrocarbon losses is terms as 'Fuel' and 'Losses' respectively. Fuel and loss, calculated on weight percent of crude throughput, has reduced from an average of 6.9% in 1984-85 to 6.2% in 1996-97 in the Indian refineries. This is still considerably higher than the 4% achieved in developed countries. Reducing fuel and loss in the Indian refineries by even 1% will save around Rs. 300 crores annually at the current crude refining capacity levels. In nut shell, fuel saved is equal to fuel produced and resultant reduced environmental pollution acts as an additional bonus. Designing energy conservation programmes through "Benchmarking" and "Targeting" strategies is a viable and realistic approach to identifying the constraints in existing performance as well as the potential energy conservation.

INTERNATIONAL PRACTICES

Various international agencies have been carrying out the review of existing refinery operation and performance for energy efficiency improvement on routine basis through their own tools and techniques. Earlier KBC-UK and British Petroleum - UK carried out energy audit of various Indian refineries. Recently, Solomon Associates have carried out 'Comparative refinery performance analysis' which included 'energy' as an attribute in the refinery performance analysis. Following is the brief summary of energy audit practices adopted by various international agencies:

SOLOMON ASSOCIATES

M/s Solomon associates (SA), primarily a management consulting company to petroleum refineries, carry out refinery performance analysis for participating companies worldwide on a regular basis. Since 1980, M/s Solomon have enlisted and analyzed the performance of 300 refineries globally. The surveys are carried out for a calendar year on a biennial basis. For the calendar year 1996. seven refineries from India namely BPCL, HPCL, CRL and IOCL (Haldia, Mathura & Gujarat) refineries participated and were included in the above survey.

STUDY METHODOLOGY

Each refinery data is converted to a common base called Equivalent Distillation Capacity (EDC) which takes info account configuration & multiplicity of the refinery. For analysis of refinery performance, configuration factors have been developed in-house by SA which are unit specific based on manpower, energy, operating cost etc. These configuration factors which are similar to that of Nelson, have been modified based on data collected by SA from their 300 member refineries. Performance and ranking of each refinery is interpreted in terms of number of indices such as Energy intensity index, Volumetric expansion index, Value added index, % Refinery utilization, Mechanical availability without shutdown etc. Moreover, SA also carries out a financial analysis by computing indices such as Gross margins, cash operating expenses. Annualized turnaround expenses etc.

The survey by SA mainly focuses on utilization of various resources such as plant facilities, energy, personnel etc. for maximization of return on investments. The standard energy consumption of each process unit for comparison with actual energy consumption is calculated in terms of KBtu/bbl of feed using SA energy standard equations. These surveys do not take into account constraints such as type of crude that can be processed, product pattern vis-a-vis local demand, ability to import/ export crude/product etc. Also, these surveys do not identify the unit specific areas where energy saving potential exists.

BRITISH PETROLEUM

M/s British petroleum (BP), primarily engaged in petroleum refining and marketing have also been carrying out Energy management studies. In past, in India they have carried out energy audit for BPCL refinery.

STUDY METHODOLOGY

BP calculates the refinery energy consumption based on main consumption parameters such as steam, cooling water, fuel and power. Net energy consumption of a unit is calculated after taking into account all energy exports and imports through process streams. For refinery performance evaluation, BP calculates Energy performance index (EPI), which is based on the ratio of acutal energy consumption and the guideline energy consumption for the same unit/operation. EPI is used as a tool for judging relative unit performance with respect to the bench-mark for that process. Further to calculating EPI, energy loss analysis is carried out and energy performance improvement plan is prepared. Initially, EPI calculation is done on monthly basis, the frequency of which is increased subsequently using online DCS.

EIL APPROACH

Based on the present technologies and considering the international norms, energy consumption "benchmarks" have been developed by EIL. The basis and approach for the same is presented in the subsequent section. Further to establishing energy benchmarks, EIL also established energy "targets" for each refinery, which have been computed after analysing complete operating and design data of refinery units keeping in view their constraints. A brief introduction to energy benchmarking and targeting approach adopted by EIL is given hereunder.

BENCHMARKING

The term "Benchmark" originally meant a surveyor's mark-out in a rock used as a point of reference. It has come to mean anything taken as a point of reference or comparison. In today's competitive world, benchmarking is recognised as an effective approach towards improvement in productivity, quality and other dimensions of performance that are determinants of competitiveness.

Benchmarking can be categorised in many different ways, according to various criteria. Benchmarking is of four types:

Result benchmarking (Inter firm Comparison). Product benchmarking (Quality Profilling). Process benchmarking.

Strategic benchmarking (Business profilling).

The role of benchmarking is to provide management with knowledge of what constitutes "best performance" or "superior performance" in a particular field. The benchmarking, as applicable to a process unit, can be for capacity utilisation, product quality, energy consumption or any other performance criterion. In a given situation, energy consumption is the single most important area in which the relative performance of the units can be widely different. Consequently, it is also the area which offers maximum potential for improvement in performance.

Energy conservation through benchmarking can be broadly categorised as "Process benchmarking" involving the following basic steps:

Identify the best available technology for the individual process units.

Collect information to thoroughly understand the process and identify key/controlling parameters. Determine the performance of the process unit.

Analyse the gap between the existing and the benchmark for the key controlling parameters. Set targets or benchmarks, keeping constraints in view, and Implement improvements based on findings.

ENERGY BENCHMARKING IN INDIAN REFINERIES

The operation and energy consumption of refineries in India vary with their size, technology adopted, location and other factors. In order to uniformly judge the performance of individual refinery in terms of their energy consumption. EIL, in association with Centre for High Technology (CHT) has established the energy benchmarks of process units based on the best available technology employed in commercial applications for the given process. Given hereunder is a brief description of the basic methodology and the approach adopted for establishing energy benchmarks for the process units:

(1) The utilities considered for calculating unit energy consumption have been identified as:

Fuel oil/Gas. Steam. Power.

Cooling Water.

(2) The benchmarking of process units and steam & power generation system has beenestablished based on the design data available from the latest EIL designed units. The energy consumption data for similar units designed by overseas licensors as well as energy audit reports available for recently conducted surveys have been also taken into account.

(3) In the case of licensed units, benchmark energy figures are based on the utility information furnished by the licensor in the process design packages for each of the units.

(4) For lube units, especially Dewaxing, there could be a wide variation in the unit energy consumption due to large number of process variables as well as due to the variation in the technologies adopted. Based on the technology details available and data received from existing Indian lube refineries, the benchmarks applicable for the lube units have been worked out.

(5) Energy figures have been estimated based on minimum economic size of the unit.

(6) The energy figures are based on normal operation of units without taking into account start ups/shutdowns, intermittent utility requirements, emergencies and upset conditions. However, the intermittent utilities required for process (and not maintenance- related), such as power consumption during coke cutting in a delayed coker unit, are included for estimating energy consumption.

(7) The following is the basis for computing benchmark unit energy consumption: Estimates are based on design energy onsumption figures.

Payback period = 3 years for cost benefit analysis.

Estimtes are for acutal unit configuration. No complexity considerations are taken into account. Credit has been given for any heat export from the nit. Energy imports into the unit in the form of hot feed or any other hot stream have been duly accounted for.

All drives in an unit are considered to be electrical unless specified otherwise.

(8) The variation in unit energy consumption with type of feedstock has been studied in case of crude and vacuum distillation unit. The relationship between unit energy consumption and % residue for CDU/VDU has been established.

Based upon the above-mentioned approach, unit standard configuration has been established as the benchmark configuration.

The energy benchmark numbers were thus computed in terms of energy per barrel (BTU/bbl) of feed processed. Actual energy consumption based on 1994-95 operating data and benchmark energy numbers for major process units are tabulated (Refer Table 1). The wide gap between the actual energy consumption and the benchmark is evident.

ENERGY TARGETING IN INDIAN REFINERIES

Consequent to establishing energy benchmarks, need was felt to review the performance of individual refinery units separately, keeping in view their configuration, feed stock availability product pattern requirement, flexibilities, local constraints etc. The energy targets have been established based on the following methodology:

1. The design and operating data for the process units, steam and power generation systems, offsites was obtained from individual refineries in the standard formats for the year 1994-95. The data was analysed for completeness and validated after interaction with individual refineries.

2. Evaluation of following critical parameters of individual unit performance in comparison to their design and benchmark values:

Feed preheat temperature.

Product temperature at cooler inlet. Stripping steam rate.

Heater efficiency.

3. Identification of gap areas for optimising energy consumption keeping in view local constraints and quantifying the potential energy.

4. Calculation of unit actualoperating energy consumption.

5. The target energy consumption for the individual refineries have been computed for fuel oil/gas, steam, power and cooling water utilities considering the following conversion factors uniformly:

1 Ton of fuel oil = 13 Tons of steam = 3600 KWH - 20,000m3 cooling water = 10,000 kcal/kg Fuel oil calorific value

6. Non refinery operations were excluded while fixing the energy target for the refineries.

ANALYSIS OF ENERGY BENCHMARK AND TARGET

Wide ranging gaps between actual, benchmark and target energy consumption have been found. Potential energy saving in feed preheat temperature. product temperature at cooler inlet, stripping steam rates and heater efficiency have emerged. Study of the existing steam and power systems has revealed that presently only 30% of Indian refineries employ gas turbine based cogeneration system. Not many of these are based on optimum configuration, since gas turbines are generally added to the existing captive power plant, as and when the need arises. Major constrains in Process Units Steam & Power Plants refineries in improving energy consumption are:

" Uneconomically small size of process units for example North-East refineries, MRL- Nagapattinam etc,

Vintage equipment especially fired heaters, boilers, compressors etc. Old processes having very high energy consumption.

Available space constraints for envisaged modifications. Study has established energy saving potential as listed in Table 2. Suggested approach for optimising energy consumption is :

Compare key parameters and identify potential areas. Gradation of potential areas in terms of savings and payback.

Implement the economically viable schemes.

CONCLUSION

Energy consumption in refineries, as in any process plant constitute a major operating cost component. With the gradual dismantling of administered pricing mechanism, building of large capacity new plants with modern technologies, the older Potential between actual and benchmark

20% 15-43% refineries will face stiff competition and pressure on their profit margins. Benchmarking and

Targeting are recognised attributes globally employed to remain more competitive and can also be used as management tools for improvement in performance and criteria for technology selection for new plants. The report fixing bechmark for individual process units, steam and power systems and energy targets for individual refineries has been already released to the refineries for their further perusal. It is recommended that benchmark and targets should be regularly updated which will help the operating companies to judge their performance as well as to remain globally competitive.

Table 1 : Comparison of actual energy consumption with benchmark for major process units

S.No.	Unit	Actual energy consumption in Indian refineries*, in BTU/BBL	Benchmark energy BTU/ BBL
1.	Crude distillation (stand-alone)	74,640-123,900	73,600-78,650
2.	Vacuum distillation (stand-alone)	86,200-198,400	65,330
3.	Crude and Vacuum (integrated)	104,900-155,700	88,000-109,000
4.	Naphtha Splitter	102,660-236,740	102,150
5.	Fluid Catalytic Cracker (with coke)	256,675-505,000	250,400
6.	Delayed Coker (LR)	370,100-421,140	316,710
7.	Aromatics Recovery	654,175	505,840
8.	Hydrocracker (once-through)	433,300	262,320
9.	Hydrogen	87,387-110,850	66,930
10.	Propane Deasphalting	454,380-573,255	261,640

** Based on actual operating data for the year 1994-95.*

Table 2 : Energy saving potential in the refineries

	Energy saving between actual and target	Potential between actual and benchmark
Process Units	8-10%	20%
Steam & Power Plants	8-10%	15-43%

REFERENCE:

http://www.centreforhightechnology.com/Literature/Articles/Energy_benchmarking.asp

Energy benchmarking & targeting - a technique to assess and improve refinery performance D. K. Gupta, S. K. Handa & *S. K. Saxena,Engineers India Limited, New Delhi