

ASSESSMENT OF ENERGY CONSERVATION POTENTIAL IN PETROLEUM REFINERIES THROUGH BENCHMARKING AND TARGETING TECHNIQUES

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INTRODUCTION

Petroleum refineries are energy intensive processes. Energy is consumed mainly as direct fuel in process heaters, indirect fuel for raising steam or generating power and power for drivers. The total energy consumption may be calculated on weight percent of crude throughput and termed as 'fuel and loss'. Fuel and loss of 6.2% in 1996-97 in the Indian refineries 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 for the crude refining capacity of 60.55 million tones per annum (MMTPA). Fuel saved is more than fuel produced (considering production and transportation losses) with an additional bonus of resultant reduction in environmental pollution.

Designing energy conservation programmes through benchmarking and targeting strategies is the most viable and realistic approach to identifying the constraints in existing performance as well as the potential energy conservation.

This paper highlights the methodology and major potential areas of energy conservation emerged out by establishing the energy benchmarks and targets for Indian refineries. This paper also covers emerging trends and new concepts, which can be used, while designing the new process unit.

BENCHMARKING

Benchmarking is defined as a point of reference for comparison. The role of benchmarking is to provide management with knowledge of what constitutes best performance in a particular field.

The benchmarking, as applicable to a process unit, can be for capacity utilization, 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. Benchmarking, in today's competitive world, is recognized as an effective approach towards improvement in productivity, quality and other dimensions of performance those are determinants of competitiveness. Therefore, energy benchmark of a process is the most energy-efficient reference point for comparative evaluation of the energy-efficiency.

Energy benchmarking of a particular process involves the identification of the best available technology for that process, collection of information for thorough understanding of the process and identification of the key parameters, determination of the performance of the process, analyzing the gap between the existing and the possible improvement key parameters, identification of the constraints, and implementation of the improvements based on these findings.

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. Most important of benchmarking procedures are by M/s Solomon Associates and M/s British Petroleum. M/s Solomon Associates (SA), in their procedure, converted each refinery data to a common base called equivalent distillation capacity which takes into account configuration and multiplicity of the refinery. This procedure mainly focuses on utilization of various resources such as plant facilities, energy, personnel etc. for maximization of return on investments. However, this does 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. M/s British Petroleum (BP), to benchmark a unit, calculates the refinery energy consumption based on main consumption parameters such as steam, cooling water, fuel and power. An energy performance index, which is calculated based on the ratio of actual energy consumption and the guideline energy consumption for the same unit/operation, is used as a tool for judging relative unit performance with respect to the bench-mark for that process. Importantly, both these methods do not identify the unit specific areas where energy saving potential exists.

To overcome the existing deficiencies, EIL has developed a benchmarking and energy targeting methodology, based on the present technologies and considering the refinery complexities and also the international norms. The basis and approach for the same has been presented earlier [1].

The major findings for benchmarking of Indian refineries are summarized in the following section.

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 Center for High Technology has established the energy benchmarks of Process units based on the best available technology employed in commercial applications for the given process [1]. The energy benchmark numbers are calculated in terms of energy per barrel (BTU/bbl) of feed processed. Table 1 shows the benchmark energy numbers for major process units against the actual energy consumption based on 1994-95 operating data. The wide gap between the actual energy consumption and the benchmark suggests the possibility of considerable improvement in energy-efficiency in Indian refineries.

Table 1: Comparison of Actual Energy Consumption with Benchmark for Major Process Units

#	Unit	Energy Number (Btu/Bbl)	
		Benchmark	Actual (1994 – 95)
1	Crude distillation (stand-alone)	73,600-78,650	74,640-123,900
2	Vacuum distillation (stand-alone)	65,330	86,200-198,400
3	Crude and Vacuum (integrated)	88,000-109,000	104,900-155,700
4	Naphtha Splitter	102,150	102,660-236,740
5	Fluid Catalytic Cracker (with coke)	250,400	256,675-505,000
6	Delayed Coker (LR)	316,710	370,100-421,140
7	Aromatics Recovery	505,840	654,175
8	Hydrocracker (once- through)	262,320	433,300
9	Hydrogen	66,930	87,387-110,850
10	Propane Deasphalting	261,640	454,380-573,255

For crude and vacuum distillation units, the variation in unit energy consumption for different types of feedstock has also been taken into consideration while benchmarking these units.

ENERGY TARGETING

Consequent to establishing energy benchmarks, it is important to review the performance of individual refinery units separately, keeping in view their configuration, feed stock availability, product pattern requirement, flexibility, local constraints etc. and identify the possible scope for energy-efficiency of the Indian refineries. The methodology by which the possible energy conservation opportunities may be identified to bridge the gap between the existing and benchmark energy consumption is known as targeting.

The design and operating data for the process units, steam and power generation systems, offsites was obtained from individual refineries. The data was analyzed for completeness and validated after interaction with individual refineries. It was identified that feed preheat temperature, product temperature at cooler inlet, stripping steam rate, and heater efficiency are the critical areas of improvements. The following are the identified energy conservation opportunities [1].

- a. Improvement of feed preheating to reduce fired heater duty.
- b. Improvement of fired heater efficiency to reduce fuel consumption.
- c. Reduction in steam tracing and losses to reduce steam consumption.
- d. Reductions in atomizing steam for fuel oil combustion in the burners.
- e. Reduction in product run-down temperature to save overall energy consumption and cooling water demand.
- f. Incorporation of additional pump-around to reduce fired heater duty.
- g. Incorporation of desalter to reduce energy demand. Low temperature heat available in the process may be fruitfully utilized in the desalter. However, the power consumption may go up slightly.

These opportunities will lead to 8-10% of energy savings in the process units [1]. Furthermore, more energy saving potential may be identified to reduce the existing 20% gap between the benchmark and actual energy consumption. Emerging technologies to reduce further energy requirement are discussed below.

Application of Pinch Analysis and Exergy Analysis of Distillation Column

One of the main advantages of pinch analysis over conventional approaches is the ability to identify energy conservation potential for an individual process or for an entire site. Experience of application of pinch analysis over forty refineries worldwide shows the following potential for energy conservation.

- a. Energy reduced by 15-35% through revamping heat exchanger networks with payback periods of 1.5-3 years.
- b. Debottlenecking of 10-20% without modifying fired heater and major pumps.

Column pinch analysis and the exergy analysis of the distillation process help in determining following energy conservation measures in distillation processes.

- a. Determination of feed pre-conditioning effect on the energy conservation potential of the distillation process
- b. Appropriate amount of pump-around
- c. Scope for side-reboiler and side-condenser
- d. Scope for pre-flashing the feed
- e. Effect of changing trays with packings
- f. Optimum operating pressure of the column and the pressure drop across the column.
- g. Scope for integrating with background process.

Generation of High-Level Steam

Wastage of high-level steam heating towards its use for low-level services should be minimized. Proper thermodynamic analysis of the process unit should be performed to address issues such as generation of high-level at the expense of low-level steam. For example, in FCC unit, it is possible to increase HP steam generation potential at the expense of LP steam usage.

Total Site Studies

Total site study is useful in identifying inter-unit energy integration potential. Total site analysis aims to optimize the interaction between the individual processes and between the individual process with utility systems of the overall site. Typical total savings resulting from a total site

study are in the range 5 to 20% of the site energy bill. However, the savings can increase to 30% where significant changes to the site cogeneration system are identified. Total site study helps in identifying refinery-wide improvements in existing steam and power management through optimizing power generation and fuel usage in the refinery. 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.

Inter-unit energy integration may be divided into two categories: direct and indirect integration. In direct integration, process streams from one unit are exported to other unit for direct exchange of thermal energy. In direct integration, operability and flexibility of the integrated units are the major concerns. That is why this approach is not preferred, though the potential for energy conservation is maximum for this kind of integration.

In indirect integration, process streams, of different units, are not integrated directly, but they are integrated indirectly through different utility levels. There is a loss in driving force and consequently the energy conservation potential for indirect integration is less compared to the direct integration approach. However, in indirect integration operability and flexibility issues are not affected as the integration is only through different utility levels, and it is most preferred approach for industrial energy integration.

In total site analysis, it is possible to identify the opportunities for energy conservation associated with transfer of intermediate streams from one upstream unit to another downstream unit. Energy loss associated with stream cooling in one upstream unit, when the following downstream unit is capable of processing a hot or warm feed stream.

CONCLUSION

Benchmarking and targeting are recognized 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. Especially when the Indian refineries are facing stiff competition because of the gradual dismantling of administered pricing mechanism and

building of large capacity new plants with modern technologies.

Designing energy conservation programs through benchmarking and targeting strategies is the most viable and realistic approach to identifying the constraints in existing performance as well as the potential energy conservation.

REFERENCE

- 1 . Gupta, D. K., et al., Energy Benchmarking & Targeting – A Technique to Assess and Improve Refinery Performance, Xth Refinery Technology Meet, Mumbai, 1998, pp 243-249.