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Energy optimization for maximum energy saving with optimal modification in Continuous Catalytic Regeneration Reformer Process

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A B S T R A C T

The heat integration retrofit analysis of the Continuous Catalytic Regeneration Reformer Process (CCRRP) was conducted to determine the major opportunities for maximum energy saving via optimal modifications of the process design. Process data used from a real existing CCRRP were extracted, which are applicable in the pinch analysis technique (PAT). The present investigations of analysis showed a great opportunity for reducing energy consumption and costs at an optimum minimum approach temperature of 40 °F. Retrofit analysis of current process to achieve the optimal modifications of process included three additional heat exchangers with shells tube of two heat exchangers according to reduction in ΔT_{min} from 87 °F to 40 °F. The evaluation of maximum energy savings as new design indicated the reduction of utilities by about 32%, which led to reduce of the total cost index (Cost/s) in the process of approximately 4.5%.

1. Introduction

Design development and improvement opportunities of the chemical process in industries represent the main target for increasing the efficiency and economic benefits of the process. An industrial chemical process considers interactions and integrated systems between different process streams and units as one complex network. The complex network requires understanding and quantifying of the process in order to achieve the optimum design. In any industrial sector, the chemical process optimization is the main important requirements in process integration.

Current issues, such as technological, political, and societal issues relating to mass and energy supplies, are a common trend among most of industrial processes. The fossil fuels, as the main source of energy, are said to generate a harmful impact on the environment. Several factors such as energy and water saving, raw materials and waste minimising, global warming, and greenhouse gas emissions have gained strategic importance [1–3].

Energy saving opportunities of continuous catalytic reforming has remained one of the most important fields of research due to the production of high octane number gasoline. For example, improving energy could be achieved through developments in process units by applying different methodologies of process integration. Process integration applications have developed to achieve process improvement, saving in heat and mass resources, reduction of gas emissions, reductions in the capital and operating costs, and increased productivity and profitability of the processes [4,5]. The development of the methodologies of heat integration for energy saving has increased based upon the growing demand for costly utilities within industries' chemical processes. Much of the effort in this area has been directed towards increasing heat recovery of chemical processes [6,7].

Heat exchange networks in chemical process industries are particularly important because of their role in recovering process heat as consumption intensive energy. The increase in the energy

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R-1 Reactor I	C-1 Debutanizer	D-3 Recontact Drum-2	D-7 Recycle gas coalescer	V-1 Debutanizer Overhead Receiver	AC-1(A-C) Reactor Products Condensers	AC-5 A/B Second stage Net gas coolers	CW-2 (A-C) Debutanizer Trim Condensers	E-2 Air Heater	F-4 Heater-VI	G-3A/B Recycle Pump
R-2 Reactor II	RG Regeneration Tower	D-4 Surge Hopper	D-8 Chloride Storage Tank	HX-1/HX-2 Vertical Combined Feed Exchangers	AC-2 (A-C) Reactor Products Condensers	AC-6 A/B First stage Net gas coolers	RB-1 Debutanizer Reboiler	F-1 Heater-I	G-1A/B Separator Pumps	K-1 Recycle gas compressor
R-3 Reactor III	D-1 Platformer Separator	D-5 Disengaging Hopper	D-9 Catalyst Addition Funnel	HX-3 Reactor Purge Exchanger	AC-3 Debutanizer Bottoms Cooler	AC-7 A/B Debutanizer Overhead Condensers	RB-2 Recycle Gas Heater	F-2 Heater-II	G-2 A/B Recontact Drum-1 Pumps	K-2 First stage Net Gas compressor
R-4 Reactor VI	D-2 Recontact Drum-1	D-6 Lock Hopper	D-10 Catalyst Addition Lock Hopper	HX-4 (A-D) Debutanizer Feed/Bottoms Exchanger	AC-4 First stage Spillback cooler	CW-1 A/B Platformate Rundown Trim Cooler	E-1 Chlorination Heater	F-3 Heater-III	G-4 Chloride Injection Pump	K-3 Second stage Net Gas compressor

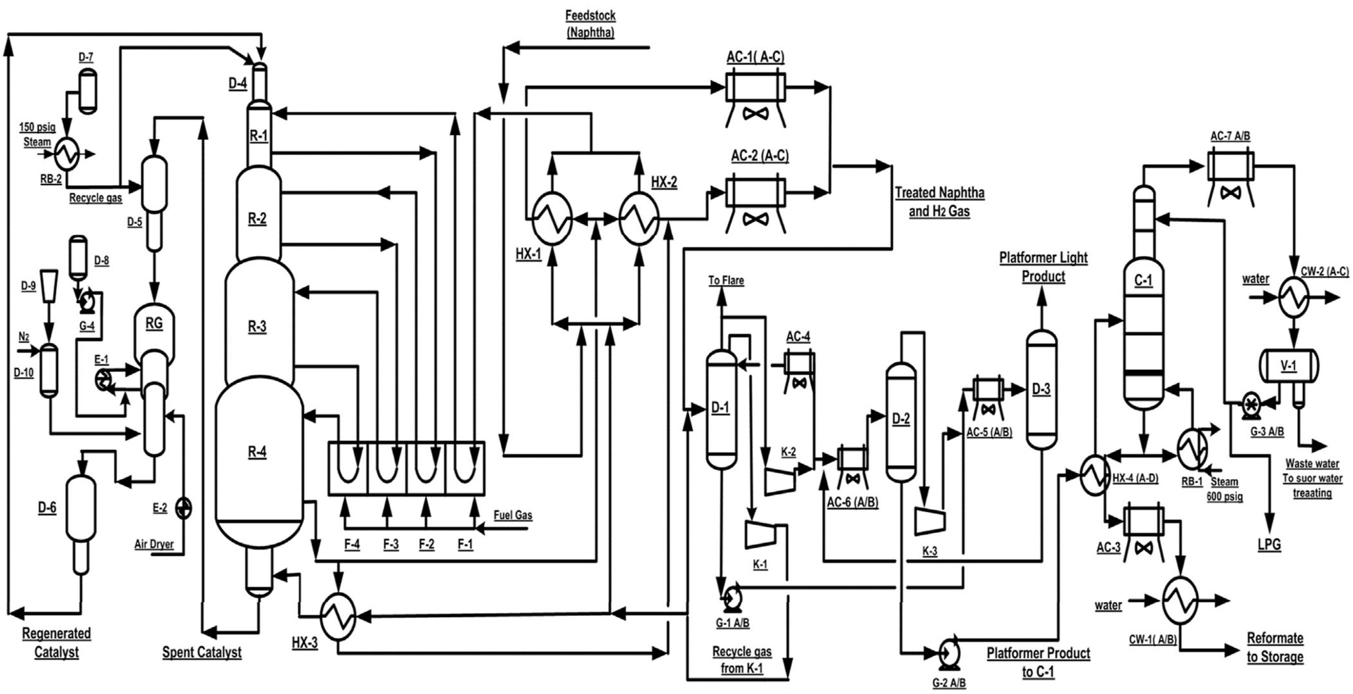

Fig. 1. The simplified process flow diagram of CCRRP.

and environmental effect of fuels combustion recently has forced the operation of energy-intensive process in economical and efficient good approaches. The process operations are a main part of an economy, which always strives to develop its performance in order to provide the best solutions to reduce energy utilization, decreasing greenhouse gases emissions as well as by-products of industry combustion. Thus, high percentage of the operating cost in any process industry is considered by the fuel constitutes. All efforts towards minimising of consumption have corresponded not only to reduce hazardous gases emissions but also to increase profitability associated with energy savings [8,9].

One of the approaches for considering heat integration and improving of heat exchanger networks design is pinch analysis method. The pinch analysis of chemical process uses thermodynamics heuristics and concepts. The pinch analysis concept has been applied to design a new process with reduced costs of energy and capital as well as for improving current processes efficiency. The modification of heat exchanger network design often added

Table 1
The current process stream data.

Symbol	Stream name	Supply temperature Ts (°F)	Target temperature Tt (°F)	Heat capacity flow rate CP (MMBtu/h°F)	Enthalpy (MMBtu/h)
HS-1	Reactor purge effluent	977	308	0.000658	0.44
HS-2	Reactor effluent	977	130	0.491145	415.99
HS-3	Debutanizer bottom	413	120	0.225255	65.99
HS-4	Spillback cooler	277	130	0.012000	1.76
HS-5	Net gas cooler	198	130	0.329118	22.38
HS-6	First stage net gas	177	130	0.422553	19.85
HS-7	Debutanizer overhead condenser	150	118	0.843750	27
CS-1	Feed naphtha	243	1020	0.718147	558
CS-2	Recycle gas	232	951	0.000612	0.44
CS-3	Debutanizer re-boiler	413	480	0.164030	10.99
CS-4	Platformer product	117	324	0.270531	55.99
CS-5	Recycle gas heater	100	300	0.012000	2.4