Engineering Consulting & Training Services

CARMAGEN Engineering, Inc.

A member of MISTRAS

eNewsReport

April 2016

Case Study – Energy Efficiency Improvement

By Roger Thomas and Jerry Lacatena

As follow-up to an earlier article on Profitability and Energy Efficiency Improvement, this is a case study of a job that we worked on.

Carmagen Engineering, Inc. (CEI) is often asked for advice in unusual situations. We try to find quick answers, but occasionally we find that a full solution requires engineering tools and technology that do not exist. However, even in these situations, we can usually meet the client's objectives.

Not long ago, we were contacted by a client who had severe fouling problems in a crude preheat train soon after a major expansion to existing facilities. The crude distillation unit (CDU) furnaces had coil inlet temperatures (CITs) that were over 20°C below design only a few months after startup. As the CDU furnaces were operating at maximum firing rates, this resulted in a lower atmospheric bottoms temperature. This stream was fed directly to the vacuum distillation unit (VDU) furnace, which was also operating at maximum duty. Thus, the VDU feed was also at too low a temperature, resulting in a lower yield of VGO, and a higher yield of vacuum resid.

As the VGO product was routed to a hydrocracker with spare capacity producing premium diesel, the economic impact was well over a million US dollars a week. This did not even include the occasions when crude throughput also had to be reduced.

We conducted a quick scoping study based on the initial data package and then visited the site to gather more information. It soon became apparent that as a result of the corrosive crudes being fed to the unit, the fouling resistance in many exchangers was increasing rapidly. On further study, it became clear that none of the more obvious solutions were attractive. While compact welded plate exchangers seemed interesting at first, several challenges soon arose. Only chemical cleaning of the exchangers was possible, and there was limited experience of using plate exchangers at very high temperatures with highly corrosive crudes. In addition, the need for exotic materials resulted in long lead times.

The other obvious solution was to add more conventional heat exchanger shells. However, the exchangers added in the expansion project were located in structures that were some distance from the original heat exchanger train. Therefore, it was difficult to see where new shells could be located. The use of additives to reduce fouling was also considered, but this was a complex problem involving multiple sample analyses and plant tests.

Work Highlights

Hydrotreating

- *Provided diesel hydrotreater catalyst sulfiding support and other technical start-up assistance onsite.*

Process

- *Provided consulting services for high-level screening of emerging technologies in the area of H_2S conversion.*

Project Management

- *Full time onsite project management and project engineering assistance for a grass roots expansion project for a US Gulf Coast refinery. The project manager assignment was for almost three years, and the project engineer assignment was for almost two years.*

Refoming

- *Performed technical support, troubleshooting, and onsite catalyst regeneration support for reformers in South America, Canada, and Far East.*

Training

- *Presented engineering training courses to clients in the US and various international locations. Topics included risk based inspection (RBI), process safety, process hazards analysis (PHA), layer of protection analysis (LOPA), process design, heat exchanger design, pump technology, design and inspection of piping systems, design and maintenance of aboveground atmospheric storage tanks, construction safety, crane lifting/safety management.*

The most feasible solution was therefore to dramatically increase the frequency of online heat exchanger cleaning. However, this required adding block valves and bypass lines to several exchangers. In addition, some major pump arounds had only a few heat exchanger shells; so, throughput would have to be significantly reduced during cleaning unless some rearrangement of the shells through minor re-piping could be made. As any change can alter many temperatures throughout the exchanger network, we needed to make an in-depth study of the entire heat exchanger system.

The heat exchanger network had close to 20 split flows. The split flow ratios had to be optimized for both the base case and all possible project cases. However, the standard heat exchanger network engineering tools are only capable of optimizing about half this number of split flows simultaneously. Therefore, global optimization could not be guaranteed. After a literature study of the latest advances in optimization theory and available technology, we devised a way to provide global optimization. This involved solving for network temperatures using a sparse matrix as is done in the best standard engineering tools. We then maximized the CIT using a non-linear optimizer, changing all split flow ratios, and continually solving for the CIT.

The technology implementation was done entirely with readily available commercial programs. This had the added advantage that the optimizer could be supplied to the customer for operational optimization. This was done without any additional cost to the client. The optimizer was very robust and ran in a few seconds on a high end personal computer. The main output was a Pareto diagram highlighting the key ratios to change, and was therefore easy for an operator to interpret.

In addition, during further work using the technology described above, we were able to optimize the cleaning schedule for the exchangers. It was found that the loss of heat recovery compared to the optimum cleaning time was minimal provided the cleaning took place within a couple of weeks of the optimum. Therefore, for expected reasonably constant fouling rate increases, the management tool became a simple time window for each exchanger. If very rapid fouling occurs, some adjustments must be made to these windows. For this particular situation, exchangers must be cleaned two to five times per year, far more frequently than previously planned.

About the Authors

Roger Thomas is a management and engineering optimization expert with extensive experience in the development of sophisticated operations management tools for the process and other industries. He applies powerful mathematical methods derived in physics to solve a wide range of very complex business problems with focus on increased profitability, energy efficiency, and reduced operating costs in major process facilities.

Jerry Lacatena has over 35 years of process engineering experience in a broad range of design applications and technologies. He is a proficient and organized multi-tasker, having extensive plant design experience on numerous revamp and grassroots projects throughout the world, with projects ranging from feasibility studies, technology evaluation, FEED, EPC development, to plant performance testing. Jerry has excellent presentation, communication, coordination, and interpersonal skills utilized to develop strong working relationships with team members, clients, vendors, sub-contractors, and technical licensors.

Please contact Jerry Lacatena, Process Department Manager (jlacatena@carmagen.com) if you'd like more information on Carmagen's expertise in this area. Carmagen Engineering, Inc. is an engineering consulting company with experienced staff that can support clients' efforts associated with energy management and profitability improvement activities.