69d Revamping a Demethanizer for Improved Separation and Energy Performance: Lessons Learned from Two Internal Retrofits

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Revamping a Demethanizer for Improved Separation and Energy Performance: Lessons Learned from Two Internal Retrofits

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Abstract:

The demethanizer column (20-T-2401) operated by Braskem Idesa experienced persistent hydraulic and separation limitations that prevented stable operation at design capacity. Two sequential revamps were implemented, focusing on internals replacement and vapor–liquid distribution improvements. The final configuration restored separation efficiency, reduced methane slip, and improved energy performance. This paper summarizes the troubleshooting methodology, design modifications, and operational results.

Introduction

Demethanizers are critical for methane removal in ethylene plants. Poor performance impacts energy consumption and downstream units. This work presents a structured revamp approach to resolve long-standing operational issues.

Original Grassroots Design

The demethanizer column (20-T-2401) was originally designed with 48 conventional trays. The top section contained three single-pass trays, while the remaining 45 trays were two-pass trays. Tray spacing was 600 mm, with a column diameter of 3000 mm and a bottom diameter of 4000 mm.

The column separates methane and lighter components as overhead products and C_2+ hydrocarbons as the bottom product. The design top recycle rate was 32 t/h, and the methane specification in the bottom product was 200 ppm. Since start-up of the ethylene plant, the demethanizer column has exhibited flooding at approximately 95% of its original design capacity, preventing stable operation at the full design rate of 125 t/h ethylene production. The key operating issues are illustrated in Figure 1. To mitigate these limitations, cracker furnace severity was increased in an effort to reduce the hydraulic load on the column. However, even under higher conversion conditions, the column continued to experience significant hydraulic constraints.

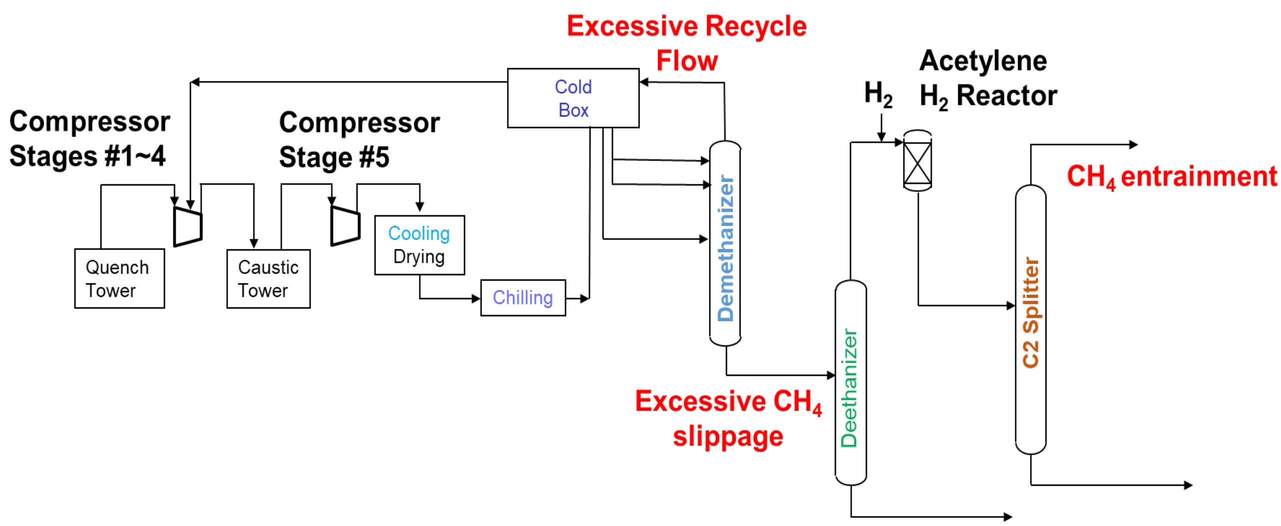


Figure 1. Operation results

As part of the troubleshooting effort, gamma scan tests were conducted, confirming internal hydraulic issues within the tray section (Figure 2).

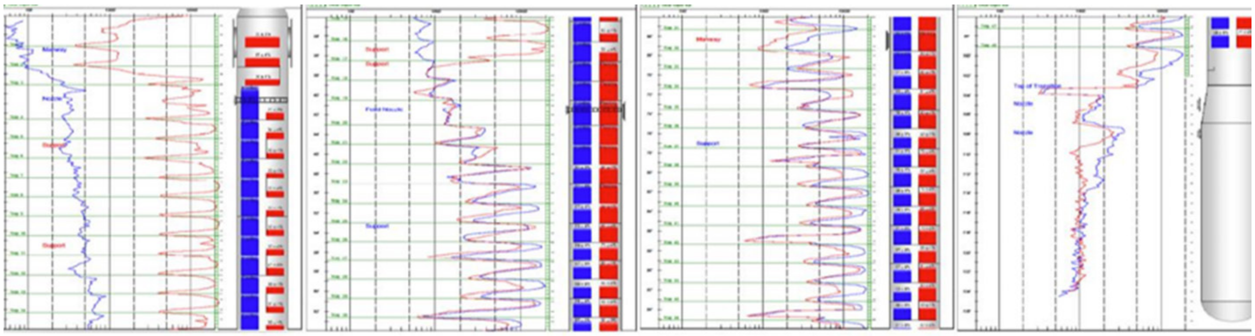


Figure 2. Gamma scan results showing maldistribution in tray section

During a scheduled shutdown in October 2016, the column was internally inspected. All trays and internal components were found to be clean and consistent with the original design drawings. Following a series of technical reviews with the technology licensor and the tray supplier, the latter developed an independent process simulation using the original design data provided by the licensor. The resulting load and physical property profiles closely matched those of the original design model. A detailed hydraulic assessment was subsequently performed, covering the existing trays, process nozzles, internal piping velocities and symmetry, and the column sump configuration. The analysis confirmed that the trays were appropriately designed for the original operating conditions. However, a critical hydraulic restriction was identified at the base of the column. This restriction occurs between the inclined baffle of the partition and the long baffle within the tray section, where the reboiler return stream must pass through a confined flow area. Both the returning liquid and entrained vapor are forced through this narrow passage, resulting in high liquid velocities, limited vapor disengagement, and restricted two-phase flow capacity. Furthermore, the inclined baffle does not provide a dedicated vapor vent. As a result, vapor attempting to escape through the same restricted opening impedes liquid flow, leading to liquid accumulation and localized foaming near the reboiler return nozzle. This condition ultimately promotes liquid carryover into the bottom tray (Tray #48).

First Internal Modification (2018)

To address the identified hydraulic limitation, the technology licensor recommended a hybrid tray–packing configuration incorporating the latest generation of random packing. Braskem Idesa was advised that a similar approach had previously been implemented successfully at another olefins facility. Accordingly, a hybrid internal configuration was adopted, combining trays and random packing across different sections of the column. In the top section, Trays #1 and #2 were retained, with a seal pan installed below Tray #2. Within the feed zone, Tray #3 was removed to improve vapor disengagement at the feed entry.

In the middle section, Trays #4 through #19 were replaced with latest-generation random packing, corresponding to a packing height of 7,700 mm and an expected separation efficiency of approximately 10 theoretical stages. The lower section, encompassing Trays #20 through #48, was similarly converted to random packing, with a total packing height of 14,800 mm, divided into two beds. The overall expected performance of the packed sections was approximately 17 theoretical stages, compared to 20 stages in the original tray-based design. According to the original internals supplier, this modest reduction in separation efficiency would result in less than a 2% increase in reboiler duty, assuming the column pressure drop remained at 0.41 kg/cm^2.

Key modifications to the lower section focused on eliminating the hydraulic restriction and improving vapor–liquid disengagement. These included a redesign of the seal pans to ensure proper liquid routing to the reboiler compartment. In addition, the existing tray weirs were removed, the vertical sump baffle was trimmed, and additional structural stiffeners were installed to maintain mechanical integrity. The revised baffle geometry was designed to improve overall flow characteristics. It is also important to note that implementation of the packing configuration required the installation of new liquid and vapor distribution hardware to ensure effective phase separation and uniform flow distribution. These included V-baffle diffusers at feed nozzles N2, N3, and N4, flashing feed galleries, orifice-deck liquid distributors, and a gas injection support plate. In addition, the bottom tray was replaced with a collector tray to facilitate proper liquid collection and redistribution. Figure 3 illustrates the scope of the modifications described above.

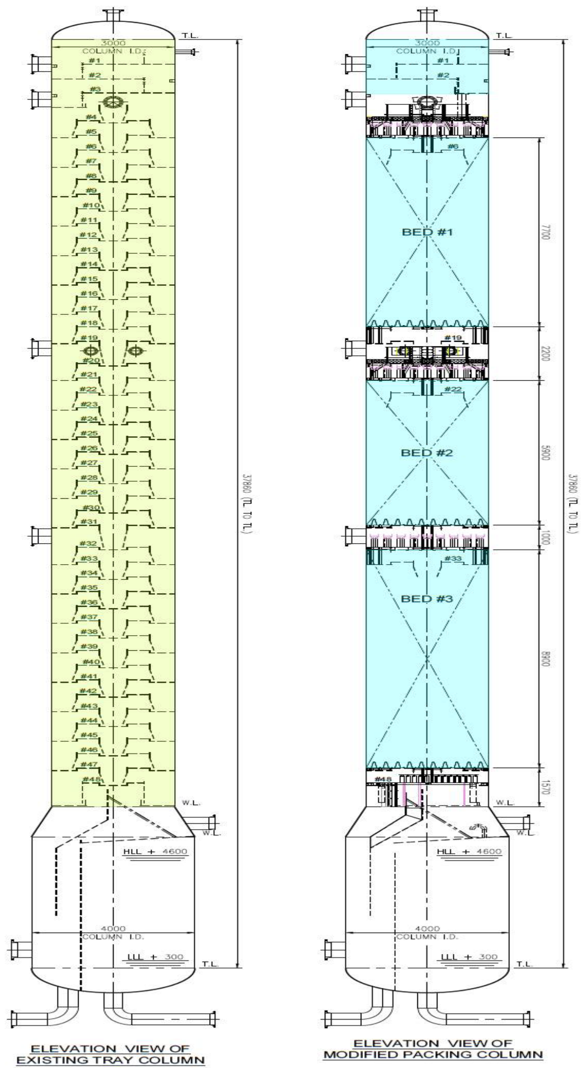


Figure 3. Original vs. first revamp internal configuration

Performance After 2018 Modification

The modified column was restarted with full-capacity operation tested in June 2018. The primary improvement observed was a reduction in column pressure drop, which enabled higher plant throughput. However, two significant issues emerged during operation. Methane concentration in the bottom product increased beyond acceptable limits, and recycle flow to the cracked gas compressor rose substantially. As a result, flow to the cold section increased from the design value of 296.5 t/h to over 330 t/h, leading to higher compressor power consumption. Elevated methane levels in the bottom product also introduced operational risks to the C_2 splitter, with the potential to cause instability or unplanned trips.

Subsequent testing, conducted at the request of the licensor, indicated that the effective number of theoretical stages had decreased significantly. Rather than the initially predicted loss of four stages, the actual reduction was estimated to be approximately twelve stages.

The licensor later concluded that the deterioration in separation performance was likely attributable to inadequate vapor distribution from the reboiler return, compounded by hydraulic obstruction associated with the seal pan and adjacent baffles. These internals were found to block more than 55% of the column cross-sectional area, thereby severely restricting vapor–liquid contact efficiency.

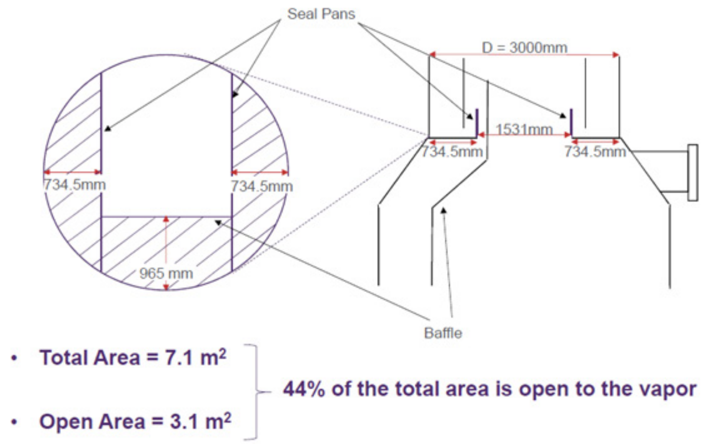


Figure 4: Bottoms Reboiler Return Arrangement

Second Internal Modification

In March 2024, a joint study was initiated by Braskem Idesa and GTI Solutions to address the persistent performance deficiencies observed following the 2018 revamp. The review identified several critical issues contributing to the loss of separation efficiency. The incoming feed was found to exhibit excessive momentum as shown in Figure 5, with an estimated vapor fraction of approximately 90%, leading to poor phase distribution upon entry to the column. Gamma scan analysis further indicated liquid accumulation at the base of Packing Bed #3, likely caused by localized vapor maldistribution.

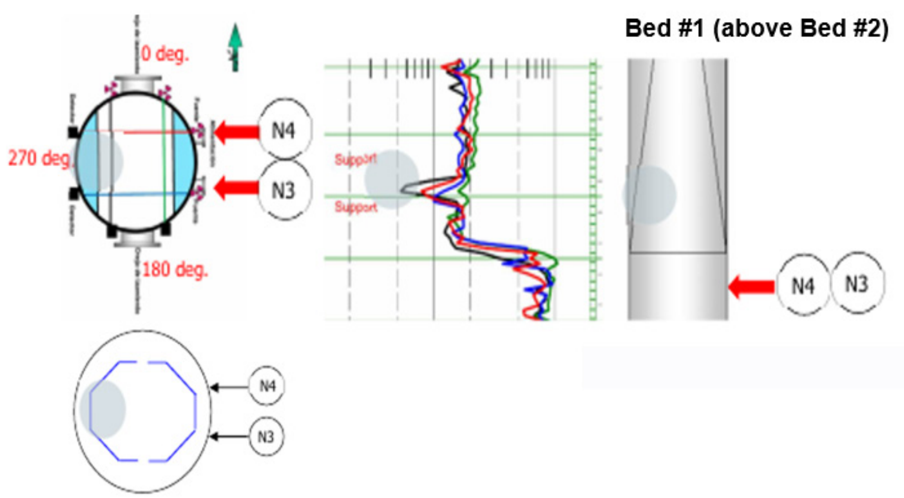


Figure 5: Excessive Feed Momentum

In addition, the existing channel collector was determined to provide inadequate vapor distribution across the column cross-section, further exacerbating maldistribution effects.

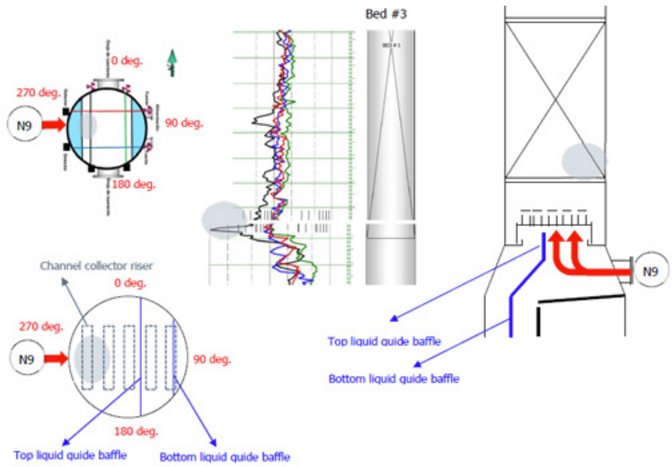


Figure 6: Reboiler Return

The height of Packing Bed #3, at 8.9 m, was also identified as a contributing factor; such an unusually tall bed remains inherently susceptible to liquid maldistribution. Additional evidence of poor fractionation was obtained from the column temperature profile. Although gamma scan interpretation in packed beds can be challenging due to the large volume of internal material, the temperature profile provides a more reliable indication of mass transfer performance. In this case, the very low temperature gradient across the bottom bed, less than 1°C (Figure 7); clearly indicated a lack of effective fractionation in this section.

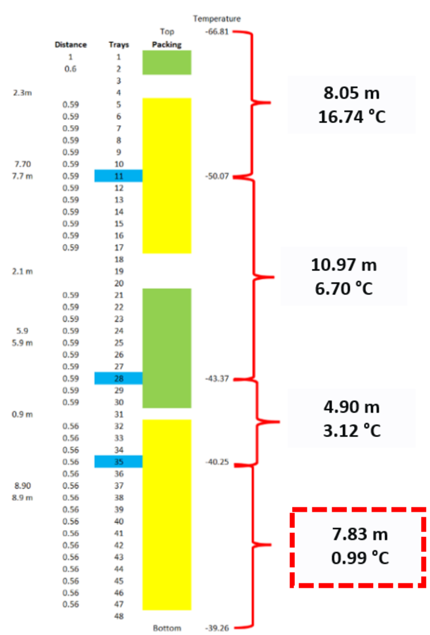


Figure 7: Column Temperature Profile after first revamp

New Internal Configuration

The following modifications were implemented during the 2025 turnaround:

Bed 1 - A new flashing feed gallery and liquid distributor were installed to improve phase distribution, while the existing packing was retained and reused.

Bed 2 - Bed 2 was upgraded with a new flashing feed gallery, liquid distributor, and V-baffle diffusers to enhance vapor and liquid distribution. The existing packing was inspected and found suitable for continued service, and was therefore reused.

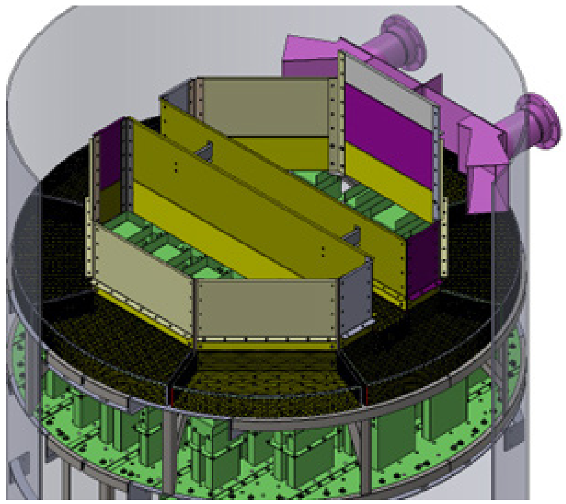
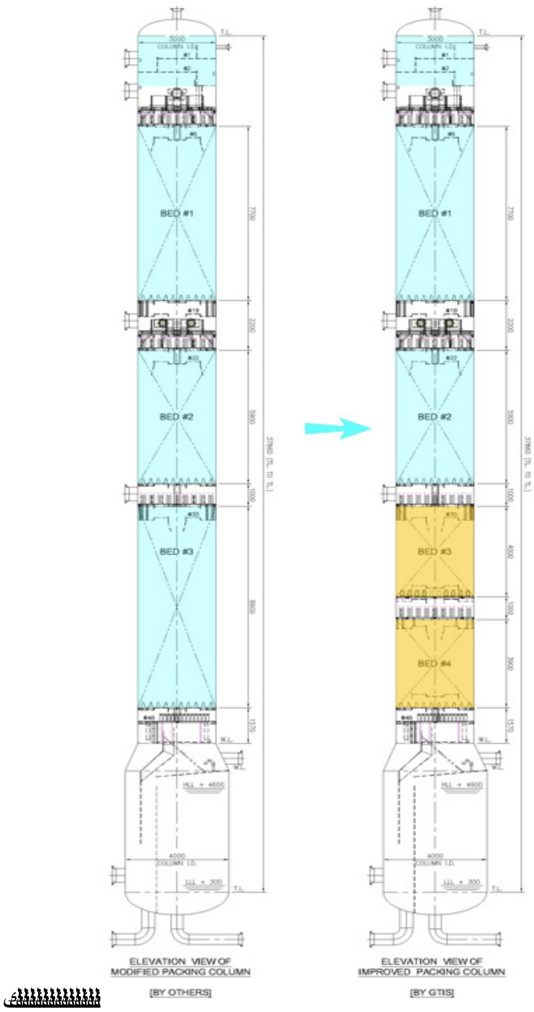


Figure 8: New Flashing Feed Gallery Arrangement

Beds 3 and 4

Packing Bed #3 was subdivided into two separate beds to reduce effective bed height and improve liquid distribution. Both sections were equipped with G-SR™ metal packing (Figure 9) and fitted with new liquid distributors to enhance phase contacting efficiency. Mechanical support systems were installed using a non-welded design, thereby avoiding any direct welding to the vessel shell and minimizing turnaround scope and risk.

Figure 9. G-SR™ High Performance Random Packing



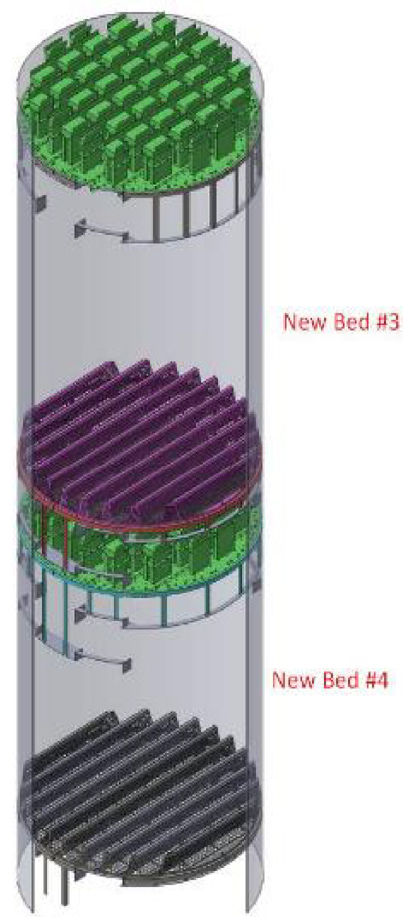


Figure 10. Column Configuration Change **Figure 11. Packed Bed 3 and 4**

Column Bottom

The column bottom internals were upgraded through installation of a DCT-210 riser collector, replacing the existing channel collector. In addition, the upper liquid guide baffle was removed to eliminate unnecessary flow obstruction. The new riser collector employs cylindrical risers equipped with restriction plates at their base, promoting uniform vapor distribution across the full column cross-section and improving overall vapor–liquid contact efficiency.

Figure 12: Bottom Arrangement

Observations During 2025 Turnaround Inspection

Inspection during the turnaround confirmed that inadequate vapor distribution was one of the root causes of the observed performance deficiencies. The previous collector tray directed liquid toward the seal pan and reboiler compartment, while the longitudinal baffle obstructed a substantial portion of the column cross-section. This configuration significantly restricted vapor flow and hindered uniform distribution across the column.

As part of the revamp, the existing collector and seal pans were removed and replaced with a riser-type vapor distributor. The new configuration provides markedly improved vapor distribution across the full column diameter, thereby enhancing overall mass transfer performance.

Results After 2025 Turnaround Revamp

Following startup after the TA2025 revamp, the demethanizer column exhibited a marked improvement in overall performance. Five operating scenarios were evaluated, including two cases prior to TA2025, two cases after TA2025 at 125 t/h, and one case at an increased throughput of 130 t/h.

Key performance indicators showed significant improvement. Top recycle flow decreased from ≥85 t/h to a range of 61–64 t/h, while methane concentration in the bottoms product was reduced from 1600~1750 ppm to around 500 ppm. These improvements provide greater operational flexibility, enabling tighter control of methane slip while minimizing recycle load to the cracked gas compressor. Column temperature profiles also demonstrated substantial enhancement in fractionation efficiency. Prior to the revamp, the temperature gradient across the bottom bed was approximately 1°C, indicating poor mass transfer. Following the modifications, the bottom bed ΔT increased to approximately 4°C, while the top section ΔT improved from 16°C to 23°C. In addition, the overhead temperature now consistently reaches the design value of −75°C, confirming improved separation performance and more effective vapor–liquid contact throughout the column.

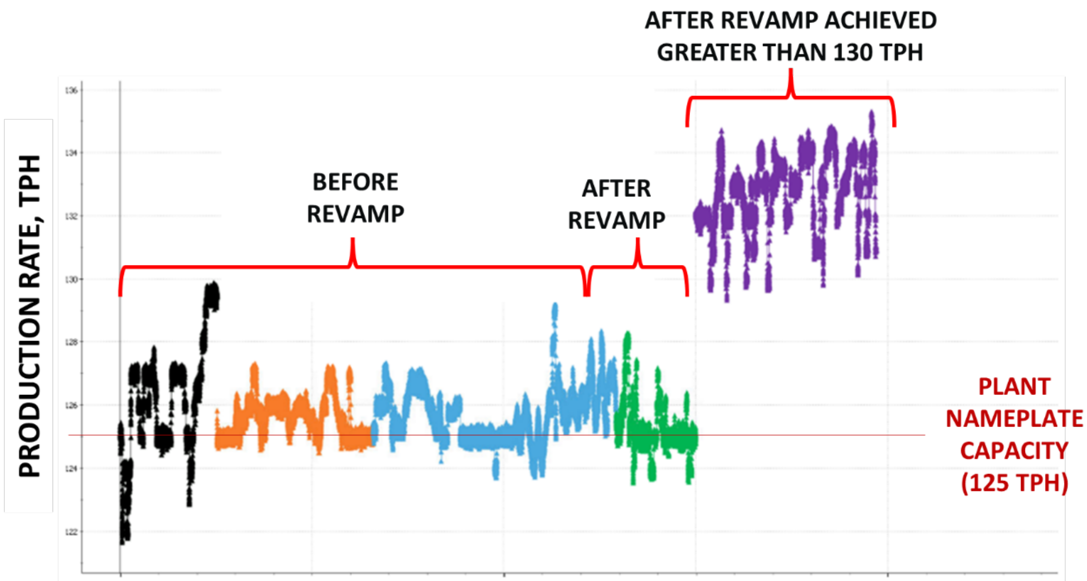


Figure 13: Post 2nd Revamp Capacity

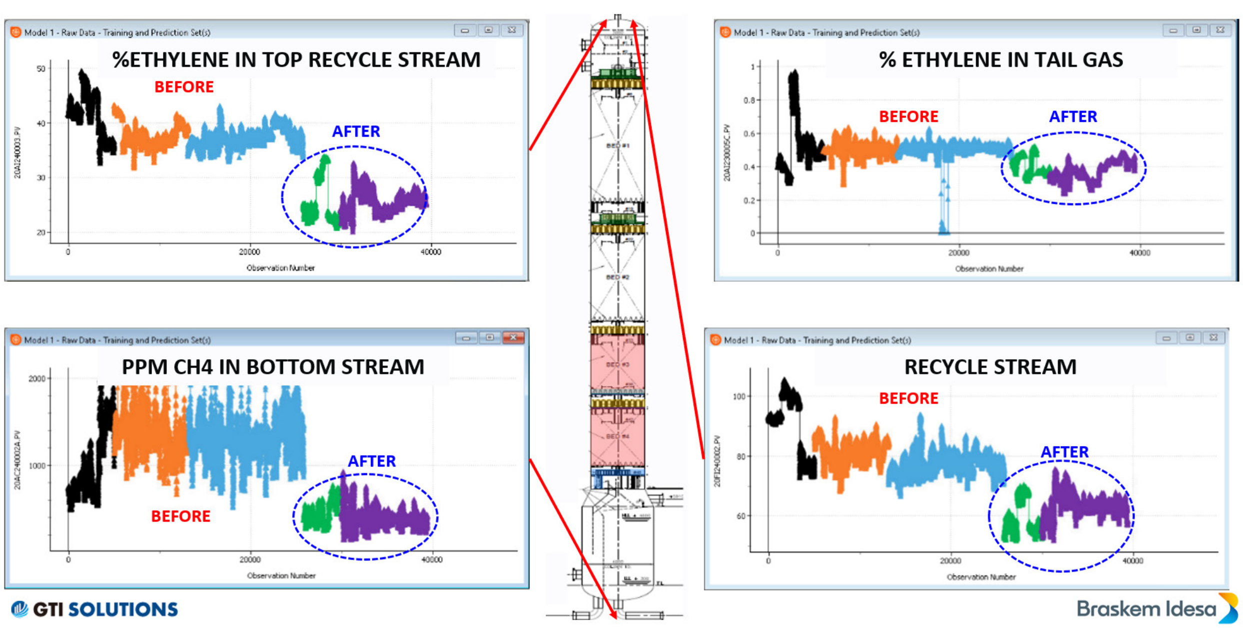


Figure 14: Post Revamp Operating Data

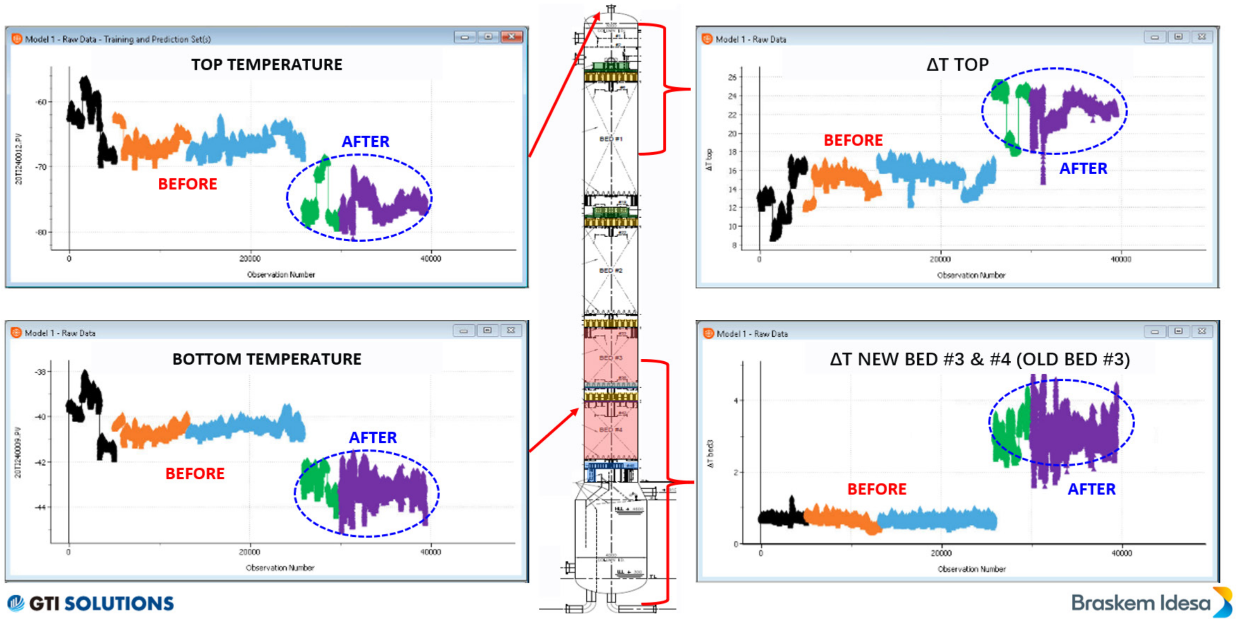


Figure 15: Post Revamp Operating Data

Lessons Learned

The revamp efforts and subsequent performance evaluations highlight several important lessons for the design and troubleshooting of fractionation columns.

First, eliminating hydraulic constraints alone does not guarantee improved separation performance. While the 2018 modification successfully reduced pressure drop and increased throughput capacity, it also demonstrated that hydraulic relief without proper phase distribution can significantly degrade mass transfer efficiency.

Second, packing bed height is a critical design parameter in fractionation service. Excessively tall beds are inherently prone to liquid maldistribution, even when mechanical integrity is maintained. Dividing the bed into shorter sections with intermediate redistribution proved essential for restoring effective separation.

Third, feed momentum and flashing behavior must be explicitly addressed in the design. High-momentum, high-vapor-fraction feeds can disrupt phase equilibrium and lead to poor distribution if not properly managed through appropriate inlet devices and flashing galleries. In addition, the study reinforced that liquid and vapor distribution are equally important for achieving optimal column performance. Improvements in vapor distribution at the column bottom, combined with enhanced liquid distribution in the packed beds, were both necessary to recover separation efficiency.

Finally, plant operating data, particularly temperature profiles and pressure drop are invaluable diagnostic tools. In this case, the temperature profile provided a clear and reliable indication of underperforming sections within the column, complementing gamma scan results and guiding the identification of root causes.