Optimization of the Product Recovery Rate in an Air Separation Plant

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Abstract

Process optimization is an area of opportunity for any organization given the recent rise in costs associated with the manufacture of products from local perspective. As part of the productivity initiatives, the decrease in the Argon recovery rate in an air separation plant was identified as opportunity, due to its direct implications on the business. The DMAIC methodology was implemented through its different phase's application, identifying as root causes deficiencies in the mechanical integrity of the main air compressor. Successful improvements implementation was completed considering the integration of control measurements resulting in sustainable changes. Daily production showed increase per evaluation indicating a positive trend towards production target objective.

Introduction

LIN is a leading global company in the industrial gases business dedicated to developing application technologies while supplying high-quality products to its customers. The company provides a wide selection of industrial products in the gas market, some of which are Oxygen, Nitrogen, Argon, Carbon Dioxide, Hydrogen and rare gases

The recent rise in production costs in the country related to manufacturing has been the main contributor towards the search for process optimization elements to reduce costs and increase the efficiency through different parts of the business. To contribute with the ongoing effort, a continuous improvement initiative was started to evaluate critical business areas. A decrease in the recovery rate of Argon was identified within the production process that supplies thousands of cubic feet per month to different industries at the local perspective. The importance of this product lies in the current added value in the market given its scarcity, especially considering its low percentage within the composition of the air.

The progressive decrease in the monthly recovery rate has had repercussions in different aspects of the business, directly impacting the metrics and key performance indicators (KPI's) of the plant at the production level. The problem has forced the management to adopt drastic business measures by incurring in additional expenses associated with the importation of product to satisfy the local demand of the clients, which is estimated to be approximately 1400 kscf (standard cubic feet).

Objective

The objective of this project is to achieve an increase in the Argon recovery rate that allows production to be matched at a minimum with the estimate of local demand based on customer consumption. It is intended with the fulfillment of this objective to make the separation process more robust and positively impact the performance indicators of this plant in the long term.

Background

Argon recovery is mainly completed within an air separation process, consisting in five (5) basic stages:

- Air Compression
- Air Cooling
- Contaminant Removal
- Separation and Liquefaction
- Production

Figure 1 presents the basic air separation process. Crude Argon column produces a Crude Argon stream of approximately 90% Argon, and 10% Oxygen to be further refined in a subsequent separation system called Argon Refinery. During this stage, Argon feed goes into a deeper purification in the high ratio column obtaining a final product within quality standards specifications for delivery either as bulk product or compressed gas [1].

Background Cont.

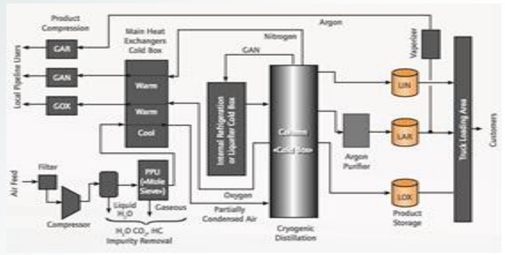

Figure 1
Air Separation Process Diagram [1]

Methodology

The research methodology implemented for the development of this project was DMAIC. This methodology is based on the Six Sigma tool with a focus on continuous optimization to guarantee quality within processes. Its application consisted of five phases, that made up a complete study of the existing problem, through the analysis of collected data, identification of root causes and determination of sustainable solutions from the business perspective [2].

Define

The definition phase purpose was to establish the problem statement with the appropriate objective for the project development. In the context of this investigation, the decrease experienced in the recovery rate of Argon product was identified as the main element of opportunity within the plant operation. The situation was escalating causing business impact related to absorption of costs for product importation to satisfy local demand and decrease in production KPI's related to this product. Considering previously stated elements, the objective defined was to increase in the Argon recovery rate in this plant for optimization purposes.

Measure

Initial situation assessment was completed during the measurement phase where the main situation was quantified through valid data collection pertaining process. The data collection strategy consisted in the compilation of variable process data regarding Argon production rates in a monthly basis obtained through the iHistorian system. The time frame selected for data gathering was 18 through 20 with the purpose of being able to establish a better comparative basis of the data per year in the subsequent phase. The range used for investigation was from May 2021 through November 2022. Figure 2 summarizes the data compilation related to Argon production. After further verification of plant records with average run time for the periods of interest, a production downward trend in July 2022 was confirmed.

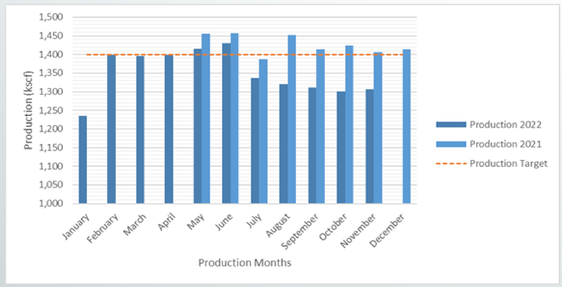

Figure 2
Argon Production Profile

Analyze

During the analysis phase, the efforts were directed towards the identification of trends, patterns of variation in the process, and elements impacting Argon production to assign them a specific reason of occurrence. The strategy followed by the team during this stage was mainly focused on the evaluation of three areas of interest being equipment performance, maintenance, and operational process performance subjects of attention. The areas of interest were verified accordingly to determine root cause for the production downward trend observed from data collected. Figure 3 demonstrates the initial brainstorming developed by team members for the observed condition. The cause-and-effect diagram (also known as fishbone diagram) was assessed for further investigation in relation with the previously defined areas of interest.

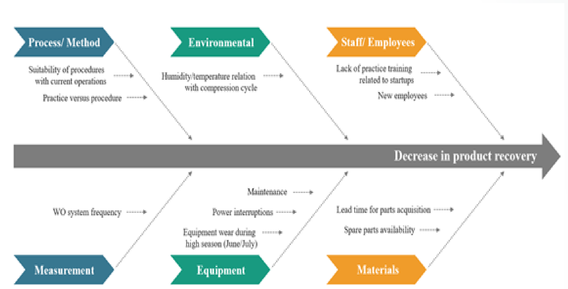

Figure 3
Cause and Effect Diagram

Figure 4 summarizes analysis assessment completed for root cause analysis investigation. After the completion of analysis phase related to Argon production decrease the identified root causes were the leakage in the main air compressor and IGV malfunction. Both elements were associated with the same equipment directly affecting the process flow that subsequently will be separated downstream into Argon product

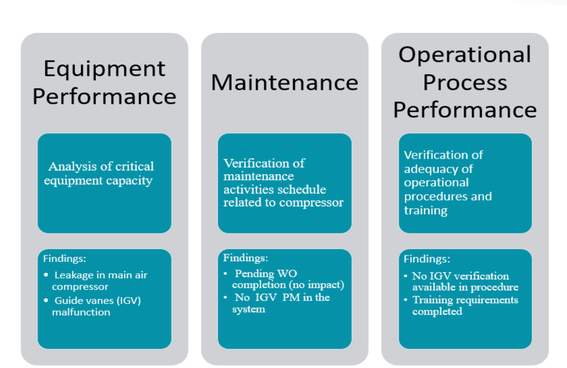

Figure 4
Analysis Strategy and Findings

Improve

Process improvement constitutes a critical part of this project emphasizing in the proposal of solutions that will eradicate root causes identified as part of project analysis. The proposed improvements were defined within the investigation team upon agreement of implementation. The solutions aimed to correct deficiencies with a sustainable approach to guarantee results.

Improve Cont.

- Intercooler gasket replacement in second stage of the compression cycle.
- IGV actuator replacement.
- Development of a preventive maintenance strategy integrating IGV inspection and intercoolers gasket replacement in the EAM system.
- Revision of main air compressor maintenance procedure to include new PM strategy.
- Revision of plant startup procedure to include power control verification instruction and guide vanes inspection.
- Training matrix update to include a practical plant startup refresher training within a year frequency.

Control

Controls measures were defined for improvements implementation sustainability in the production scenery. As part of the monitoring strategy the agreement was that the operations department will be responsible of the generation of a monthly report related to Argon production that will be submitted to the productivity department for further analysis related to production costs. It was also determined the implementation of an Argon production dashboard that will be available at the plant with the purpose having the information accessible while integrating employee towards metric commitment. Monthly meetings will be scheduled within plant members, management, and productivity to discuss production results and align efforts within plant personnel.

Results

Mechanical and operational improvement implementation was successfully completed within plant operations. Process flowrates were balanced obtaining an inlet flowrate that matched the compressor capacity according to requirements. Evaluation showed that the Argon production rate was improved per day in a weekly base period. Forecast indicates that if production trend continues with the average recovery rate obtained during investigation period, the production target of 1,400 kscf will be accomplished at the end of the month per defined objective, thus reducing costs of current production. Further data will be evaluated during the month for trend assurance.

Conclusion

The proposed investigation successfully identified the root causes associated to the decrease of Argon recovery in the plant. The DMAIC methodology application addressed deficiencies related to the main compressor guide vanes and air leakage that were negatively impacting production KPI's. Improvement proposal focused on correcting equipment mechanical integrity while integrating changes assurance through supporting actions in the operations scenery. Preliminary results indicated that the implementation positively impacted production rate in a daily basis, thus obtaining a promising forecast that will allow production target to be accomplished per defined objective.

References

[1] Chemical Engineering World, "Cryogenic Distillation of Air," Chemical Engineering World, Jul. 04, 2020. https://chemicalengineeringworld.com/cryogenic-distillation-of-air/ (accessed Feb. 04, 2023)

[2] K. Selvi and R. Majumdar, "Six Sigma- Overview of DMAIC and DMADV," International Journal of Innovative Science and Modern Engineering, vol. 2, no. 5, Apr. 2014, Accessed: Dec. 12, 2022. [Online]. Available: https://www.researchgate.net/publication/346081379_Six_Sigma-Overview_of_DMAIC_and_DMADV