ABSTRACT

Cryogenic air separation units (ASU) separate the free available raw material air into its constituents, primarily oxygen, nitrogen and argon in varying purity, state and quantity. However, the high running cost increase the final price of the products. Recently, safety and operational flexibility have also come to the forefront. This work focuses on reducing costs while maintaining the safety and enhancing the operational flexibility of the plants.

Out of the separated components oxygen finds its major applications. Pressurized oxygen at a purity of 99.5% may be supplied through pipelines at a pressure of 30-40 bar to steel making units or transported in oxygen cylinders which are filled at pressure ranging from 150-300 bar. The properties of oxygen below and above its critical pressure of 50 bar vary differently. Even the results obtained for a large scale plant supplying sub-critical oxygen at 30-40 bar through pipeline to an integrated steel industry may not be applicable for a small or medium scale plant filling oxygen cylinders at a super critical pressure of 150-300 bar, hence, dealt separately. Internal compression based plants require appropriate combinations of pressure and flow of air streams and size of the man heat exchanger to vaporize pumped liquid oxygen with reasonable specific power consumption. Based on exergy analysis and economic estimation of the plant after simulating in Aspen HYSYS®™8.6, the values of parameters which give high exergy efficiency with low capital and operating expenditures are determined.

Large scale ASU having double and single column configuration producing pressurized oxygen through internal compression method are modified to cater simultaneously to the steel making unit and blast furnace which resulted in reduction of specific power consumption and total hourly estimated expenditure by approximately 20% and 10% respectively. Single column ASU is found to be less power and total cost incurring compared to double column, so further investigation of the distillation column helped to propose two additional reboilers that resulted in net reduction of specific power consumption by 40% compared to the basic double column plant. Operational strategies to generate three different oxygen product mixes from a single ASU are also proposed. Medium scale ASU filling oxygen cylinders having the safest external vaporization method are also improved to utilize the cold of externally pumped liquid oxygen to substantially reduce specific power consumption approximately by 30%. The operational strategies to generate three different pressures of oxygen from a single ASU at 150, 230 and 300 bar are also elaborated.

Keywords: Cryogenic air separation, Steel industry, Oxygen cylinder filling, Internal compression, Operational flexibility, Exergy efficiency, Economic estimation.