

Performance Analysis of a Helium Turboexpander for Cryogenic Applications with a Process Modeling Tool: Aspen HYSYS

Darshna M. Joshi

Lecturer, Department of Instrumentation and Control Engineering, Government Polytechnic, Ahmedabad, Gujarat, India

ABSTRACT: Cryogenic system refers to interacting group of components involving low temperature. Cryogenic engineering deals with the development and improvement of low temperature techniques, processes and equipment. They are applicable to helium refrigerators and various liquefiers. Nowadays, the energy crisis has forced the need to recover the energy which is normally wasted in other industrial processes. Reduction of gas pressure is one of such process in which there is a high loss of energy. To prevent such high wastage of energy, Turboexpander which is the heart for the production of low temperature by reducing the pressure to a low value, has been introduced in the industries. Turboexpanders are used in almost every segments of the oil and gas industry to produce Cryogenic refrigeration. Before implementation of such a critical component in the plant, it is necessary to carry out the performance analysis of turboexpander.

In this paper, a process simulator called Aspen HYSYS is used for the analysis of Helium turboexpander (Helium gas is taken as a process sample gas) and detailed observation is carried out for checking the performance of helium turboexpander at various adiabatic efficiencies. The results provide useful indications on the selection of turboexpander to obtain required output at various efficiencies with variation in temperature. Keeping the constraints of the plant in mind, this analysis can thus result in the design of an efficient productive plant.

KEYWORDS: Aspen HYSYS, Cryogenic, Helium, Performance Analysis, Turboexpander.

I. INTRODUCTION

Aspen HYSYS is a powerful and innovative engineering tool especially designed for the chemical and gas industries. Cryogenics is an important area for the gas industries, where you have to deal with extremely low temperature. This process modeling tool helps in avoiding production delays by giving an analysis of the performance of various equipment that are to be placed in the processing plant.

Performance analysis of various equipment like compressor, expander, control valves, distillation column, that plays a keen role in a Cryogenic plant can all be analyzed for its performance by this process modeling tool. Such analysis gives a clear idea about the selection of equipment and thus production costs can be reduced which leads to the profitability of the organization [1] [2] [3] [4].

II. RELATED WORK

The expansion turbine or the turboexpander is one of the important component of most cryogenic system. Since the turboexpander plays the role of the main cold generator, its properties – reliability and working efficiency, to a great extent, affect the cost effectiveness parameters of the entire cryogenic plant.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

Turboexpander is a machine, which continuously converts kinetic energy into mechanical energy. This is done by expanding the high pressure gas from upstream to a lower pressure downstream through the expander. The high pressure gas causes the radial expander to rotate. Rotation is transmitted to the shaft, which is supported by a set of bearings. The energy transmitted to the shaft can be used to drive a compressor (i.e. wastage of energy can be prevented). Figure 1. shows a helium turboexpander, that is, helium gas is used as a process sample gas[5][6][7][8][9].

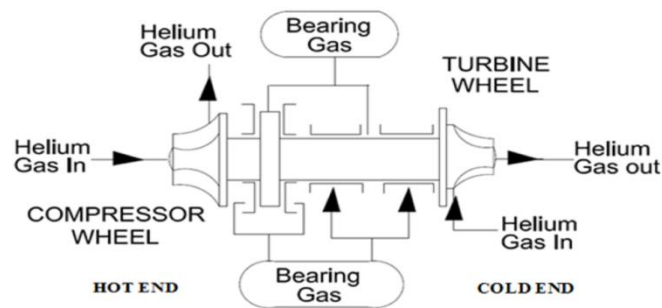


Fig. 1. Helium Turboexpander

III. ANALYSIS OF HELIUM TURBOEXPANDER WITH ASPEN HYSYS

Analysis of helium turboexpander is carried out with the process modeling tool called ASPEN HYSYS. This tool helps in analyzing the important parameters of turboexpander like temperature, pressure, heat flow, work done and mainly the optimum efficiency of turboexpander can be analyzed. Hence we can wisely choose the efficiency of turboexpander for getting the optimum productivity [10].

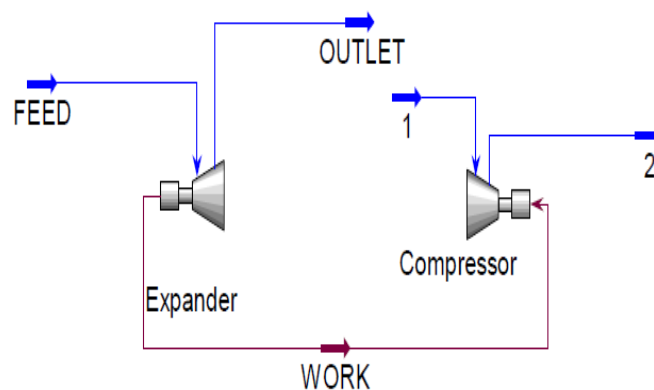


Fig 2. Modeling Helium Turboexpander in ASPEN HYSYS

Figure 2 shows the model of turboexpander, where the sample gas is taken as helium and the work output is used to drive a compressor.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

Material Streams					
		FEED	OUTLET	1	2
Vapour Fraction		1.0000	1.0000	1.0000	1.0000
Temperature	K	35.00	23.63	35.00	46.06
Pressure	bar	13.50	5.000	13.50	22.98
Molar Flow	kgmole/h	107.9	107.9	107.9	107.9
Mass Flow	g/s	120.0	120.0	120.0	120.0
Liquid Volume Flow	m3/h	3.482	3.482	3.482	3.482
Heat Flow	kW	21.74	14.51	21.74	28.97

Fig 3. Material Streams of Turboexpander in ASPEN HYSYS

Figure 3 shows the values of various parameters used and obtained from modeling of helium turboexpander.

Energy Streams		
		WORK
Heat Flow	kW	7.227

Fig 4. Energy/Work output Stream of Turboexpander in ASPEN HYSYS

Figure 4 shows the energy obtained from the helium expander. This energy which was else wasted can be used to drive a compressor. This is carried out in ASPEN HYSYS, which can be observed in Figure 2.

IV. ADIABATIC EFFICIENCY OF HELIUM TURBOEXPANDER WITH ASPEN HYSYS

The efficiency of turboexpander plays the major role while selecting or purchasing procedure. Efficiency of an expander is the maximum expansion it can provide by reducing the temperature in the most efficient way. ASPEN HYSYS is a platform where you can easily choose the parameter on which you are supposed to do expansion and can observe its behavior. Figure 5 shows the graph for adiabatic efficiency vs outlet temperature. It is observed that with increased efficiency of expander, we can get more reduction in the temperature which is a very important point while dealing with cryogenics. It is observed from the graph that we can get approximately 23K of temperature at the outlet of expander with the 100% efficiency ideally. So, practically we can choose the optimum efficiency required for the plant[11][12].

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

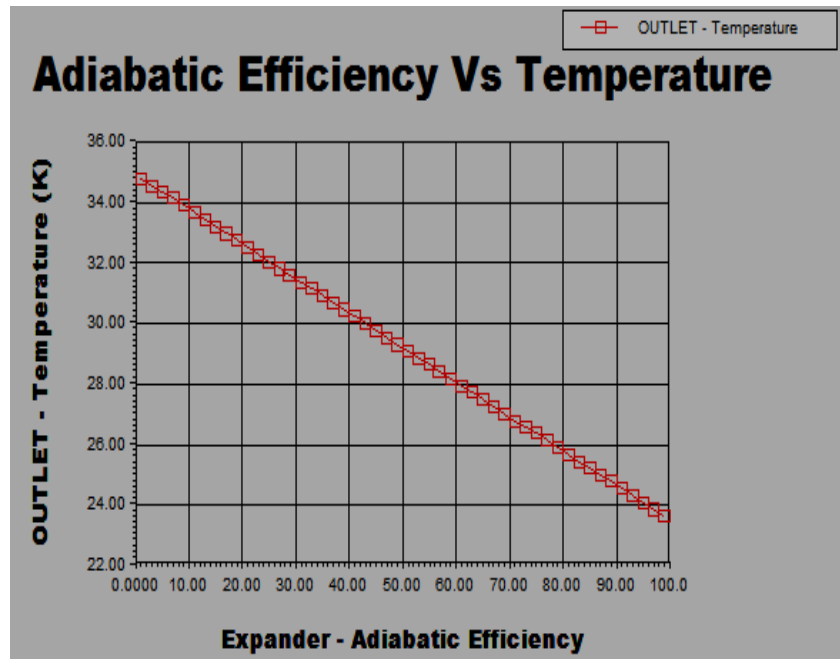


Fig 5. Adiabatic Efficiency Vs Outlet Temperature of Turboexpander in ASPEN HYSYS

Thus, it is seen that the helium gas is expanded from a temperature of 35K to 23K approximately, which is quite a good expansion ideally. Similarly, we can analyse the expander and can get the optimum required efficiency of expander which can help us in the costing of the device and hence the overall plant.

V. SIMULATION & RESULTS

Now, at last we can have the overall result analysis of the modelling we have carried out in ASPEN HYSYS. Table 1 below shows the overall results of the simulation carried out in ASPEN HYSYS. This result can be delivered to the end user for complete concluded values to be kept for the plant, to obtain the optimum output.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017


1	 LEGENDS Calgary, Alberta CANADA		Case Name: F:\ASPENTECH\ASPEN HYSYS 2006\CASES\TURBOEXPANDER.HSC			
2			Unit Set: NewUser			
3			Date/Time: Thu Jan 19 21:26:14 2017			
4						
5						
6	Workbook: Case (Main)					
7						
8						
9	Material Streams					Fluid Pkg: All
10						
11	Name	FEED	OUTLET	1	2	
12	Vapour Fraction	1.0000 *	1.0000	1.0000 *	1.0000	
13	Temperature (K)	35.00 *	23.63	35.00 *	46.06	
14	Pressure (bar)	13.50 *	5.000 *	13.50 *	22.98	
15	Molar Flow (kmole/h)	107.9	107.9	107.9	107.9	
16	Mass Flow (g/s)	120.0 *	120.0	120.0 *	120.0	
17	Liquid Volume Flow (m3/h)	3.482	3.482	3.482	3.482	
18	Heat Flow (KW)	21.74	14.51	21.74	28.97	
19	Compositions					Fluid Pkg: All
20						
21	Name	FEED	OUTLET	1	2	
22	Comp Mole Frac (Helium)	1.0000 *	1.0000	1.0000 *	1.0000	
23						
24	Energy Streams					Fluid Pkg: All
25	Name	WORK				
26	Heat Flow (KW)	7.227				
27						
28	Unit Ops					
29	Operation Name	Operation Type	Feeds	Products	Ignored	Calc Level
30	Expander	Expander	FEED	OUTLET	No	500.0 *
31			WORK			
32	Compressor	Compressor	1	2	No	500.0 *
33			WORK			

Table1. Results of the Modelling plant obtained from ASPEN HYSYS

VI. CONCLUSION

The analysis of the turboexpander plant is carried out with the simulation tool Aspen HYSYS. The result obtained plays an important role in performing experiments with the actual hardware before its actual implementation in the

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

plant. The optimum adiabatic efficiency can be obtained with variation in the outlet temperature of expander. Thus, Aspen HYSYS as a process modeling simulation tool, proves to be very useful in deciding the productivity and thus the profitability of the plant efficiently.

REFERENCES

- [1] Chuen Chan, "Aspen simulation", in Dept of Chemical Engineering.
- [2] Aspen HYSYS User Guide, 2004.2.
- [3] Barron Randall F., "Cryogenic Systems", New York, Oxford University Press, 1985.
- [4] Flynn Thomas M., "Cryogenic Engineering", Colorado, Oxford University Press, 1992.
- [5] Darshna M Joshi, H.K.Patel, "Automatic PID Control Loops Design for Performance Improvement of Cryogenic Turboexpander", Volume-10, April 22, 2015, IOP Journal of Instrumentation- JINST.
- [6] Darshna M. Joshi, H.K.Patel and Disha K. Shah "Qualitative Considerations for the Instrumentation and Control System Design for Cryogenic Turboexpander", Saffrony Institute of Technology International Conference on Advances in Engineering, International Journal of Advanced Research (IJAR), 22-23 January 2015, V5, 7-9.
- [7] Venkatarathnam, G, "Cryogenic Mixed Refrigerant Processes", 2008, Springer, ISBN- 978-0- 387-78513-4.
- [8] R. G. SCURLOCK (1990), "A matter of degrees: a brief history of cryogenics", Volume 30, Issue 6, Pages 483-500.
- [9] Stoecker W.F, "Design of Thermal systems", Toronto, Tata McGraw Hill, 1986.
- [10] Seider, W., D., Seader, J., D., Lewin, Daniel, R.: "Process Design Principles - Synthesis, Analysis, and Evaluation", John Wiley, NY, 1999.
- [11] Jaroslav Poživil "Use of Expansion Turbines in Natural Gas Pressure Reduction Stations", Acta Montanistica Slovaca Ročník 9 (2004), číslo 3, 258-260.
- [12] John c. Polasek, Stephen t. Donnelly, jerry a. bullin, "Process Simulation and Optimization of Cryogenic Operations Using Multi-Stream Brazed Aluminum Exchangers", Bryan Research and Engineering, Inc, 2001.