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Modeling of a Gas Pressure Increasing Station's Performance at Design and Off-Design Points

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ABSTRACT: In this paper modeling of the turbocompressors of a gas pressure increasing station has been done at the design point and off-design point. First the performance characteristics of the station have to be determined, after that with changing the physical properties of the inlet gas as well as the performance characteristics of the used setups with usage of their characteristic curves, the off-design point modeling and analysis are done. To do this, MATLAB and Aspen HYSYS have been used in parallel. Thus the results of the codes in MATLAB can be compared with the Aspen HYSYS results. After modeling is done, working points of the station are determined. By determining the position of working points on the characteristic curves of the station setups, the equilibrium working range of the station is achieved. Thus in practice, if the station's working point is near to this range, the efficiency of the station will be higher and problems like surge will not occur.

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1- Introduction

After the natural gas extraction from gas fields and being refined in special refineries, it is transferred to cities and industrial centers through gas transfer pipelines. Gas should move with an acceptable velocity in pipelines, because of this, gas pressure should not be decreased lower than a defined limit. With long gas transfer pipelines, frictional pressure drops are increased, also pressure drops due to meanders in the route of the pipelines decrease pressure gas under the defined limit. Thus gas pressure must be increased on its way in distinct distances in order to increase gas velocity in pipelines to maintain a constant mass flow rate. The task of a gas pressure increasing station is to enhance the pressure of its inlet gas with a special mechanism and return the gas to the pipeline; therefore, in the path of the gas transfer pipelines, gas pressure increasing stations must be installed in distinct distances. The distance between the stations depends on the geographical conditions of the area and is about 100 to 150 kilometers. One of the most relevant works that has been done about the off-design point analysis of a gas pressure increasing station is reference [1]. In that project, thermodynamic and dynamic modeling of a gas pressure increasing station is done by using the characteristic curves of the MAPNA group. They focused on the gas compressor as the main equipment of the station but they didn't consider other parts of the station. Also they have done dynamic modeling of the station and they considered the response of the gas compressor to the inlet turbulences.

In the present work, off-design point analysis of the other station equipment has been done in addition to gas compressor such as high and low pressure turbines and air compressor. In present work all of the calculations and analysis have been done with two software in parallel. Thus the results of the softwares can be compared to each other.

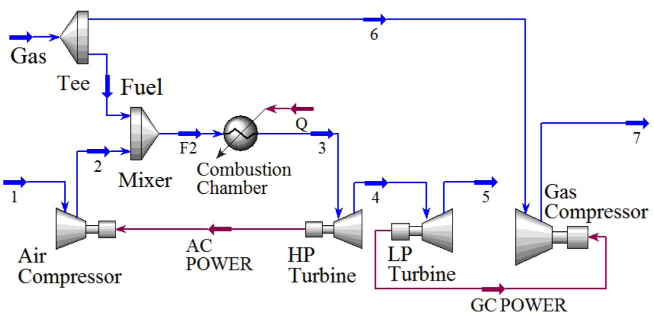

Figure 1. Schematic of gas pressure increasing station modeled in HYSYS

2- Structure of the pressure increasing station

Generally, a pressure increasing station has these equipment: a centrifugal compressor which is called gas compressor, an axial compressor with the name of air compressor, two axial turbines with the names of high and low pressure turbines, a combustion chamber, scrubbers and etc. The schematic of gas pressure increasing station has been shown in Fig. 1. In most gas stations that have been made recently in Iran, Alstom gas turbines are used to drive natural gas compressors which mainly are made by Siemens. Schematic of an Alstom turbine has been shown in Fig. 2 [2].

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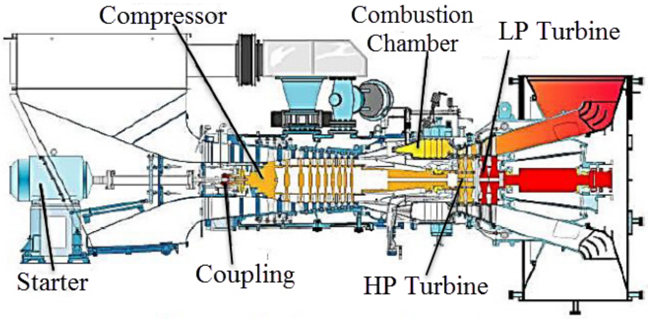

Figure 2. Schematic of Alstom G.T.10B2 gas turbine [3]

3- Design point and off-design point analysis of gas compressor

First it must be considered that what are the factors that can affect working conditions of the system. Generally, factors are divided into two groups: first group, thermo-physical properties of the gas and second group, working conditions of the turbomachines. In considering the thermo-physical conditions of gas, two independent thermodynamic properties (here temperature and pressure) are considered. Because temperature of the ambient air around the pipeline changes considerably in different seasons of the year, the gas temperature alters consequently. Variation of gas pressure depends on many factors including distance of the station to the former station, roughness of the pipes, geographical properties of the area and etc. Non-dimensionalizing effective factors has two advantages. First, in all of official references of turbomachinery, characteristic curves are plotted in non-dimensional form. Second, the number of affecting factors decreases and effect of some factors can be seen in one non-dimensional group. For example, in Fig. 3 gas compressor power consumption is plotted versus pressure ratio.

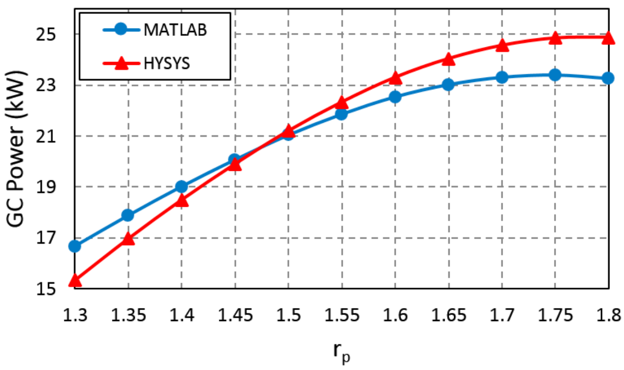

Figure 3. GC power consumption versus pressure ratio

4- Off-design point analysis of power turbine and generating gas cycle

Now relations between all of parameters of gas compressor have been reached. The aim is to calculate working parameters of other members of station and consider when other members can work in optimized conditions by changing working conditions of gas compressor.

Power turbine is another name of low pressure turbine which supplies gas compressor demanding power. The most related member of station to gas compressor is power turbine because of two reasons. First, power turbine and gas compressor have been installed on the same shaft and consequently they have same speed of rotation. Second, the power which is demanded by gas compressor determines the lower limit of power which power turbine must generate.

5- Conclusion

- The low pressure turbine has the smallest changes in its parameters with respect to other members of the station and the high pressure turbine has small changes in its pressure ratio and mass flow rate but changes in its efficiency are considerable.
- By increasing gas compressor mass flow rate, high and low pressure turbine efficiencies are increased and gas compressor efficiency changes are negligible. Also the outlet gas temperature is decreased and air compressor mass flow rate and pressure ratio are increased.
- With increasing gas compressor pressure ratio, high and low pressure turbine efficiencies are decreased and gas compressor efficiency changes are negligible. Also high and low pressure turbines pressure ratios are increased and air compressor mass flow rate and pressure ratio are decreased.
- As compressors speed are increased, their demanding power is decreased and turbines generating power is decreased too. Consequently, in warm seasons of the year when natural gas consumption is less than cold seasons, with decreasing compressors speed less than design point speed, the performance of station will be optimized.
- For the same reasons in cold seasons of the year the station must work with its full capacity. Consequently, compressors speed must be increased higher than design point speed which decreases the efficiency of the system.

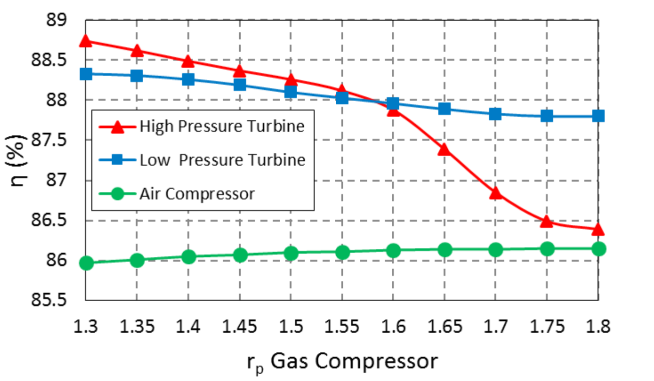

Figure 4. Turbines efficiency versus GC pressure ratio

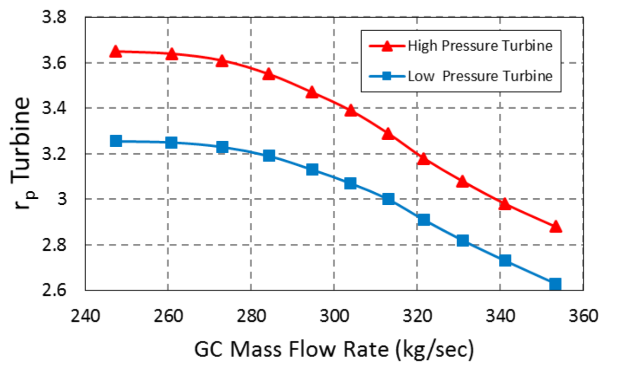

Figure 5. Turbines pressure ratio versus GC flow rate

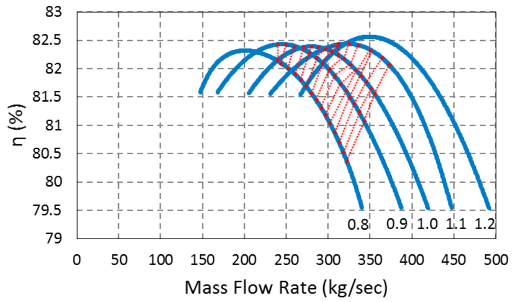

Figure 6. Proposed range for operation of GC on the efficiency versus mass flow rate characteristic curve

References

[1] Razaghi, M., "*Thermodynamically and Dynamically Modeling of Gas Compression Station*". MS Thesis, Iran University of Science and Technology, 2011.(In Persian)

[2] Ludwig, Ernest E., "*Applied Process Design for chemical and petrochemical Plant*", 3, Third Edition, 2002.

[3] Nordstrom, L., "*Construction of a Simulator for the Siemens Gas Turbine SGT-600*", Linköping 2005.

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