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Improving Turbine and Compressor Performance

By: Alexsander Moreira Alves Valeriano, Energy Solutions International, Rio de Janeiro, Brazil; Raymundo César m. Castro, TBG – Transportadora Brasileira Gasoduto Bolivia Brasil S/A, Rio de Janeiro, Brazil

Recently, Transportadora Brasileira Gasoduto Bolivia Brasil S/A (TBG) performed an operational analysis review to ensure the performance of the turbines and compressors on the Bolivia-to-Brazil gas pipeline. The analysis included the use of online and offline simulators, as well as software developed specifically for the TBG system.

The work involved analysis of field operations tests, vibration, fuel gas consumption and various operating points, as well as surge control and start number control. These efforts have increased the reliability of TBG's gas machinery by more than 10% in just a few months, and have enabled TBG to optimize the planning for its overhauls and maintenance shutdowns.

Performance analysis

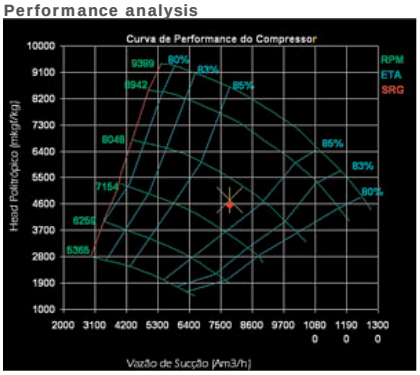

Figure 1. Centrifugal compressor performance simulator.

In pipeline operations, one of the most important issues to control is the performance of the turbine and compressors, because this equipment is vital for gas transportation and pipeline availability. In order to have an appropriate control of this performance and obtain the necessary operating information, TBG created a group that was specially dedicated to perform this analysis.

Software development

A special software solution was developed to insure accurate performance analysis. This tool can reproduce in detail all turbine and compressor operational conditions, as well as estimate fuel usage consumption and surge control. An online simulator is also used to compare and validate the analysis.

Development stages

To develop this tool, it was necessary to study all machine characteristics and create a data bank with the maximum number of operational data. These data were obtained from SCADA data bank and from visits to the field. TBG has two kinds of turbocompressor stations, so two different sets of tools were developed to accomplish that.

Compressor performance tool

This tool is responsible for simulating the compressor performance, and gives the specialists all the data used in the analysis (Figure 1). This tool has a copy of the SCADA screen and informs the operational point. The yellow "X" shows the real point and the red point shows the nominal point. The simulator also calculates the real and the nominal efficiency that gives the specialists the exact condition of the compressor.

Based on this information, the specialist can determine if the compressor is operating in a safe condition, and if the SCADA system is giving the right feedback for the gas controllers. This is especially important since TBG operates all its compressor station remotely via satellite.

Turbine performance tool

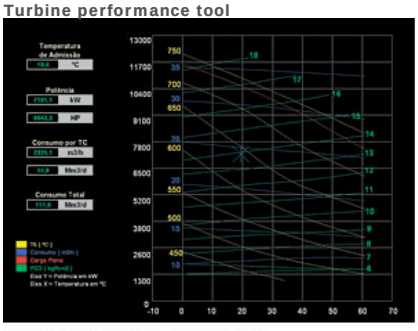

Figure 2. Turbine performance simulator.

This tool is responsible for simulating the turbine performance, and provides the specialists the data that they need to perform the analysis (Figure 2). This was developed through visits to the field, and the recognition of the real relation between NGP and NPT. With this data in hand, the points were plotted and a function was defined to give a very good approximation of the real numbers.

Online compressor performance tool

In order to insure the accuracy of the analysis, as well as the results given by the performance simulator, TBG also has an online system that reproduces compressor performance. This tool receives live data from the SCADA system, processes it, and then gives the operational point, discharge temperature, head, adiabatic efficiency, fuel flow and surge flow. The specialists can then verify these parameters against the results obtained with the offline simulator.

In order to perform the analysis, the specialists go to the compressor stations and submit the turbines and compressors to a detailed analysis of all operational points. The

main points considered in the analysis are: mechanical and adiabatic efficiency, discharge temperature, head, surge control, power required, fuel gas usage, NPT, NGP and vibration information. This analysis could be performed at TBG main headquarters in Rio de Janeiro, but to keep deadbands out of the process, all of the analyses are performed onsite.

Efficiency

The efficiency of the compressors is calculated by both systems, online and offline and then compared to the SCADA online data. A diference of 10% is considered allowed; but, if the difference exceeds 7%, a closer look is recommended. The performance simulator calculates both design and actual efficiency, and it is possible to determine if the machine is operating efficiently based on this information.

Discharge temperature

The discharge temperature obtained from both tools is compared to the real temperature and, again, the maximum difference tolerated is 10%. The procedure is the same as that used in efficiency. Discharge temperature is also used to analyze if there are any internal problems in the compressor, such as internal leaks caused by corrosion (for example).

Head

The calculated head is compared to project specifications and real conditions. This analysis can indicate not only a decrease in performance but also a difference between design conditions and actual operating conditions.

Surge control

The analysis of surge control variables show if the surge protection system is operating properly. If there are big differences between the calculated and real data, there will be a recommendation to check the surge control system. In this case, the machine will be stopped and will not operate until the problem is resolved.

Fuel gas usage

The results of these analyses indicate whether the machines are operating at their best conditions, and if the load-sharing system is controlling the operational points on maximum efficiency. TBG has “load share” functionality in all of its compressor stations. Most of the time, the machines operate under “auto mode.” This means that the system is responsible to keep the machines away from surge and operating at maximum efficiency.

Vibration

This is one of the most important variables analyzed during the test. Special attention is paid to this item, because vibration can cause irreversible losses to compressors and turbines. The analysis is done through live SCADA data and through measurements done in the machine, in the discharge and suction pipes, and in the pipes supports as well. The points that are not monitored by SCADA are measured through the use of a portable vibration analyzer. If vibration is very high, an early overhaul is worth considering. It is worth noting that TBG has changed the overhaul priority twice since this analysis started.

NGP x NPT

These variables give a snapshot of the efficiency of the power transmission. They must be close to design, because if they are not, the compressor station will not be able to accomplish its requirements. Again the calculated values in this relation are verfied against the real data. The simulator can recreate the power transmission through historical data stored in the system database.

Required power

The power required by the driver is also analyzed in this process. The contamination factor is used in this analysis to determine whether the turbine is responding with the same efficiency showed in the acceptance test.

Test results

The test results are used in maintenance planning as well as in overhaul planning. The overhaul planning goes through a meters and performance analysis. The overhauls are scheduled to take place when the machines reach 30,000 hours of continuous operation. At Campo Grande compressor station, one of the compressors had reached 30,000 hours in April 2006; and another one in August of the same year. The analyses indicated that the second compressor was presenting excessive vibration, while the first one had all the variables in perfect conditions. The decision was made to postpone the maintenance for the first compressor to 35,000 hours, and to keep an eye on the second one. With this decision, TBG opted to remove a machine in perfect condition, and delay the decision to remove the other one. It is recognized that turbine changeout or replacement affects operational availability.

Acknowledgment

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