Available online at www.sciencedirect.com
ScienceDirect
Procedia Engineering 69 (2014) 986 – 990
Procedia Engineering
www.elsevier.com/locate/procedia

24th DAAAM International Symposium on Intelligent Manufacturing and Automation, 2013

Recovery of Wasted Mechanical Energy from the Reduction of Natural Gas Pressure

Iancu Andrei[a*], Tudorache Valentin[b], Tarean Cristina[c], Toma Niculae[d]

[a]*Piata Trandafirilor no. 21, Targu Mures, Romania*
[b]*1848 no. 1-3, Ploiesti, Romania*
[c] *Piata Trandafirilor no. 17, Targu Mures, Romania*
[d]*220 D Iuliu Maniu Ave., Bucuresti, Romania*

Abstract

At the present time in Romania, the transition from the natural gas transportation system to the distribution system is done only thru the use of pressure reducing stations. Here the pressure drop is usually done by using throttle valves or pressure reducing valves, where the gas energy is spent without doing any work. In this article we propose the use of turbo-expanders in the pressure reducing stations, where the natural gas pressure from the transportation grid is high and needs to drop to lower levels to enter the distribution grids, in this way part of the energy consumed in the compression stations are recovered. The plans are made at this time for a pilot project at the pressure reducing station in the city of Onesti, Bacau County.

Keywords: energy recuperation; expander

1. Introduction

We live in a world were the main energy source is represented by fossil fuels. With the ever increasing deeps at which are extracted translate into higher costs of their final products we look at other energy sources or at least new way of optimizing the current energy use as Tilich has researched [1]. One of these methods of optimization can be used in the natural gas field, where the gas pressure needs to be reduced. By using turbo-expanders in the pressure reducing stations, where the natural gas pressure from the transportation grid is high and needs to drop to lower

* Corresponding author. Tel.: +4-075-093-668;
E-mail address: andianc@yahoo.com

doi:10.1016/j.proeng.2014.03.080

levels to enter the distribution grids, in this way part of the energy consumed in the compression stations is recovered. Usually the turbo-expanders are used as sources of refrigeration in industrial processes. The power generated from expansion is lower when compared to classical gas power plants and the flow rates will vary according to a series of external factors like time of day, seasonal cycles and the industrial consumers.

The turbo-expander technology is currently implemented in countries like USA, UK, Italy, Canada and Russia. The San Diego Gas & Electric Company is using turbo-expanders since 1983[2] and in 2009 a project was initiated in London's natural gas distribution grid, were turbo-expanders were combined with bio-fuel burning generators to produce 20MW [3]. Mirandola and Minca [4] presented detailed analysis of power generation from high pressure natural gas and provided guidelines for designing such installations, taking into consideration thermodynamics, gas flow rates, number of expansion stages and pre-heating requirements. In a subsequent paper, Mirandola and Macor [5] presented experimental data from a pilot project conducted in Italy, showing that if pre-heating is required, most of the heat is recovered as electricity.

Poživil [6] reported simulation results for a gas transmission station in the Czech Republic. It is mentioned that temperature drop in the throttle valve can be of 0.45-0.6˚C per bar of pressure drop, whereas with turbo-expanders can reach 1.5-2˚C per bar.

In Romania, the average transportation pressure is of 20 bar and the distribution one is of 2 bar, thus the potential of using turbo-expanders is high. A pilot project is implemented in Onesti, Bacau County and it is using a two stage turbo-expander. The turbo-expander was made by converting two CU128 screw compressors from GHH Rand [7,8].

2. Installation description

The turbo-expander system is composed of:

- Assembled frame;
- Assembled caisson;
- Helicoidally turbine;
- Synchronous generator – 250 kVA, 1500 rpm, 400 V, 50 Hz;
- Coupling assembly;
- Expander – suction valve section;
- Expander – separation vessel section;
- Lubrication and injection system;
- Command and control adjustment system.

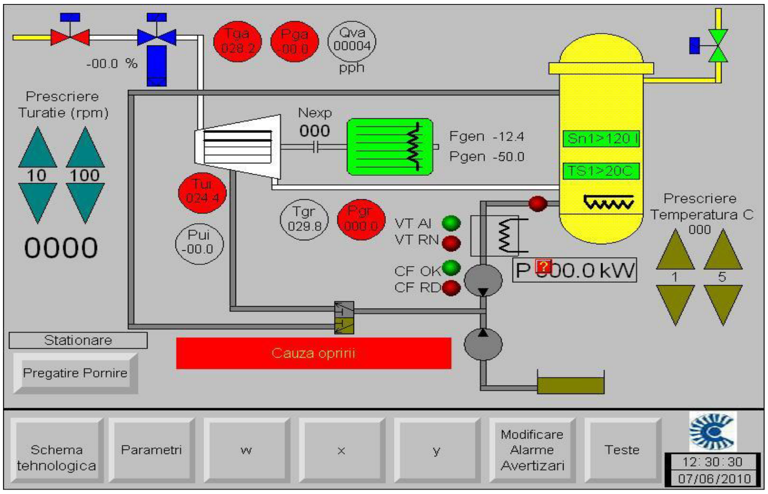

Fig. 1.Turbo-expander technological chart.

The frame is a welded construction on which there are mounted, thru the caisson, the turbine and the electric generator. The separation vessel is also mounted on the frame, has the role of separating the oil from the gas after it leaves the helicoidally turbine. The suction valve regulates the flow and pressure for maintaining an optimal revolution of 1500 rpm corresponding to the 50 Hz frequency of the electrical generator. The expander – separator vessel section makes the connection between the expander installation and the separation vessel.

The command and control adjustment system (fig.1) is tracking the thermal, mechanical and electrical parameters, under normal and transitional work conditions and their adjustment to assure maximum operational security.

2.1. Turbo-expander main features

The expander (fig.2.) global parameters:

- Medium: natural gas;
- Inlet temperature: 80˚C;
- Inlet pressure: 20 bar;
- Outlet pressure: 3,5 bar;
- Internal volume ratio (Vi): 2,6;
- Mass flow: 4800 kg/h;
- Power: 180 kW;
- Revolution per minute: 1500.

Fig. 2. Helicoidally expander - generator system - isometric view [2].

2.2. Experimentation data with air

The expander (fig.3.) has been tested with air, recreating the conditions from the pressure reducing station where it will be installed. The discharged flow was at 26% from the optimal one and the intake gas pressure was at 5.5 bar. All data has been digitally recorded.

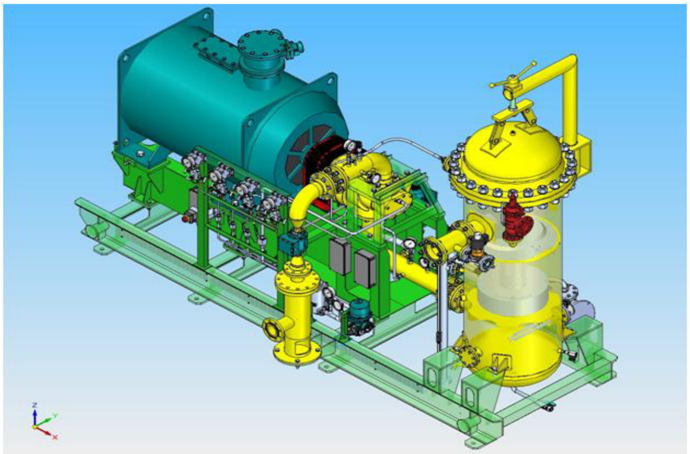

Fig. 3. Experimental installation.

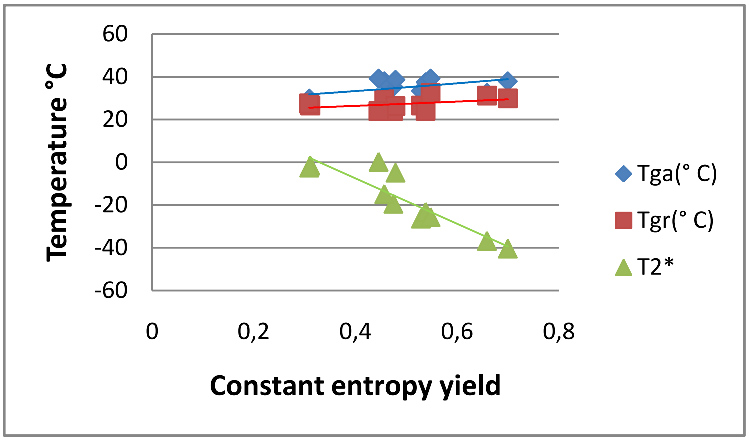

Fig 4.. Power based on constant entropy yield.

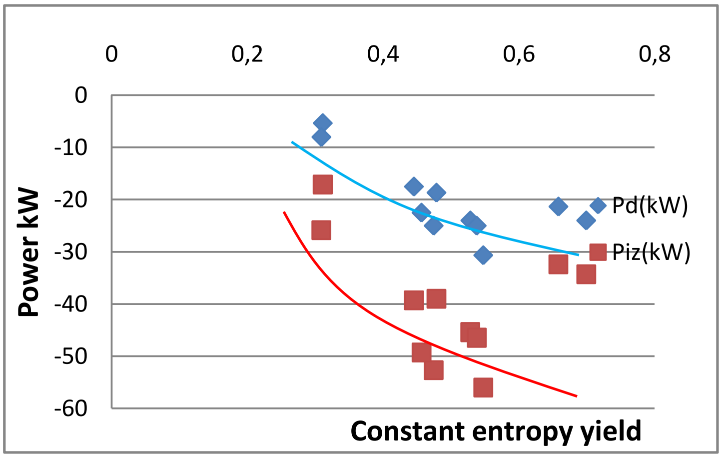

Fig. 5. Temperature based on constant entropy yield.

The experiments were conducted with a rotation speed between 1000-1500 rpm. Operating modes lead to yields between 0.75 and 0.8, yields that the electrical generator manufacturer has confirmed. At the rated speed of 1500 rpm and a 50 Hz frequency has been generated a voltage of 280 V.

The main diagrams obtained from the experimental data are represented in figure 4 and 5.

Nomenclature

Pd	the expander shaft power
Piz	the expander constant entropy power
Tga	inlet air temperature
Tgr	outlet air temperature
T2*	theoretical air temperature

3. Conclusion

There exists a good potential energy gain in the use of turbo-expander in the pressure reduction station in Onesti. Although the power generated is lower in comparison to the conventional power plants, if we extrapolate the results to the whole country [9], the sum of all locations could be substantial. It needs to be noted that the gas does not need to be pre-heated, the outlet gas temperature being higher than the temperature at which the gas hydrates appear. With a temperature of over 20°C at the expander outlet, we need a lower heating of the injected oil. At this temperature we don't have to worry about the apparition of natural gas hydrates, otherwise about 0.18-0.25% of the gas would have been used for heating. The experimental data with air reveals that the expander will reach the designed parameters in real world conditions.

The next step is to see what the effects of flow variation are. A study on the consumption of domestic consumers based on time of day or seasonal cycles needs to be made as Stulec, Bakovic and Hruska showed in their study [10].

References

[1] Tilich, D. S.: Energy consumption of Romanias' development regions.

[2] Heinz, P. B and Soares, C.: "Turboexpanders and Process Applications", ISBN 978-0-88415-509-6.

[3] Rheuban, J.: "Turbo expanders: Harnessing the Hidden Potential of Our Natural Gas Distribution System", Article, March 9th, 2009.

[4] Mirandola, A. and Minca, L.: "Energy Recovery by Expansion of High Pressure Natural Gas", Proc.of the 21st Intersociety Energy Conversion Engineering Conference, Vol. 1, pp. 16-21, San Diego, California, Aug. 25-29, 1986.

[5] Mirandola, A. and Macor, A.: "Experimental Analysis of an Energy Recovery Plant by Expansion of Natural Gas", Proc. of the 23rd Intersociety Energy Conversion Engineering Conference, Vol. 4, pp. 33-38, Denver, Colorado, July 31-Aug. 5, 1988.

[6] Poživil, J.: "Use of Expansion Turbines inNatural Gas Pressure Reduction Stations", Acta Montanistica Slovaca,Volume 9 (2004), Number 3,pp 258-260.

[7] Prospect Oil injected screw compressors – GHH Rand Sraibenkompressoren.

[8] Manual de instalare a compresoarelor CF, CR, CU – GHH Rand.

[9] Trifan, C., Albulescu, M., Chisalita, D., Simescu, N. - Natural Gas Activity in Romania, Petroleum-Gas University, 2008.

[10] Stulec, I.; Bakovic, T. & Hruska, D.: Weather Risk Management in Energy Sector, Annals of DAAAM for 2012 & Proceedings of the 23rd International DAAAM Symposium, Volume 23, No.1, ISSN 2304-1382 ISBN 978-3-901509-91-9, CDROM version, Ed. B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2012, pp 0089-0094.