Testing Group of Helicoidal Expander – Electric Generator at Comoti Test Bench, Using Air Supplied by 3 Compressors Type CU128G

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Abstract: *The paper describe a project dedicated to exploitation of natural gas, an important quantity of mechanical clean energy is loosed continuously by not using expansion energy in laminating process gas. A group of helicoidal expander – electrical generator was manufactured and tested. It is designed to produce electric energy for own facilities of a gas station or to supply local networks of gas distribution.*

Key words: *helicoidal expander, turbine, electric generator, clean energy, green energy, natural gas.*

1. INTRODUCTION

Nowadays, valves, usually warmed, are used for the lamination of gas, to reduce gas pressure in regulating and measuring stations located on main pipelines. This operating mode leads to an important loss of green energy; it can be recovered using effectively the differential pressure on the expander. The purpose is to replace the valve and laminar regulators with a helicoidal turbine that uses adiabatic expansion to produce useful and clean energy. A new expander was built in helicoidal turbine configuration to take advantages of screw compressors: high efficiency, low maintenance costs due to very good reliability, fewer moving parts and not least competitive price. The solution has not been studied in Romania and is not applied to any plant of ROMGAZ or TRANSGAZ (both are Romanian gas transportation and distribution companies). The advantages of using such equipment are, besides producing green electricity, the gas availability to other consumers, thus reducing the amount of CO_2 released in the environment, the possibility of selling CO_2 certificates and green vouchers.

2. EXPERIMENTATION IN COMOTI TEST BENCH

The expander was tested in COMOTI test bench. The test configuration was determined by the possibility of using an air pressure source for the intake (3 compressors of CU128G type). The air test programme follows the test procedure dedicated to gas station, in range of the available parameters on test bench. All measurements were digital recorded and then transferred to a computer for the on-line processing. The air flow cumulated by all 3 compressors was a maximum of 2426 kg/h and the air pressure to the expander intake was 6.75 bara.

2.1. Test description

2.1.1. Preliminary actions for starting up the expander:

- warming oil to 70°C;
- opening 30% the suction valve located on the expander air intake.

2.1.2. Starting up the air compressor no. 1:

- push the button "Start up preparation" for expander simultaneously with the start up of compressor no. 1; push the button "Start up" for expander after finishing the start up preparation sequence;
- the electrical generator is charged increasing the excitation voltage proportionaly with air flow delivered from the compressor no. 1;
- power, voltage and current of generator are recorded at maximum air flow.

2.1.3. Air source: compressors no. 1 and 2:

- start up the second compressor and charge the generator increasing excitation voltage;
- power, voltage and current of the generator are recorded at maximum air flow cumulated.

Fig. 1 Group of helicoidal expander-electric generator at COMOTI test bench.

2.1.4. Air source: compressors no. 1, 2 and 3:

- start up the 3rd compressor and charge the generator increasing excitation voltage;
- power, voltage and current of the generator are recorded at maximum air flow cumulated.

2.1.5. Setting the expander speed at 1500 rpm:

- adjust the excitation voltage to get 1500 rpm at expander – generator;
- power, voltage and current of the generator are recorded.

2.1.6. Test finish

- the air compressors stop one by one, in reverse order (3^{rd}, 2^{nd} and 1^{st});
- push the button “Shut down” of the expander after the last compressor shut down; the by-pass valve releases the suction pressure to gas-oil separator.

Tests are made running the expander – generator in range of 1000…1500 rpm. Operating data have resulted in an efficiency of generator η_{gen} of 0.75...0.80 confirmed by the manufacturer of the electric generator, Electroputere Craiova. To stabilize the expander speed at 1500 rpm, a three-phase variable ballast resistance was placed in the generator stator circuit. With this resistance and an adequate voltage excitation, a stable operating mode was obtained at 1500 rpm, the generator being able to connect at the electric network.

Negative values for power means the power is produced, not consumed.

2.2. Notations and symbols

QM	air mass flow	kg/h
N_{exp}	expander speed	rpm
$p_1=p_{ga}=p_{statDV}$	suction air pressure, after suction valve	bara
$p_2=p_{gr}=p_{statREF}$	discharge air pressure	bara
P_d	power at expander shaft	kW
P_{gen}	generated electric power	kW
P_{iz}	isentropic power of expander	kW
p_{ui}	oil pressure in main lubrication line	bara
$T_1=T_{ga}=T_{GA}$	suction air temperature	^oC
T_2*	air theoretical temperature of discharge	^oC
$T_{gr}=T_{totREF}$	air total temperature of discharge	^oC
T_{ui}	oil temperature	^oC
η_{gen}	generator efficiency	-
η_{iz}	isentropic efficiency of expander	-

Table 1. Measured parameters.

No.	Date	Time	N_{exp} (rpm)	F (Hz)	p_{ga} (bara)	p_{gr} (bara)	T_{ga} (° C)
1	05.10.2011	13:37:00	1000	37.0	3.29	1	31.45
2	05.10.2011	13:43:00	1400	45.3	4.86	1	34.23
3	05.10.2011	13:45:00	1500	50.0	4.92	1	34.00
4	05.10.2011	13:47:00	1500	50.0	6.54	1	36.13
5	05.10.2011	13:49:00	1400	46.0	6.75	1	37.21

Table 2. Measured parameters.

No.	Date	Time	T_{gr} (° C)	p_{ui} (bara)	T_{ui} (° C)	QM (kg/h)	P_{gen} (kW)
1	05.10.2011	13:37:00	51.4	4.82	66.30	868	13
2	05.10.2011	13:43:00	35.82	6.08	58.93	1828	34
3	05.10.2011	13:45:00	35.9	6.09	59.10	1830	31
4	05.10.2011	13:47:00	18.42	8.39	50.68	2426	49
5	05.10.2011	13:49:00	17.62	8.78	47.65	2400	51

Table 3. Calculated parameters.

No.	Date	Time	η_{gen} (-)	P_d (kW)	P_{iz} (kW)	η_{iz} (-)	T_2^* (° C)
1	05.10.2011	13:37:00	0.75	17.333	21.240	0.816	-40.255
2	05.10.2011	13:43:00	0.75	45.333	56.896	0.797	-54.814
3	05.10.2011	13:45:00	0.80	41.333	57.265	0.722	-47.099
4	05.10.2011	13:47:00	0.80	61.250	86.798	0.706	-54.520
5	05.10.2011	13:49:00	0.75	63.750	87.258	0.731	-58.161

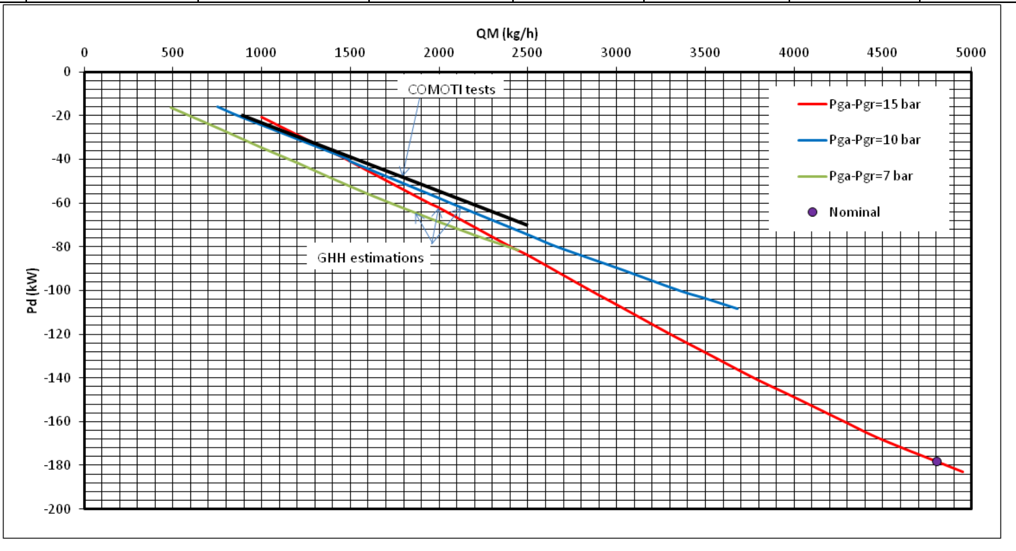

Fig. 2 Electrical power generated by the group of helicoidal expander-electric generator.

Fig. 2 shows experimental curves obtained on conditions of COMOTI test bench (tests with air – air flow and pressures lower than nominal) versus the estimation of GHH Germany (gas estimation).

3. CONCLUSIONS

1. The equipment functionality was proved.
2. With test conditions (maximum air flow 2400 kg/h at 6.75 bara pressure) the shaft power of turbine rises at 63.75 kW (Pgen=51 kW), with 0.73 isentropic efficiency of the expander.
3. An elevated discharge temperature was obtained (grater than 20° C), showing that a reduced warming of oil is possible.

A general conclusion is obvious after analyzing data: with stand conditions, the isentropic efficiency of the turbine versus shaft power of the turbine and real air temperature of discharge shows an evolution very close to the estimation of the expander manufacturer, GHH Germany.

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