VENT GAS COLLECTION SYSTEM FOR GAS COMPRESSOR DRY GAS SEALS

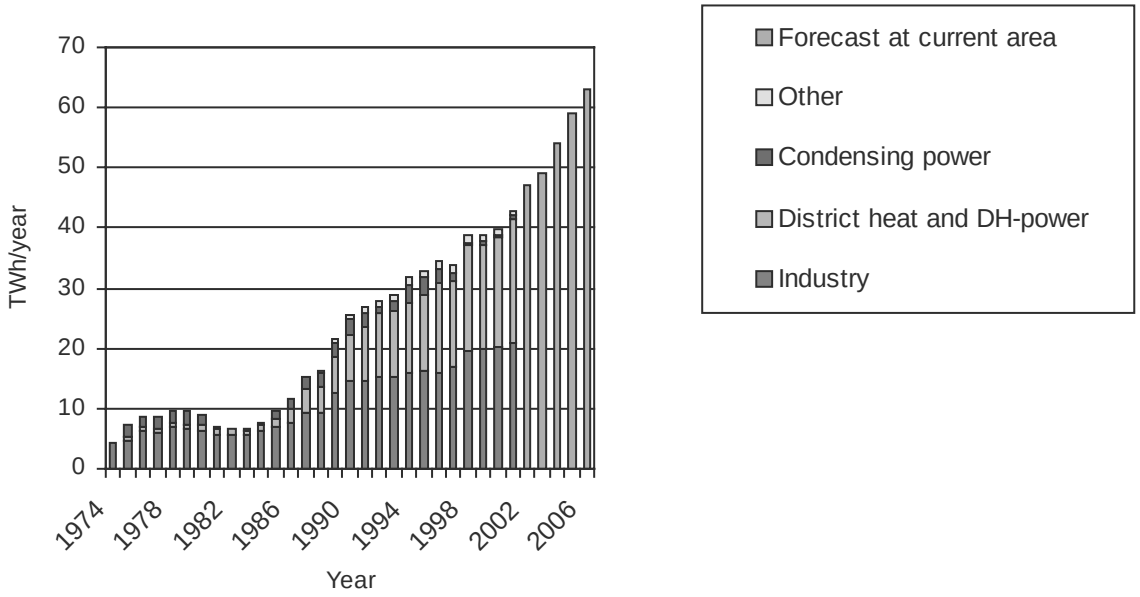
1. GENERAL

Gasum Oy is a company based in Finland and is responsible for importing natural gas, maintaining and extending the natural gas pipeline in Finland and for marketing and selling natural gas to wholesale customers such as industrial plants, energy companies and local distribution companies.

Gasum Group consists of Gasum Oy, the parent company, and its subsidiaries Helsinkikaasu Oy, Suomen Kaasuenergia Oy, Helsingin Kaupunkikaasu Oy and Gas Exchange Ltd (Kaasupörssi Oy). These subsidiaries are mainly related to the gas equipment sales and service, gas distribution network operations and construction, gas sales to customers like for small industrial plants and domestic use. Gas Exchange Ltd is for secondary gas trading.

Gasum Group turnover in year 2001 was 587 million €, operating profit was 45 million €. The share of the parent company of the group turnover was 99 %. Number of employees of Gasum Group in 2001 was 180, from which about 150 was in the parent company.

The history of Gasum starts from year 1971 when the contract to supply natural gas to Finland was undersigned by the governments of Soviet Union and Finland. Neste Oy, a Finnish oil, gas and chemical industry company, was nominated to be the company taking care of the gas transmission network construction, operation and maintenance as well as the sales and marketing of natural gas. The first cubic meter of natural gas was imported to Finland in 1974, when the gas network was some hundreds of kilometers long and ended at the Kymi river, near the town Kouvola in south eastern part of Finland. During the second energy crisis in early 1980s the gas consumption was declining due high gas price caused by linkages to oil price. Nevertheless, the management of the company decided to extent the gas network to Helsinki and Tampere region, two major cities in the southern part of Finland. The construction work was ready in 1985, and utilisation of gas started to increase steadily. Some additional branch lines were added to the gas transmission network later on and currently the gas transmission network covers about 1000 km of pipeline and around 200 gas delivery points. Currently gas represents 11,3% of primary energy consumption. Development of gas deliveries during the years is presented in picture 1.



Picture 1 .Natural Gas consumption in Finland

In 1994 Neste Oy natural gas and related assets were transferred to a founded company, Gasum Oy, which was owned by Neste Oy (75%) and OAO Gazprom (25%). As a consequence of the merger between Imatran Voima Oy, a Finnish electricity company, and Neste Oy to form Fortum Oy, major part of Gasum was sold in 1999 in order to fulfil the EU requirements concerning the monopolistic position in energy markets. The year 2002 is Gasum's ninth year of business. The ownership structure since summer 1999 has been:

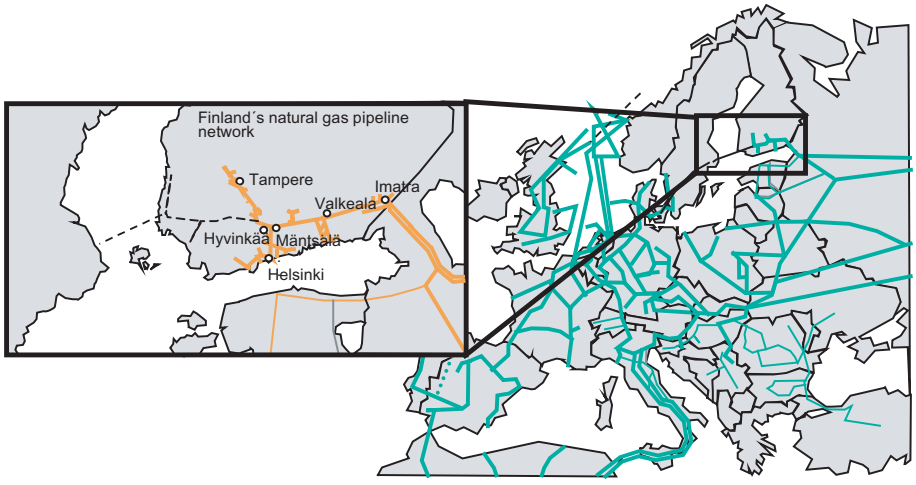
Fortum Oil and Gas Oy	25%
OAO Gazprom	25%
Finnish state	24%
Ruhrgas Energie Beteiligungs Aktiengesellschaft	20%
M-real Corporation	2%
Stora Enso Oyj	2%
UPM-Kymmene Corporation	2%

During the course of the years Gasum Oy has acquired its subsidiaries listed earlier, mainly to perform gas distribution and gas related services sales. Suomen Kaasuenergia Oy is the gas sales and distribution company for natural gas in the distribution network, and has around 35000 customers, main part of those are individual households in Helsinki. Helsinkikaasu Oy is a company who is responsible mainly for construction, maintenance and sales of gas related equipment. Helsingin Kaupunkikaasu Oy is like a holding company for the gas distribution network located in Helsinki, previously using city gas and partly originating from 19th century but converted to natural gas in 1991. Last subsidiary, Gas Exchange Ltd (Kaasupörssi Oy), was founded in 2001. The Gas Exchange Ltd is a market place on an Internet solution, where the customers can give sell and purchase offers and get all essential trading information. According to the Finnish Natural Gas Markets Act (in force since 1st August 2000), natural gas end users and distribution companies that use or sale more than 5 million cubic meters of natural gas per year have been eligible to trade on a secondary gas market as from 1st March 2001. This opening of the natural gas markets was basically the reason for founding the subsidiary to be first in the gas exchange business and utilise the gained expertise from strong and widely used information technology applications in Gasum Group.

2. PIPELINE NETWORK

Gasum's transmission pipeline is approximately 1000 km and has about 200 delivery points where the gas is filtered and heated, pressure regulated and flow measured. The transmission pressure is maintained by three compressor stations located in Imatra, Valkeala and Mäntsälä.

All Gasum's compressor stations are unmanned and they are remotely monitored and controlled with DCS-system from Valkeala dispatching centre. Compressor units and stations were built in several stages, latest ones in 1997.



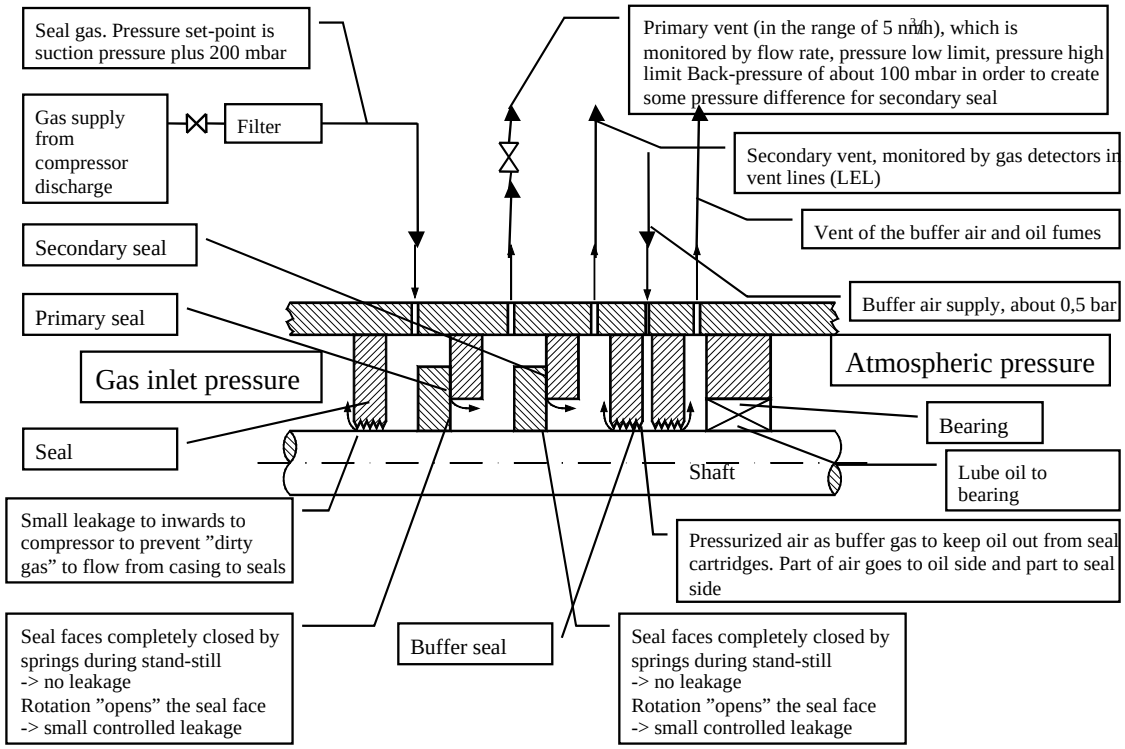
Picture 2. Finland's natural gas network

3. DRY GAS SEALS FUNCTION

In 1997 built compressor units latest technology was used and among other things, compressors were equipped with John Crane 28XP dry gas seals. Otherwise satisfactory operation of dry gas seals was having a disadvantage of methane emissions. Utilisation of this methane emission was studied in Gasum for some years and finally a satisfactory solution was found.

The application described in this paper was installed in four compressor units during summer 2001. The compressors are centrifugal barrel type compressors, two of those are Nuovo Pignone PCL603 driven by a PGT10DLE (shaft power 10 MW) gas turbine and two of those are Demag DeLaval 2B-18/18 driven by Alstom Power Tornado gas turbines (shaft power 6,5 MW)

It is normal to dry gas seals to have a small leakage of gas through the sealing surfaces due to the function principle and required cooling of the seals. This emitted gas (from primary seal) is normally in the range of 5 nm^3/h of natural gas per compressor unit in Gasum's application. This leakage occurs only during the operation of the compressor unit, during the stand-still the leakage is zero. In picture 3, a simplified operating diagram of a seal operating principle is described. Diagram is based on the Nuovo Pignone solution with John Crane 28XP tandem gas seals.



Picture 3. Function of dry gas seals

Depending on operating hours, the total amount of emitted gas in Gasum's units was in year 2000 in the range of 50.000 nm^3 per four compressor units. This is a significant amount of gas emissions, not only in environmental reasons, but also due to economical loss.

The problem faced in this study was to find an efficient method to collect the dry gas seal vent gas and utilise it. It was also required, that the solution and it's investment costs must be feasible and the pay-back time of the investment must be at acceptable level.

4. ALTERNATIVE SOLUTIONS

The basis for the solution was to find a simple method for primary seal vent gas collection with an equipment, which:

- is safe enough and do not cause any risk to the compressor unit
- requires minimum amount of maintenance
- is easy to use in an unmanned station and can be controlled by existing automation
- do not have high investment cost

Some alternatives were investigated. Those were for example utilisation of the gas as a fuel for a generator set (patented solution), collecting the gas to a bag and pump it back to the main line, flaring of the vent gas (well known solution), feeding the vent gas to the gas turbine fuel flow with an ejector and feeding the vent gas to the gas turbine inlet air flow.

All investigated alternatives were possible in some circumstances, but the basic requirements were not always met.

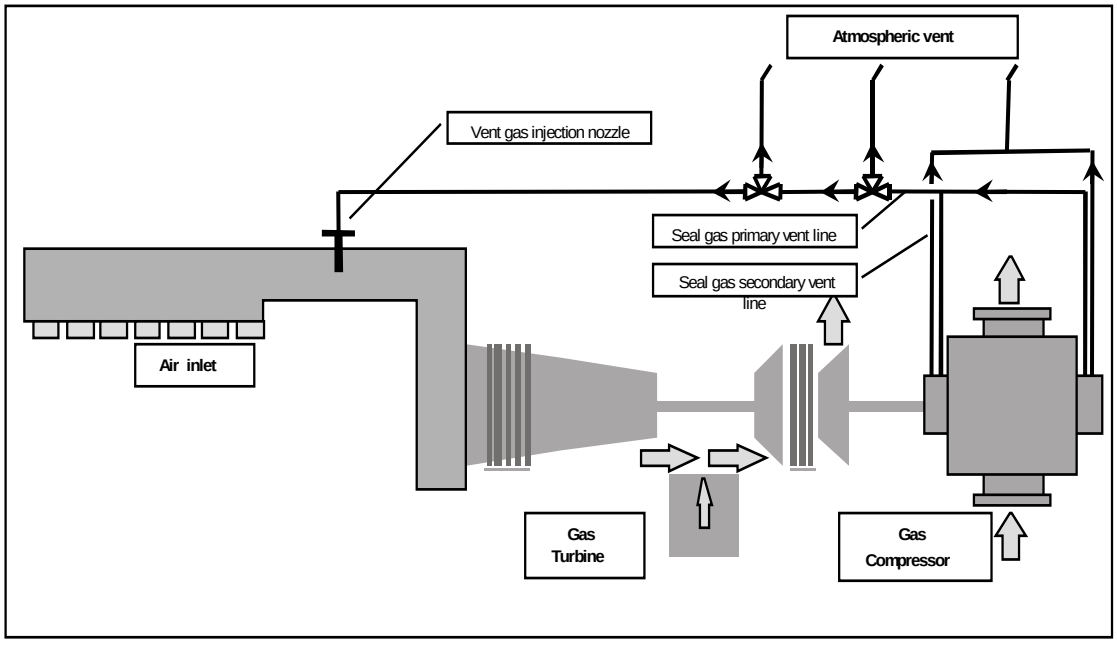
5. CHOSEN SOLUTION

As a solution, two alternatives rose above others:

- feeding the vent gas to the gas turbine fuel flow with an ejector
- feeding the vent gas to gas turbine inlet air flow.

Both cases were technically possible, but the feeding to the gas turbine fuel flow with an ejector required much higher flow ratio (main flow versus side flow) than it was possible with Gasum's compressor units. This possibility was investigated with some ejector manufacturers and technical institutes, but finally the solution was rejected due to too complicated ejector construction and risks on it's functionality.

Instead of the vent gas injection to the fuel flow, injection to gas turbine inlet air flow was selected. Schematic diagram of selected solution is presented in picture 4. By this solution, the vent gases will be utilised by the gas turbine as a fuel. Injection of slightly overpressurised vent gas to the inlet air duct is easy due to the lower pressure in the duct. Lower pressure is naturally caused by the axial compressor suction and inlet air filters. Additionally a special design injection nozzle was used to ensure trouble free injection.



Picture 4. Principle diagram of vent gas collection system

The amount of injected gas to the air flow is marginal. The mass flow of gas in normally 10 nm^3/h and gas turbine air mass flow is in the range of 120.000 nm^3/h. This ratio leads to a mixture of approximately 0,17 % LEL. In the situations, where the turbine is running in partial load and the vent gas flow rate is it's maximum allowed (before trip due to high flow), the mixture can rise to 0,43 % LEL.

In order to ensure the safety of the vent gas collection system, it is possible to control the valves in collecting position only when the compressor unit is in loaded status (i.e. in it's normal operating power). If there is a malfunction in the seal gas system, it is indicated with installed instrumentation and causing an alarm at the first stage and compressor emergency shut-down ESD at the second stage. Both alarm and ESD will control the vent gas collection system to it's safe position and instead of injecting vent gases to the gas turbine inlet air flow, the gases are vented to the atmosphere. In addition to the instrumentation in the seal gas system, the piping was equipped with two 3-way valves in series in order to enable double block and bleed configuration. These pressurised air operated and spring return 3-way valves are also made in fail-safe principle to transfer into safe position in case of control signal failure.

The complete vent gas collection system comprises from simple elements, mainly piping and two 3-way valves.

6. EXPERIENCE

The system was installed in four compressor units during summer and autumn 2001. The operating experience so far has been several thousands of operating hours and it there has been no malfunction of the system. The vent gas collection does not cause any change in the operating parameters of the seal gas system.

Normally all vented gas is measured and the amount is registered by the information system and methane emission reports. If the vent gas collection system is started, the vent gas amount is not any more registered in the methane emission reports. The amount of collected gas by this system has been about 75.000 nm^3 in 2002.

In Gasum it was originally estimated, that the potential amount of gas collected annually with this system would be as an average of 80.000 nm^3. The total cost of the system for four units was about 85.000 €. Local environmental authority economically supported the project with 40 % of the costs. Based on these figures and depending on the appreciation of the gas itself and the used interest rate, the pay-back time of the investment remains well in acceptable level.