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DESIGN OF A NEW CHEMICAL INJECTION PUMP SYSTEM FOR GAS HYDRATE INHIBITION

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In this study the main feature of chemical injection systems used in gas industry are detailed. The two main energy sources of these systems are air and electric power source. The general structure and main properties of these injection systems are discussed. Examples for a pneumatic commercial and a newly developed, electric system are compared.

Keywords: chemical injection system, hydrate inhibition, solar energy, pneumatic system

Introduction

During the production of gas, a major problem is the formation of hydrate crystals in the pipeline. A considerable amount of hydrate crystal can cause hydrate plugs in the pipeline. The hydrate plug effect lengthens production outages and results in loss of money for the maintainer [1], because elimination of the plug is a time consuming procedure. One of the most widely used traditional solutions to prevent hydrate formation is addition of methanol to the steaming gas. The methanol helps to dehydrate the gas, thus, the growth of hydrate crystal is limited [2]. The methanol can be transported from the gas separator station or gas collection station to the gas wells via a dedicated pipeline. This traditional solution was the most popular practice for a long time in gas industry. This technology is safe, but has several drawbacks, such as the cost of additional pipe to the gas wells, the cost of the methanol regeneration [3], and methanol contamination of the environment. Regardless the methanol technologies are still major solutions for hydrate inhibition for the currently operating gas wells. The modern installations use methanol in low concentrations for newly installed gas wells. These bring the need for injecting methanol locally at the site of the gas wells. Thus, an injection unit is needed for this purpose.

The production-related aspects such as the consumers expecting increased flexibility from gas provider cannot be neglected, because of the habits of the consumers and the appearance of competitive energy-saving technologies. Therefore the different injection systems spread noticeably dynamically in recent years.

In the first part of the paper, the main features of the commercial injection systems are detailed followed by the introduction of a newly developed injection system.

Chemical injection systems

In gas industry there are two applications, where chemical injection is required. The first one is the above described gas hydrate inhibition technology. The second one is where usage of corrosion prevention chemicals is needed. New chemical injection technology appeared in sophisticated form using a wide service range as a result of a change in gas production and distribution in the last decade.

Structure of pneumatic chemical injection pump systems

The most commonly used chemical injection units in gas industry employ the energy of gas for dosing. These systems are called “operating without auxiliary power systems”. In details, the energy of gas steam in the pipeline is used as a power source in the dosing of hydrate inhibiting chemical pump systems. This method has the major advantage that the gas is always available, or it is not necessary to provide a separate power source for the equipment to operate.

Big disadvantage of the technique is that gas is required for operation and this gas is emitted to environment, which is a harmful effect, moreover, the cost of it is also not negligible. There are some solutions to utilize the emitted gases, but these methods raise the price of the pump.

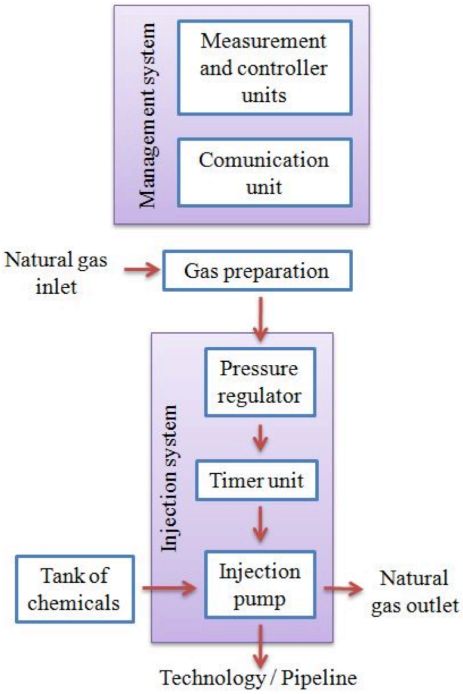

Figure 1: Block scheme of chemical injection system

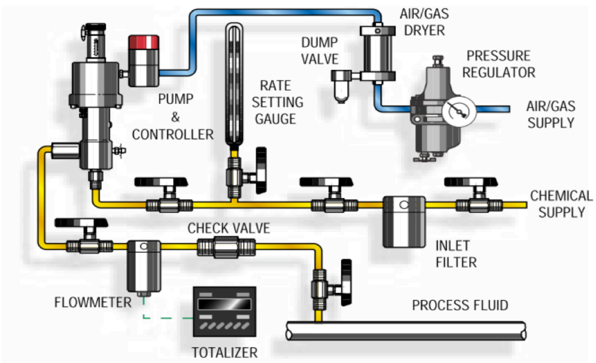

Figure 3: Pneumatic injection system from HASKEL MILTON ROY [4]

Fig.1 shows a common structure of chemical injection pump systems, which illustrates how the actuated gas gets into the injection system through a gas preparation unit. This unit is typically a special tank, which is filled with methanol. By using this type of conditioning one can be sure that the gas is sufficiently dry, thus, the water does not disturb the operation of the pump. It is needed to avoid the risk of freezing out various components. The gas bubbles through the methanol, so it loses a significant part its water content. The replacement of the methanol is needed at appropriate intervals of time as a technology management. After the gas leaves the conditioning unit, the gas steams through a two-stage pressure regulator. This unit provides the required pressure to the system for operation. The timer unit is responsible for providing appropriate technological demands of the schedule, i.e. sufficient number of strokes is needed to operate the pump. The chemical is injected with the piston of the injection pump. The injection system includes other components, which are essential for the

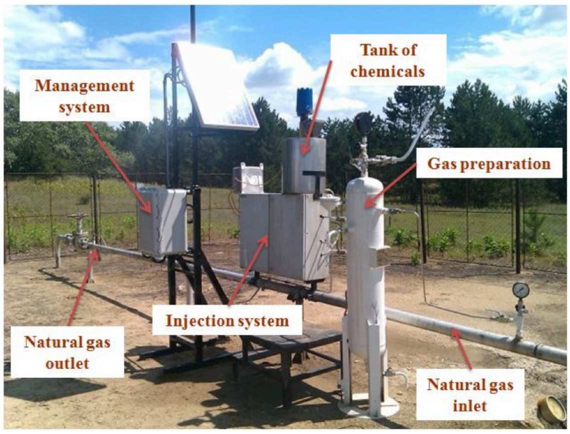

Figure 2: Chemical injection system on a gas well

operation, such as check valves, ball valves and other fittings. The hydrate inhibitor compound can be found in the tank.

The main task of the control system is the monitoring of the injection system, so several parameters are required to be measured, e.g. the level of chemical in the tank, the pressure of the after the regulator and the ambient temperature. One of the most substantial information about the injection pump is the entry of the inhibitor to the pipeline. To measure these parameters, transducers are needed, which require some solar energy for the operation. *Fig.2* shows a well-organized, modern gas well in Hungary. The injection system used employs the gas of the well for its operation.

Injection system from HASKEL MILTON ROY

The HASKEL MILTON ROY company develops and manufactures various injection systems for special oil and gas applications for many years. Chemical Injection Pump (CIP) series is one of the most widely used equipment for gas wells. A pneumatic version of the device is shown in *Fig.3*, as a typical system. The driving gas or air is fed from the regulator to the gas-drying unit. The air is let into the injection pump, which includes the timer unit. The chemical enters the pump through the appropriate valves and filters. The dosage of chemicals can be adjusted through the rate setting gauge unit (typically it is a burette) at, which the quantity of chemical of one injection is displayed. The strokes can be counted by using the flow meter on the system. The check valve prevents the injection pump from the backpressure of the process fluid. The company can deliver the complete unit in different versions according to the quantity of injection, e.g. the given series can be adjusted from 0.27–25.8 dm^3 min^{-1}. The range of operation pressure is also wide, typically 120–600 bar.

Structure of electric injection systems

This category includes systems, where the electricity is the only energy source. In general, the site of the gas

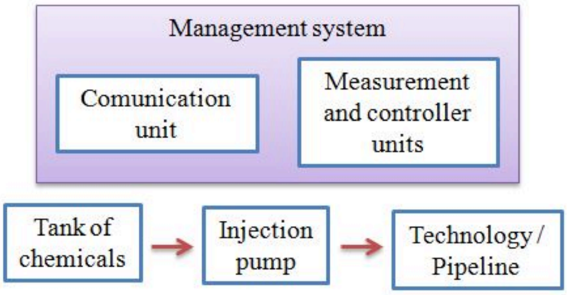

Figure 4: Block scheme of electric power injection system

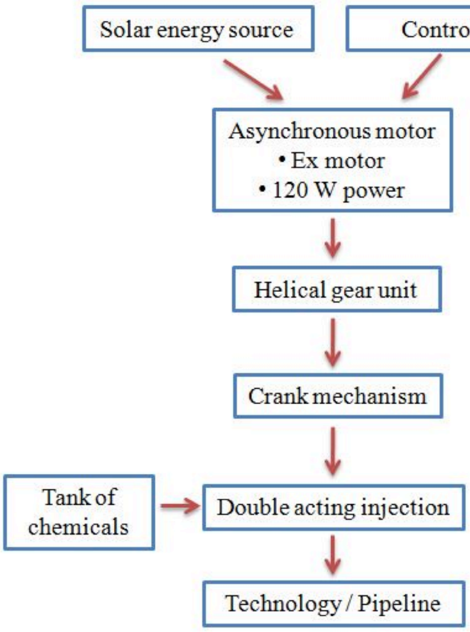

Figure 5: Block scheme of new injection system

well is not equipped with electric power because of the relatively large distance from the processor (separator station, collector, etc.). Thus, these systems are not commonly employed in the gas well applications.

Most of the electric chemical injection pump systems are based on the principle of displacement pumps. These high-pressure pumps provide the chemical injection by using speed adjustment in a wide range, or with different piston volumes.

As shown in *Fig.4*, the electrical injection pump system contains relatively few units. It cannot be ignored that the electric pump does not only include a motor-driven piston with frequency inverter, the controller electronics is also an important part of the system. Solar energy can be applied as energy source of this type of system. This source can feed the control electronic besides the main actuator of the system.

In-house designed injection system

The development of the injection system was a part of a bigger project with the Scada Ltd, a company from automation industry. The aim of development was to

Table 1: Main parameters of the injection pump designed

Asynchronous motor	
Nominal voltage	230 V(Y) /400 V (D), 50 Hz
Nominal power	0,12 kW
Ex class	PTB 07 ATEX 1058 X II2G Ex de IIC T4
Type	DEx 63K/4K
Vendor	HEW
Helical gear unit	
Gear ratio	41,58
Ex class	Ex II 2G c IIC T4 X
Type	SK02F-IEC63 /26-63 S/4 TF/2G
Vendor	Nord
Crank mechanism	
Length of stroke	20 mm
Ratio of mechanics	7
Injection unit	
Diameter of piston	5 mm
Vendor of seals	Trelleborg
Type of seals	Turcon® Variseal®

create an injection system, which can be used mainly at Hungarian gas wells. Thus, the temperature requirement of the system was in the -40 °C to 60 °C range. The system must be capable of working in ‘Ex’ environment with high efficiency. The power source of the actuator is solar energy to reach close to zero emission of the system. In the system, corrosive chemical has to be injected, thus, a corrosive resistant is required at critical parts of the equipment e.g. piston, piston space, etc. The maximal working pressure was 160 bars. A wide range of injection volume was also a fundamental requirement. These requirements were the main parameters at the design phase of the equipment. The block scheme of the developed system can be seen in *Fig.5*.

The base of the system is an Ex class asynchronous motor *(Table 1),* which is assembled with a helical gear unit from Nord manufacturer. The base of injection system is a crank mechanism, which transforms the rotary motion to alternating motion. The pump has two pistons to reach higher injection volume and a well-balanced load of the motor. The main parameters of the mechanics can be found in *Table 1*.

The sealing of the mechanism is a critical design point. The relatively high pressure, corrosive fluids, and high stroke number require special solution for sealing. A single acting, spring energized-seal was selected. The application conditions demanded the tight guiding of neck of piston, to avoid the damage of seals during the operation of pump *(Fig.6).* The electromechanical actuator gives the opportunity to smoothly alter the injected volume in continuous or in periodic operation. *Table 2* shows the injected volume of the pump at different frequency of the inverter in continuous mode. The power source of the system is an array of solar cells. The power of solar energy system was 2 kW to get extended service and short recharge time. The capacity of the accumulators was 800 Ah. The developed equipment has a PLC-based control system to monitor the main parameters of the technology and to change the behaviour of the injection system.

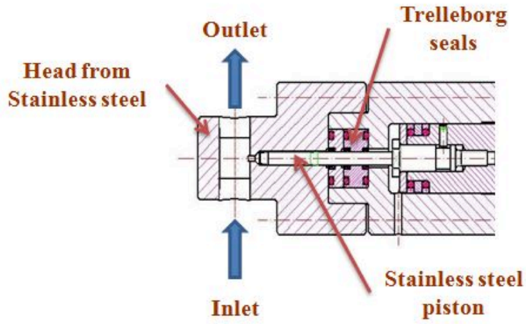

Figure 6: Section of injection unit

Table 2: Injected volume of pump at 150 bars

Frequency of inverter, Hz	Injected volume, $dm^3\ h^{-1}$
30	21.71
50	36.19
70	50.67
90	65.14

The measured parameters are the pressure of siphon of well, drill pipe, injection pipe; the temperature of pipe of well, soil, chemicals, controller, temperature of inverter; the level of the chemical in the tank; the current and the voltage of the inverter. The frequency of the inverter can be changed in function of the conditions of the well.

The injection system is able to communicate wirelessly with a server. By using modern computer technology, the main parameters of the system can be monitored and changed. *Fig.7* shows the website of the system, which shows, on one hand, the main actual online parameters of the system, on other hand, the trends and history of the parameters on diagrams. The structure of the website is user friendly, simple. A model technology for an actual gas well was set up at the site of the Scada Ltd. near to Hajdúszoboszló *(Fig.8)*. At the test site, main parameters like level of the chemical in the tank, process gas pressure, frequency of the inverter, etc. were monitored and measured. After the successful test of the model technology, the equipment was moved to a real gas well at Békásmegyer in October 2012.

Conclusion

A new solar energy-based chemical injection pump system was developed with a modern control and computerized support system at University of Miskolc, Research Institute of Applied Earth Sciences. The equipment meets the modern requirements. It is an efficient injection system; it has wide operation range and has user-friendly high-level computer support. In the process automation field of gas industry, the adaptation of new approaches appear slower in consumer or in industrial environments than in other fields of industry. The new, energy efficient, solar supplied, standalone chemical injection systems hopefully can enter in the field and will be utilized more wells in Hungary.

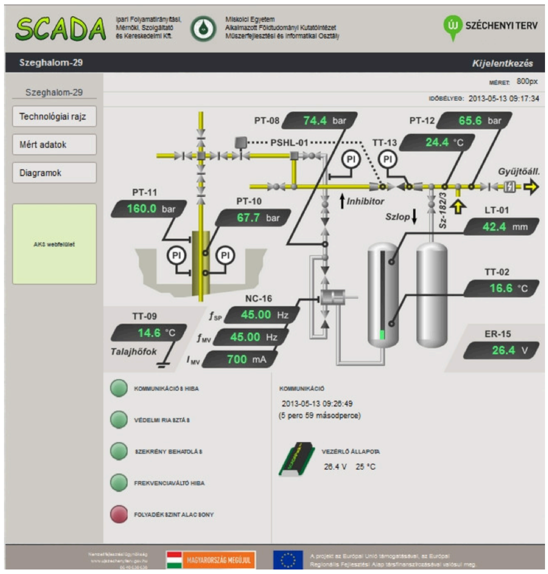

Figure 7: Website of pump system

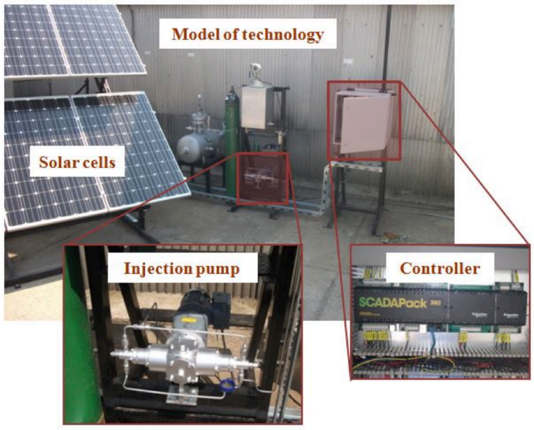

Figure 8: Block scheme of chemical injection system

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