Force Sensors of Sucker Rod Oil Pumps

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Abstract—The present article describes a version of force sensor of sucker rod oil pumps built on the basis of load cell of pocket dynamometer with application of modern pressure sensors, controllers, interfaces and communication protocols.

Keywords—dynamometry; force sensors; load cell; oil extraction; sucker rod pump; traverse

I. INTRODUCTION

As of today, basic elements of automation systems of sucker rod pumping units (SPU) are dynamometry sensors, since only they allow obtaining dynamometer cards containing the information required for analysis of faults of deep-well pump and mode of its operation.

As is known [1], dynamometry sensors are stroke sensor and force sensor. Stroke sensors are designed for determination of motion parameters: suspension points of sucker rod strings – stroke length, time of swing and moments of rod passing the lower and the upper dead points. Force sensors determine the load on the polished rod, which is the weight of liquid raised from the well, the weight of sucker rod strings and friction force in the pump and string combined. Such sensors must work at SPU uninterruptedly for long periods of time in the condition of wide temperature range, endure exposure to moisture, sulfur and other destructive factors, be resistive to overloads and ensure operation in exposure hazard zones.

In the period of SPU operation, numerous force sensors have been developed. Depending on the location and method of placement at SPU, force sensors are classified as follows.

1) Force sensors installed at the beam of SPU. They measure beam deformation, which allows one to estimate the force applied on the polished rod. Operating principle of such sensors is based on measuring the travel distance as a result of deformation of the beam curve. First, beams are known to be of placement at SPU, force sensors are classified as follows.

- the form of a horseshoe, which facilitates its installation on the suspension between traverses;
- microcontroller built in DU-04 sensor, transforming voltage, which is received from the measuring bridge diagonal and proportional to the load, into digital and pulse-width signals, increases performance capacity;
There are many pressure sensors, from which most acceptable ones must be chosen.

Criteria for choice of a pressure meter are as follows:
- pressure range;
- low electric power consumption;
- proportional conversion of pressure into electric signal;
- high accuracy of conversion of pressure into electric signal;
- change of the original value of the output signal due to temperature;
- low cost;
- wide operating temperature range;
- high load capacity.

Analysis of available pressure meters resulted in choice of MD 10 – 40 V integral pressure tensosconverter of MD series [9].

To compensate the influence of change in environmental temperature on the value of the output signal of pressure meter, a correction must be made to the measurement result. This requires measuring of temperature.

No strict requirements of measurement accuracy and range for temperature meter are specified in this case. However, its mass and size should be minimal.

Use of widespread microcontrollers in development of industrial products leads to improvement of their engineering and economical performance (reduction of cost, power consumption, size, increased reliability) and allows shortening development time considerable and putting off obsolescence of products. It also gives them crucially new consumer properties (expanded functionality, modifiability, adaptability, etc.). To simplify the scheme, increase reliability and provide flexibility of force sensor, building them on the basis of single-chip microcomputers, i.e. microcontrollers, is suggested. A number of microprocessors and microcontrollers exist, from which most acceptable for the purpose should be chosen.

Considering all the above-mentioned, block diagram of intelligent intertraverse force sensor of sucker rod pumps based on load cell of GDM-3 dynamograph (Fig. 1) can be offered.

The block diagram of intelligent intertraverse force sensor (HFS) consists of the load cell of dynamograph (LC), pressure meter (PM), temperature meter (TM), microcontroller (MC), digital-to-analog coverter (DAC), wireless modem (WM), antenna (A) and power supply (PS) that includes an accumulator (AC) and a direct current to direct current converter (DC-DC Converter).

Successful operation of force sensor in this diagram depends in many ways on the right choice of microcontroller.

Analysis of characteristics and architectures of microcontrollers with allowance for the given task requirements demonstrates that controllers with RISC (Reduced Instruction Set Commands) architecture are the simplest and most appropriate controller for the purpose.
They are characterized with reduced instruction set commands and AVR structure. Microcontrollers of AVR structure have 32 registers directly connected to arithmetic-logic unit (ALU), which allows performing operation in one step. As a result, its speed performance exceeds regular microcontrollers with CISC (Complex Instruction Set Command) architecture dozens of times. Most known microcontrollers with RISC architecture are AT90S, ATMEGA, ARM microcontroller families manufactured by Atmel, microcontrollers manufactured by PIC, Scenix, Holtek.

Considering the above-mentioned advantages, we have chosen ATMEGA 32 microcontroller from Atmel. Its operation algorithm has been offered.

REFERENCES

[9] Integral Pressure Tensoconverters of “MD” Series Integral Tensoconverters (“Integralnye tenzopreobrazovateli davleniya seri MD” Integralnye tenzopreobrazovateli, in Russian) www.clo.ru/Catalog/Pribor/IzmRegDavl/izmregdavl.htm

Figure 1. Block diagram of intelligent intertraverse force sensor (IIFS) of sucker rod pumps based on load cell of GDM-3 dynamograph