RECONSTUCTION AND FURTHER DEVELOPMENT OF A HIGH PRESSURE GENERATOR

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ABSTRACT: Ruska Instrument Corporation is a leading manufacturer of precision laboratory instrumentation by offering the world's most accurate primary pressure standards, transfer standards, and air data test sets since 1944. Ruska sells and services its instrumentation worldwide. One of their products is the Model 2231 High Pressure Generator. The article is about the reconstruction and further development of this equipment.

1. INTRODUCTION

The Ruska Model 2231 equipment (See: Figure 1) was developed and produced by the Ruska Instrument Corporation in the 1980s, and nowadays it is being reconstructed and further developed by the Research Institute of Applied Earth Sciences, at the Department of Research Instrumentation and Information Technology, at the University of Miskolc, on the behalf of MOL Plc.

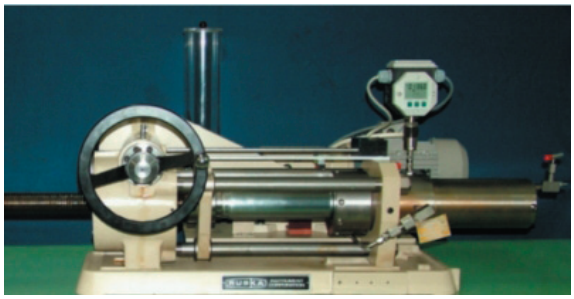

Figure 1: Hardware of Ruska Model 2231

The high pressure generator is used as an injection pump mainly at the displacement process. Naturally, it can be used for other purposes, too. It is responsible for the displacement principle, and makes it suitable for laboratory simulation and for tasks which need a pressure generator.

2. HARDWARE CONFIGURATION

At the design of the original equipment, the solid plunger forms an integral unit with the spindle. The feed nut revolves about the spindle. The feed nut is rotated by a worm gear and a worm. The spindle nut bearings, worm and worm gear assembly are enclosed in an oil-filled housing. The hand wheel is mounted on the worm shaft to make volumetric fine adjustments. In the motorized pump, the worm shaft is driven by a motor directly or through an appropriate transmission.

Since it was a perfect construction as an equipment hardware, there was no demand of its further development, just a renewal was needed [1].

2. ELECTRICAL CONFIGURATION

This equipment is a bench-mounted motorized pump. These kind of generators are mounted on pan-shaped, cast-iron bases. The servo motor, the redactor, the chain and the sprocket are mounted on one side of the pump. The position drive amplifier is housed in the Equipment Box, which is connected to the Remote Control Box (See: Figure 2). It includes a position feedback loop and electronics to control motion functions. To accomplish this, the motor uses resolver feedback. The resolver converter electronics in the amplifier generates velocity and position feedback signals required for high performance and precise velocity and position control.

Figure 2: Old style of Remote Control Box and Equipment Box

The Remote Control Box houses the keyboard and a power on/off switch. The rear panel of the remote control houses connectors for connection to the main pump or the equipment box, in the case of a bench pump. It also houses a RS232 connector for serial interfacing to a host computer.

The two box system of the electrical configuration – Remote Control Box and Equipment Box – was replaced by a single Electrical Box.

Figure 3: Electrical Box

After reconstruction, a Siemens three-phase low voltage squirrel motor drives the pump, which is controlled by an Omron V1000 type frequency inverter. An Omron E6C2 rotary encoder is responsible for the feedback of the position. There are two end-switches on the device for the safe operation of the piston. All electrical parts were housed in the Electrical Box, except for the Siemens motor, the Omron encoder and the end-switches (See: Figure 3 and 4).

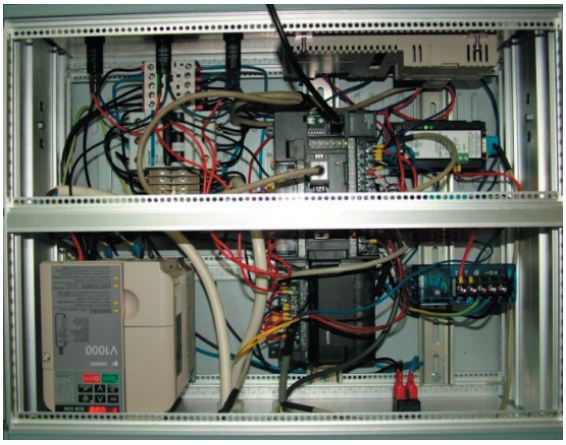

Figure 4: Inside of electrical box

The pressure generator is controlled by a programmable logic controller, which is an OMRON CP1L PLC (See: Figure 5, Sign PLC). The PLC is responsible for controlling the operation of the servo-drive, for positioning the piston, for processing the data of pressure transmitter (See: Figure 5, Sign PT), and for communication with the computer (PC1) and the human machine interface (HMI).

The original keyboard data input unit was replaced by an OMRON NT21 touch-screen type HMI unit, which is a data input and output unit. It is responsible for two major tasks: first, it displays the measured values, feature of the control and the data which are necessary for the operation of the pump. These can be: pressure values and actual position values. On the other hand, set points can be given and functions can be run by using the touch panel.

The PC1 is a desktop type computer (See: Figure 5, Sign PC1), which is responsible for collecting, storing and processing data which was sent by the PLC.

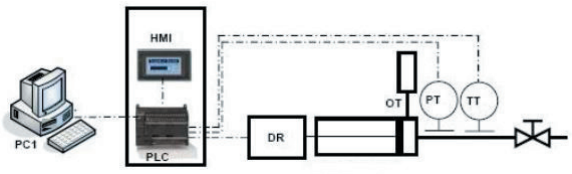

Figure 5: Basic configuration of the equipment

Finally it can be said that the new equipment is consisting of three units. One of them is the pump, the second is the electrical box, and the last one is the computer, which is connected to the electrical box (See: Figure 5) [1] [2].

3. LOW-LEVEL SOFTWARE

The original equipment was "traditional" laboratory equipment, which used a measuring card for central controlling. The reconstructed equipment is controlled by an OMRON PLC, so it can be said that it became an intelligent device.

There are five kinds of functions at original equipment:

- In the *Absolute Discharge* function the generator discharges or recharges to a specified absolute position at a specified flow rate.
- In the *Incremental Discharge* function the pump discharges or recharges a specified incremental volume at a specified flow rate.
- In the *Jog* function the pressure generator discharges fluid from the cylinder or

recharges the cylinder at a variable flow rate.

- In the *Home* function the pump plunger moves to a predefined position, for example the beginning of the stroke, or the zero position of the pump scale.
- In the *Constant Pressure* function the generator reaches a desired pressure value and maintains it.

During the reconstruction, we found it important not to change the characteristics of the original functions, as the new equipment is designed for the operation of the same tasks. Unlike the original version, it's fully parametric, which promotes its wide range application. Moreover, the HMI interface made the pressure pump user friendly.

The processes which are controlled by the PLC are: the data, which was sent by pressure transmitter, are received, processed and forwarded to the computer by it. It also controls the frequency-inverter and runs kinetic algorithms. The communication – with PC and HMI – and safety are also controlled with it.

The used programming language of the PLC was ladder. Motion controls are realized by simple logical functions. The transmitter is an analogue device, so the signal processing is realized by simple data scaling.

It was necessary to build up the communication between the computer and the PLC in order to use the high pressure pump in remote control mode, similarly to the original equipment.

If an RS-232C is used, the OMRON CP1L could be functioned as a Modbus-RTU Master to send Modbus-RTU commands by manipulating software switches. OMRON CP1L does not support functioning as a Modbus Slave.

If more than one device is connected to the computer, it is indispensable to use master-slave communication between PC and PLC, i.e. the PC has to be master and PLC has to be slave.

PLC can function as a slave, but then it is necessary to use another communication protocol. To solve the problem, our own protocol was created, with no-protocol communication being used to send data in one direction to/from standard devices. No-protocol type communications enable sending and receiving data without using a protocol and without data conversion – for example: no retry processing, data type conversion, or process branching based on the received data [3].

4. HIGH-LEVEL SOFTWARE

Unlike the original high pressure pump, for this equipment, it is available to be controlled by a self-made software from a PC connected to the system.

The software was developed by C Sharp Builder. The program is not platform-free, it was made for Microsoft Windows operating systems. This software is suitable for collecting, storing and processing the data which are forwarded by the PLC; displaying measured and calculated values; controlling the remote-controlled equipments, which are parts of the measuring system.

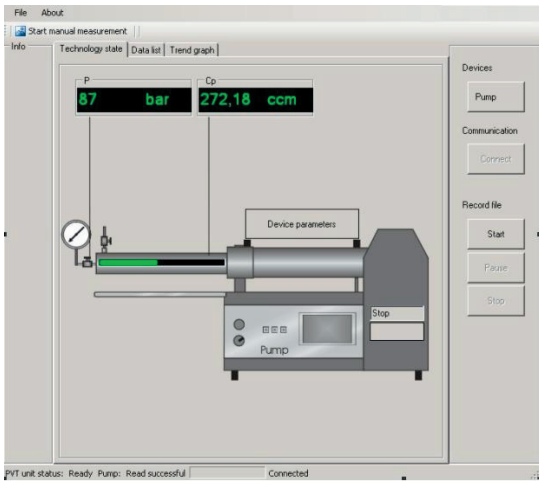

Figure 6: PC Software

5. ACKNOWLEDGEMENT

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6. REFERENCES

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[2] ME-AFKI-MÜFIO: Renewed Ruska Pump, Manual, Miskolc, 2010

[3] OMRON: Programming Manual for SYSMAC CP1H/CP1L CPU Unit, 2007