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Process Controls for Hydraulic and Pneumatic Pipeline Conveying Systems

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Prozeßsteuerungen für hydraulische und pneumatische Rohrförderanlagen
Automatismes industriels pour des installations de transport hydraulique et pneumatique par tubes
Controles de proceso para sistemas de transporte hidráulicos y pneumáticos por tubería
水力・空気パイプライン運搬システムのプロセス・コントロール
液压与气压管线输送系统的加工控制
التحكم في العمليات المتعاقبة في أنظمة النقل بخطوط الأنابيب التي تعمل هيدروليكيا أو بالهواء المضغوط

Summary

Due to the high investment costs involved in the installation of hydraulic and pneumatic conveying systems, associated control systems should have a high degree of availability. High grade *open* and *closed-loop* control and monitoring systems are a decisive prerequisite for this. This paper deals specifically with the application of such controllers to the control and monitoring tasks relating to long distance solids transportation pipeline systems.

1. Indroduction

Hydraulic solids conveying systems for bulk materials such as ore and coal are mostly conceived as long-distance transport systems.

On the other hand, pneumatic conveying systems are predominantly used for the purpose of direct materials handling or of transport within production sequences.

The tasks to be fulfilled by the control technician differ depending on the system to be used.

In the one case, the most important aspects are the particular characteristics of long-distance transport and, in the other case, emphasis must be placed on intergration into the necessary production sequences.

In the case of long-distance transport, the technical problems to be solved are similar to those known in the fields of oil and gas pipelines or long distance belt conveyor systems.

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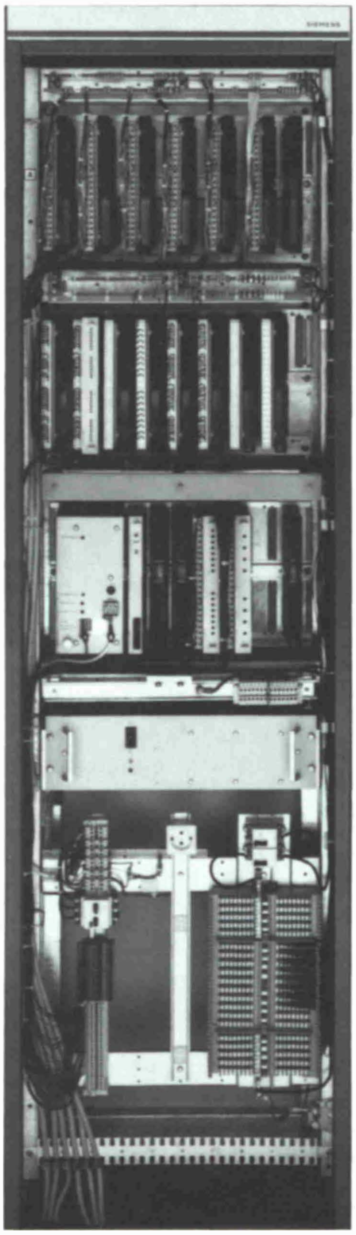

Fig. 1: Siemens SIMATIC S 5—150 automation equipment for a substation with central unit

These systems cover at least several kilometres and sometimes even several hundred kilometres. The overall concept comprises one central station with several substations. The central station will always be manned, the substations can also operate unmanned.

The configuration of such system controls must have clear hierarchical structures. Even if they are not manned, the substations will be equipped with a fully operable manual control with a semi-automatic control such as, for example, simple operating, measuring and signalling panels. This control system is designed with all necessary internal interlocking functions as one operable entity. Power supplies, main pump and auxiliary drives will have sequential controls. Compulsory resetting is provided for starting operations or automatic control processes and for gate valve settings.

Analog closed-loop control systems are available for automatic control tasks. For example, these can be used to control the speed of conveyor pumps (flow rate) which must operate with dependence on density measurement on the receiver side. The control loop must be included in the semi-automatic control system of the substation.

At the present level of development of programmable controllers, such as the Siemens SIMATIC-S 5 system, the control tasks of the substations can be implemented economically and expediently with such stored program techniques. Here, particular mention must be made of the necessity for flexibility in the integration of additional functions during the trial phase, freedom from the need for maintenance and the economical realization of a complex signalling philosophy (Fig. 1).

2. SIMATIC S5 Controllers

The Simatic S5 automatic controllers have a modular structure. The central processing unit with the power supply can be supplemented by modules for digital and analog inputs and outputs depending on the number of peripheral signal transmitters and receivers. The size of memory modules depends on the number of instructions and logic operations to be processed. It is possible to connect input/output typewriters or individual display units or to interface equivalent systems to each other or to higher-ranking process computer systems.

Programming units serve as on-line or off-line interfaces. These serve the purpose of correspondence with the automatic controller and are used to enter the information contents of the memory.

This *manual control with semi-automatic control loops* can also consist of conventional contactors or relays.

2.1 Local Control

In all cases, a *local control* should be subordinated to the *manual control with semi-automatic control loops* of the substation. A simple *on/off* control which acts directly upon the main switching contactors must be installed directly at the motor or gate valve with provision for bypassing all higher-ranking interlocking conditions. This control primarily serves the purpose of repair and maintenance operation and must therefore be conceived in such a way that any activation by the central station or by the substation manual control during maintenance work is suppressed. If desired, the local control station can also be made lockable.

Independently of the higher control levels, the emergency off circuit is also fully effective during locally controlled operation.

Such a *local control* will also be advantageous for commissioning work and long interruptions in automatic mode.

2.2 Central Station

The central station is superimposed on the *manual control with semi-automatic control loops* in the substations. The complete system with the conveying route and the preceding material preparation processes including the energy supply is displayed in a central control room. The material flow is represented symbolically on a mimic diagram. Operational signals and fault signals and valve position displays are integrated into this diagram with their correct respective positions. At the same time, the actual values obtained from flow rate, density and volume measurements are indicated and the set points are input by means of adjusting controls. Important measurements will be logged. Equally, all operations and faults should be logged with the times of beginning and end. Plaintext printouts are preferable. In addition, visual display units may be put to use. Operating and display elements using symbols should be given preference for all interventions in the control process. Alphanumeric inputs and outputs should be limited to the data processing level.

Depending on the intended volume of data processing, a decision must be made as to whether the central control is to be implemented with an automatic control system, i.e. programmable controllers as are used for the substation, or with a process computer.

The programming language for programmable controllers is easier to understand.

3. Central Control

The process computer should be used in all applications requiring a large amount of data storage and processing. This is so for applications in which quantity and grade calculations for individual outlets and the storage of optimum setpoint data such as density, conveying rate, etc., appear appropriate for the transport of various material grades.

In accordance with the concept of a hierarchical system configuration, the central control should merely output instructions to the substations such as, for example, the start of a pump set with run up to a certain conveying speed, and receive the completion message from the substation. As a result of this, the central station will then initiate further measures in other substations. Everything happening in the substation in conjunction with this operation will be carried out by the semi-automatic control loops of this substation.

A similar concept applies for the *closed-loop* control circuits. The control of the conveyor flow rate, which naturally must be uniform within the whole system, is only output by the central station as a setpoint to the individual pumps of the substations. These in their turn, will report back the actual value. The central control will not intervene unless it is necessary to correct serious deviations caused, for example, by a fault which cannot be balanced out by the *closed-loop* control equipment in the substations. This may be carried out, for example, by a general reduction in performance or by deactivating the complete conveying route.

A failsafe and efficient telecontrol link must exist between the central station and the substations which are remotely controlled and monitored. Control and signalling instructions must be transmitted in both directions and measured values must be transmitted in one direction. Due to the large distances to be covered, use will seldom be made of a direct wire link. Therefore, it will generally be necessary to utilize a telecontrol system.

4. Siemens SINAUT-8FW Telecontrol System

The Siemens SINAUT-8 FW is a suitable telecontrol system. This system operates as a computerized time multiplex system; i.e., the signals are sent out at consecutive time intervals in the form of pulse telegrams. Measured values are also converted to pulse telegrams. These telegrams are decoded by the receiver and subjected to validity checks.

Each telegram consists of an address block, an information block and the data protection block. The address block identifies the subset of the complete information contained in the telegram and additionally identifies the data type with additional characters. The data protection block serves to detect signal implausibilities occurring on the transmission path.

The system has a modular structure and is thus capable of expansion, both for purely digital information and for the transmission of analog values. It can consist of varying system configurations, for example with a central unit assigned to several substation units. It can be used for cyclic transmission, transmission on demand and spontaneous transmission. The latter transmission mode is important in the event of status changes due to faults (Fig. 2).

A further possibility is the use of frequency multiplex systems. The information contents are accommodated in certain frequency bands superimposed on each other. These systems are not so capable of expansion as only a limited bandwidth can be utilized in each channel with economically justifiable means.

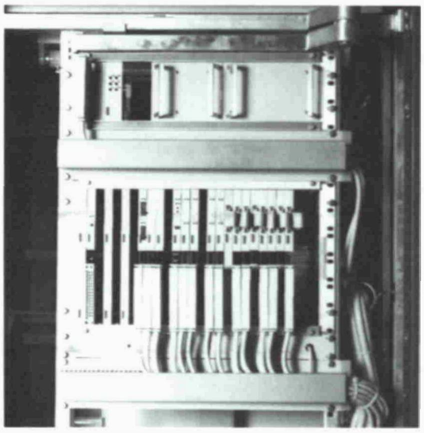

Fig. 2: SINAUT-8 FW remote control equipment in a substation with central unit and plug-in-type transmitter and receiver modules

However, the advantage of such systems is that a sort of *closed circut* can be set up for the self-monitoring of safety circuits and emergency off circuits. In this case, a certain frequency is applied as a continuous tone, when a certain forcible interlocking condition is fulfilled.

Thus, both systems can meaningfully complement each other. All usual forms of communication paths can be used as the transmission link between the central station and the substations.

It is self-evident that the preceding material preparation and stocking phases and the subsequent drainage and stocking phases must be integrated into the *open-loop* control, measurement and *closed-loop* control system of the long-distance conveyor system. The material flow may be regarded as a chain and each link of this chain determines the overall operation of the system.

5. Pneumatic Conveyor Systems

Pneumatic conveyor systems can be found primarily in direct materials handling or in the production process. In principle, the same can be said about these systems as has been said for hydraulic conveyors. The control configuration must also have a hierarchical structure (Fig. 3):

— Central control
— Semi-automatic control loops for conveyor sections
— Local control of individual drives.

Due to the small spatial spread of such systems, the central control and the semi-automatic control loops of the substation can be combined. There is no need for telecontrols. If Simatic S 5 programmable controllers are used, the central unit and the units of the substations can be directly linked to each other. Information is transferred in time multiplex mode. Siemens Simatic S 5 units can be directly coupled up to a distance of 1 km. Beyond this, special measures must be taken.

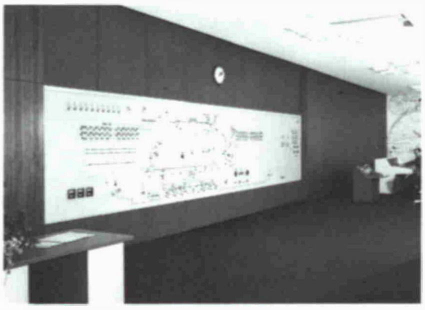

Fig. 3: Central control room for processing and pneumatic conveying of pulverised material

It can be assumed that pneumatic conveyor systems contain a considerably greater amount of junctions in the conveying route. Therefore, open-loop control complexity is clearly greater. On the other hand, such a system comprises hardly any measurement and closed-loop control equipment. However, in the case of materials handling systems as can be found, for example, in a consumer delivery store for pulverised goods, an extensive amount of weighing equipment will be required. Such systems frequently have a process computer, as this facilitates commercial operations such as monitoring and balancing stocks according to quantities and grades, as well as issuing the shipping documents and invoices. In this case, it is also necessary to split up the system into several control levels and to form hierarchies. Commercial tasks must be separated from control tasks. The computer does not directly intervene in the control process, for example by selecting a certain gate valve to set up a certain conveying route. It need only output selection commands to the subordinated semi-automatic control level, from which it receives the completion signals. The computer then registers the start and end of the conveying flow, it logs and registers the quantity and grade of material and subjects these data to further processing.

6. Conclusions

The more extensive a system is and the greater its availability ought to be, the more important is a wide-ranging and detailed signalling system. The elimination of faults is often considerable shorter than fault-finding. A good signalling system considerably shortens fault-finding.

Faults can be reduced considerably if preventive maintenance is carried out. This is additionally facilitated if the process computer system is also used to register operating hours and, as a result of this, to print out specific maintenance instructions for the individual expendable parts. In addition, the computer can order particularly frequently required spare parts.

Due to the high investments for long-distance transport systems, internal company transfer systems or transport systems in the production flow, control systems should have a high degree of availability. Technically and qualitatively high-grade *open* and *closed-loop* control and monitoring systems are a decisive prerequisite for this. They must be conceived in such a way that they facilitate and simplify operation and maintenance of the system.