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exist for the publication of theoretical and experimental investigations of all aspects of the mechanics and thermodynamics of fluid-flow with special reference to fluid-flow machinery



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na temat

TURBINY PAROWE WIELKIEJ MOCY

Gdańsk, 24 - 27 września 1974 r.

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STEAM TURBINES OF GREAT OUTPUT

Gdańsk, September 24 - 27, 1974

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III НАУЧНАЯ КОНФЕРЕНЦИЯ

на тему

ПАРОВЫЕ ТУРБИНЫ БОЛЬШОЙ МОЩНОСТИ

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# Electrohydraulic Control of 125 MW Condensing Turbines

Electrohydraulic control (EHC) of steam turbines has been developed as a result of putting into operation a system of automatic control of interchangeable power and frequency (ACFP) in the power network.

Due to the requirements of the ACFP system the electrohydraulic control assembly should contain an active power control, a frequency control and a regulator of the steam pressure before the turbine; the regulator limits the power of the turbo-set in case of disturbances limiting the quantity of steam generated in the boiler.

A turbo-set is being connected to the ACFP system after a load exceeding the technical minimum of the turbo-set steam generator block is attained and a thermal equilibrium is established; the dumping stations are then closed and the interception valves are opened fully.

The range of power changes of a turbo-set operating in the ACFP system is 50 to 100% of the maximum rating. Considering the above, EHC does not require an electronic speed governor and can control the HP governor valves only.

However, in order to take the full advantage of the merits of EHC and for its further development it was found useful to equip the turbo-set with an electronic speed governor due to which the start-up of the turbo-set may be carried out from the speed of the turning gear up to the synchronous speed.

The electrohydraulic controller was designed in accordance with the basic following assumptions:

– the hydraulic control system of the turbine remains unchanged,

– introduction of the EHC does not disturb the functional aptitude of the hydraulic system of the turbine control; moreover, all the safeguards acting in this system are not limited,

– switching from the hydraulic control system to the electrohydraulic system and vice-versa can not present any difficulty or cause any change of load on the turbo-set,

– in case of damage to the EHC the automatic control system switches it off and leaves the turbine under the load that had been connected immediately before the disturbance.

The properties of the hydraulic system of control have a basic influence on the design of the EHC. And so, in the range of loads of over 100 MW the power gain factor

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is approximately 150 MW/at of the control oil pressure in the HP governor valve servomotors. Very accurate maintenance of the oil pressure is therefore required.

For that reason this oil pressure was accepted as the feedback signal.

The effectiveness of introducing readings of the position of the HP governor valves as the feedback signal was also considered. After careful analysis of this problem and after preliminary tests it was decided not to introduce measurements of the position of the governor valves. This simplified considerably the EHC design.

The diagram of the electrohydraulic control of the turbine is shown in Fig. 1.

To ensure participation of the turboset in the frequency control of the power network a frequency control was applied utilizing a frequency transducer of 0.03% accuracy and a measuring range of 49 - 51 Hz. The analog signal of the frequency error is fed into the power integrating node with the gain selected so as to ensure that the power variation of the turbo-set brought about by the frequency variation of the network during a 24-hour period is contained in the range of 4 to 5% of the maximum rating of the turboset.

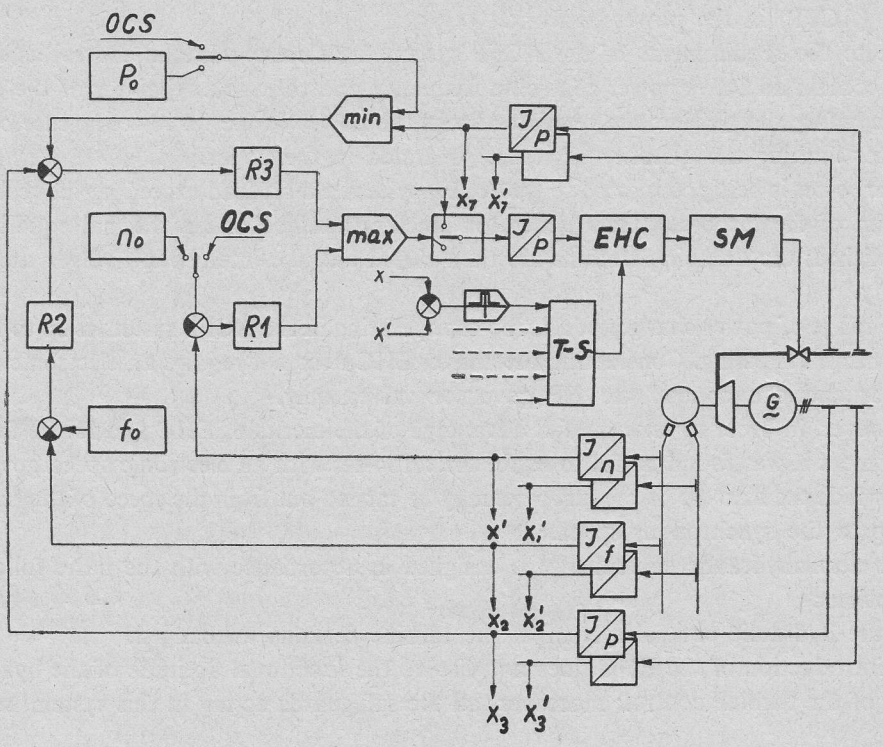


Fig. 1.

Figure 2 illustrates the correction of the generator active power introduced by the frequency deviation of the power network.

Investigations have confirmed the high sensitivity of the frequency transducer and the whole system reacting to frequency changes smaller than 0.02 Hz.

The method of limiting the turbo-set power in case of the boiler operation disturbance caused, for instance, by damaging the coal mill, the fan or the feed pump, was the subject

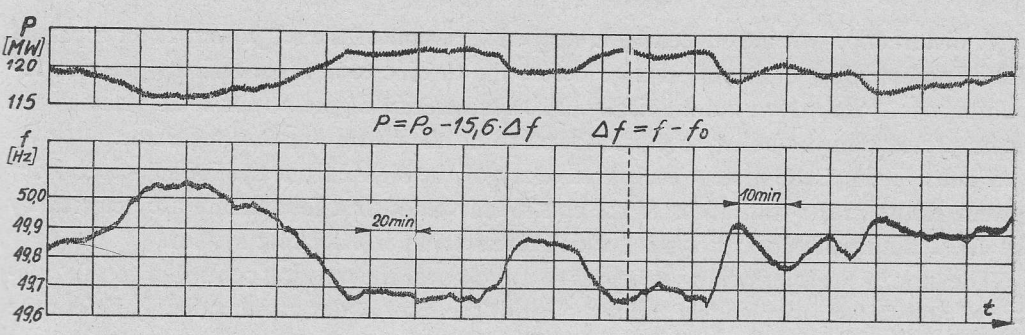


Fig. 2

of extensive analysis. In such a case the admissible loading of the turbo-set steam generator block may be determined by checking the condition of the basic equipment of the boiler or by measuring the pressure in the boiler.

The latter method was accepted, as it is used at present in the Polish power stations. Besides, it takes the variation of the fuel heat value into consideration, which in case of firing with lignite is especially important.

The manner of introducing the signal from the steam pressure before the turbine to the control system was also analysed.

Two versions were considered. The first version consisted in comparing the signals from the power control with the signal from the steam pressure regulator and selecting the smaller one.

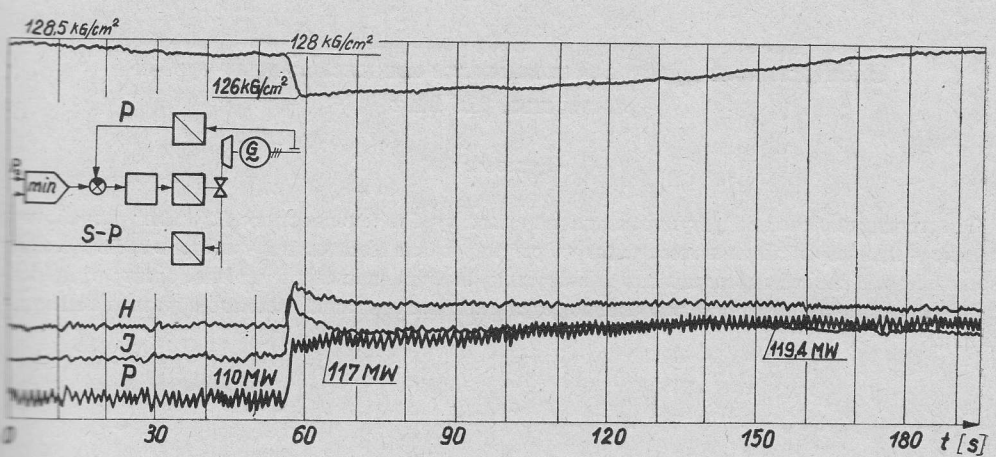


Fig. 3

The second version consisted in limiting the value of the set power to the admissible level dependent on the steam pressure before the turbine. This method is cheaper in the making and it was accepted.

Figure 3 illustrates the characteristics of the power control with the automatics of the coal feeder switched on and the steam pressure regulator before the turbine also switched on.

A disturbance was introduced by a stepped variation of the set power. After a partial rise of power a loss of steam pressure before the turbine took place and the pressure regulator was switched on automatically. The further rise of the power took place as the steam pressure in the boiler rose as allowed to by the steam pressure regulator.

Faults in the EHC system such as a decay of the signal from the ACFP supervisory system, faults in the transducer of the controlled values or a feed failure are detected by the EHC automatic control system which actuates an interlocking system.

The task of the interlocking system is to switch over the opening controller to the "memory" and to keep the load of the turbo-set at the level it was at immediately before the appearance of the disturbance.

The electrohydraulic controller is designed basing on the newest developments in Polish electronics. Long-term operational investigations may confirm the validity of the assumed solutions.

## Regulacja elektrohydrauliczna turbin kondensacyjnych 125 MW

Streszczenie

Elektrohydrauliczna regulacja turbin parowych 125 MW została opracowana w związku z wprowadzeniem systemu automatycznej regulacji mocy i częstotliwości w sieci elektroenergetycznej. W referacie przedstawiono założenia konstrukcyjne i rozwiązanie elektrohydraulicznego regulatora. Podano również ważniejsze wyniki badań prototypu w elektrowni.

## Электрогидравлическое регулирование конденсационных турбин мощностью 125 Мвт

Резюме

Электрогидравлическое регулирование паровых турбин мощностью 125 Мвт разработано в связи с введением системы автоматического регулирования мощности и частоты в электроэнергетической сети. В докладе представлены конструкционные предпосылки и решение электрогидравлического регулятора. Даны также важнейшие результаты исследований главного образца на электростанции.