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Magnetically controlled shunt reactors operation experience in 110-500 kV power grids

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High voltage and ultra-high voltage power lines operation experience shows the demand to control shunt reactors reactive power consumption according to line active power transfer in order to operate full transmission capacity. The most striking example was twofold natural load decrease of 1150 kV “Ekibastuz – Kokshetau – Kostanay – Chelyabinsk” power line due to application of uncontrollable shunt reactors while pilot operation in 1984. Therefore in the years 1980–1990, a significant work package had been performed to create a controllable shunt reactor (CSR). At the moment, the best known shunt reactors are thyristor controlled shunt reactor (TCSR), using thyristors to change current in secondary winding and control reactor power, and magnetically controlled shunt reactor (MCSR), and using magnetic circuit saturation to control reactive power absorption. More than hundred MCSR (with total power approximately 8900 Mvar, Table 1) had been constructed and deployed in electric grids of Russia, Kazakhstan, Belarus, Lithuania, and Angola from 1998 until present.

With many efforts of scientists, the implementation of great number of power system operational control devices (FACTS) has been succeeded in Russian electric-power industry.

TABLE I. F LIST OF ISTALLED MCSR

Voltage rating, kV	Total quantity	Total Power, MVAr	Basing country
10	6×10	60	Russia
35	13×25	325	Russia
110	31×25 + 63	838	Russia
220	2×25 + 60 + 7×63+20×100	2551	Russia, Kazakhstan, Angola
330	6×180	1080	Russia, Belarus, Lithuania
400	7×100	700	Angola
500	18×180	3240	Russia, Kazakhstan
TOTAL	110	8794	

Controllable shunt reactors application and operation background shows following main MCSR's (or MCSR-based reactive power sources) coverage areas:

- Within 330-500 kV power transmission lines;
- On high-power electric stations and substations buses with multiple or/and long-distant transmission lines connected;
- In isolated power systems with high voltage quality indices demands. It is important to note, that the great part of CSR's have been deployed in 110 kV grids of oil and gas extraction facilities in order to stabilize network voltage level, relieve motors starting modes and compensate network reactive power flows.

The great part of CSR's have been deployed in **110 kV grids of isolated power systems** with high voltage quality indices demands (motor load, oil and gas extraction facilities etc.). Under such conditions, great reactive power control features required in order to stabilize voltage level and compensate network reactive power flows. MCSR's fit such requirements.

MCSR's past experience shows that using both CSR and high-power capacitor bank provides stable voltage level in all operating modes.

Interruption of the electric power supply, in particular during oil extraction process, tend to result in disorderly closedown in a matter of seconds after emergency with further system restoration not earlier than one or two hours or even a few days in a limited number of cases. Therefore, the highest priority in design of new oil-field power supply systems, which, on numerous occasions, are isolated, should be devoted to ensuring uninterrupted, reliable and qualitative electric power generation as well as system survivability under variety of unpredictable incidents. It is also well known, that power interruptions during exploration drilling could entail much worse consequences.

Qualitative combination of power consumers in oil-field isolated networks may dramatically differ from the same indices of bulk power system. In particular, total share of motor load could reach 95% (about 55% of induction motors and 40% of synchronous ones). While small signal stability limits are many times as large as active power flows in normal operations, the quantity indices of transient stability, such as critical fault clearance time, could be lower than standard levels. Acceleration of generators and slowdown of synchronous motors during severe accident, e.g. two- or three-phase short circuit at high-voltage side of power plant, could cause the loss of synchronism between them much faster than the shortest tripping time of modern switchgear is.

The results of isolated power system transient analysis show that application of this combined unit (controllable reactor + capacitor bank) allows to enhance transient stability. Motor shutdowns can be eliminated by stabilizing voltage level at load substations.

A powerful resource of reactive power control allows to implement the original engineering solutions ensuring reliable power supply of important consumers connected to the grid by a "weak" ties.