Synchronous Condenser operation of Hydro Sets - An overview

T. Mulchandani
Former Addl. GM, BHEL, Nagpur (M.S.) India.

ABSTRACT
This article discusses usefulness of hydro sets in maintaining grid voltage by operating in synchronous condenser mode (SCO) by easily delivering or absorbing reactive power (Q) from it, particularly during lean periods of hydrological cycle when water level in the dam is low. Broad Contours of process of transferring and operating the set in (SCO) mode are given along with some practical data from sites.

Keywords: Synchronous condenser operation (SCO), Synchronous condenser relay (SCR), active/reactive powers (P&Q), Solenoid operated servo valves, L.P. air compressors and storage tanks, D.T. level sensors, Oil pressure unit (OPU)

Abbreviations

D/s	Downstream
DT	Draft Tube
EHG	Electro Hydraulic Governor
GV	Guide Vanes
MDDL	Minimum Draw down Level
MIV	Main Inlet Valve
SCO	Synchronous condenser Operation
SCR	Synchronous Condenser Relay
S/y	Switchyard
OPU	Oil Pressure Unit
TRC	Tail Race Channel
UCB	Unit Control Board

I INTRODUCTION

For power line voltage regulation in the grid, it is essential to match the incoming supply of reactive power (Q) with the Outgoing demand on real time basis. Hydro sets are very well suited for this, as they are easy to start/stop and operate. Generally, they are operated in generator mode, producing both active and reactive power (+P+Q) when water to run the turbine is available in plenty in the dam or weir. But, in some circumstances as given below, only SCO mode of operation is possible and desirable for keeping these sets in running condition for availing the following benefits.

(a) When water level in the dam or weir is low, around MDDL
(b) When the load controller of the grid instructs for it, for reactive power balance in the grid.
(c) When the D/s water demand for irrigation or drinking is not required to be fulfilled, as in multipurpose projects.

II BENIFITS OF SCO MODE OF HYDROSETS

As is well known, there are several ways available to the utilities for supplementing the requirement of reactive power in the system, like installation of capacitor banks in switchyard etc. But the SCO mode, wherever provided in the power houses, scores over all these methods for the following reasons.

(a) Hydro sets by their inherent mechanical inertia, electrical inductance effect, provide Stability to the grid during rapid / sudden fluctuations of loads. This is unlike of Capacitor banks which are static equipment.
(b) Hydro sets being easy to Start/Stop and operate lend themselves for quickly delivering or even absorbing reactive power to meet immediate requirements. (Capacitor banks Cannot absorb reactive power)
(c) Quantum of reactive power delivered by hydro sets is not dependent on system voltage which is also unlike of capacitor banks.
(d) By running hydro sets in SCO mode during lean months of April to June, Men & machinery would remain in good shape, not idling away and rusting. This will be indeed good utilization of idle period.
(e) As the machine is already synchronized with the grid, transfer back from SCO to Generator mode would be faster.

III CONCEPT OF SYNCHRONOUS CONDENSER OPERATION MODE

A hydro set, unlike a thermal set, can operate in the system in reverse power mode (- P + Q) without any problem. But, when this happens inadvertently due to closure of guide vanes or MIV, the generator is immediately isolated by reverse power protection to avoid drawl of large amount of power P from the System owing to heavy churning losses of turbine runner. But in SCO mode, these losses are reduced to minimum (Less than 1 MW) by first closing the guide vanes and then injecting pressurized air in the DT, such that water level is forced to recede below the runner while the unit remains connected to grid in normal way to supply reactive power Q while drawing a small active power P (- Δ P + Q). The amount of reactive power Q is controlled from excitation system of generator as normally.

IV PRE REQUIREMENTS AND PROCESS DETAILS FOR TRANSFER TO SCO MODE

Given below in Figure 1 is the typical integrated scheme of SCO mode.

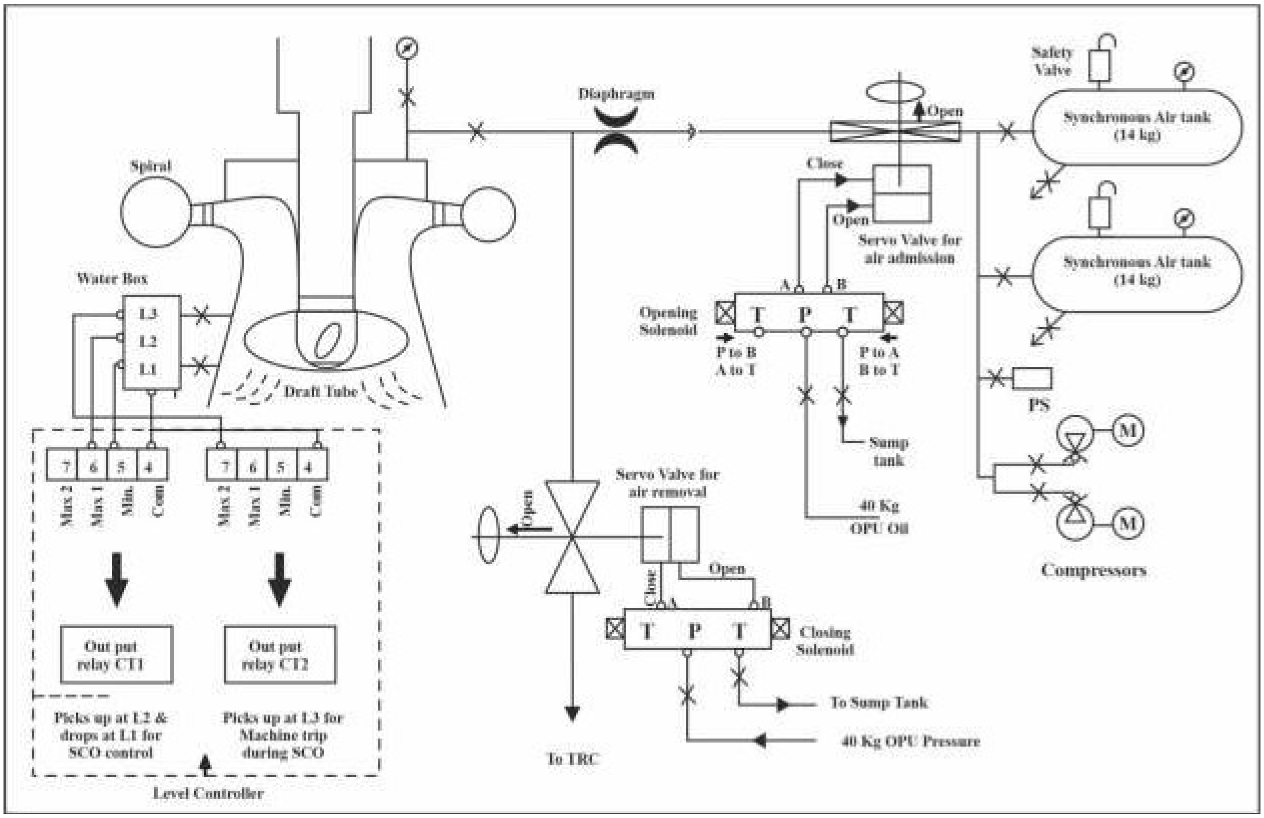

Fig. 1 Typical Integrated Scheme for SCO Mode

1. Following are the pre-requirements before transfer to SCO mode.
   (a) EHG system must be in auto working mode.
   (b) The LP compressors supplying compressed air for SCO must be working in auto, under control of their pressure switches.
   (c) DT water level monitoring by level controllers must be functioning properly as the success of SCO mode predominantly depends on this.
   (d) Solenoid operated servo valves for air admission & release from DT must be working well. The return line from T ports to sump tank must be open & clear for free flow of oil.
   (e) Proper functioning and co-ordination of Governor, UCB and protection control schemes must be ensured.

2. Process Details of SCO mode

(a) Machine is started in auto governing mode, synchronized as normally for generator mode on minimum load, just floating on the bus
(b) On issuing Command from Auto Sequencer Panel/UCB panel for transfer from generator mode to SCO mode, a synchronous Condenser relay (SCR) gets energized in the governor control circuits for following actions-
   (i) Reverse power relay operation is blocked.
   (ii) Guide vanes are closed.
   (iii) Bulk Compressed air flow into DT takes place by energization of opening solenoid of servo valve which gets closed upon water reaching below runner as sensed by level controller. This completes the transfer to sco mode for reactive power (Q) generation by increasing the excitation.

(iv) When due to air leakages from DT, water level rises above the runner, Servo Valve again opens by action of Level Controller, to allow flow of make-up air for restoring the water Level below the runner.

(v) If for any reason water level rises to a pre-determined higher lever, Machine is tripped by the action of another level controller switch.

(vi) For transfer back to generator mode, Command for SCO to Generator mode (SCO → Gen) is issued which by de-energization of SCR, reverses the process steps. At first DT air is removed by energization of opening Solenoid of Servo valve of air removal followed by GV opening and unblocking of reverse power relay. Load on machine comes immediately through governor circuits after water level in DT becomes normal.

V FEEDBACK FROM SITES

Considering the benefits of SCO, provision of equipment's for SCO has been made in many hydro power projects for voltage management,

(a) In the 6 x 200 MW Sardar Sarovar RBPH in Gujarat, both positive and negative reactive power (±Q) is generated/absorbed in SCO mode as per directions of regional grid on regular basis, during which the unit draws approximately 4 MW Power (- ΔP) from the grid.

(b) In the 3 x 15 MW Rajghat hydro power project (M.P.) during trials for SCO, following data were recorded.

From Gen to SCO

Time Taken = 140 seconds.
ΔP = -0.4 MW

From SCO to Gen

Time Taken = 275 seconds.
ΔP = 3 MW

(c) In the 6x130 MW Idduki Power house in Kerala, Effect of reactive power Q generation /absorption in SCO mode was recorded as given in Table 1.

Table 1
Effect of Reactive Power

Regime	MVAR	Bus Voltage, kV	MVAR	Bus Voltage kV
In under excited Condition	0	224	-57.5	220
In overexcited Condition	0	224	31	226

VI CONCLUSION

The above presentation highlights a very useful feature of SCO mode capability of hydro sets for achieving voltage management of the grid in a cost effective manner. As such, it must be put to use wherever equipment for it has been provided, depending upon site conditions. All the same, contentious matter of sharing revenue loss in drawing some negative active power (- ΔP) for meeting churning losses of turbine and for excitation power of generator needs attention of authorities and of turbine designers for the consequential heating effect of turbine parts like labyrinth seal etc. For obtaining successful operation in Synchronous Condenser mode, only requirement is of ensuring "assured" transfers every time on giving commands for Gen → SCO & vice versa for which sufficiency of compressed air for initial bulk quantity for water depression, functional reliability of DT water level sensors amongst others, is essential. MW transducers for water level sensing may also be used in place of electromechanical level sensing controllers such that when -ΔP is -0.4 MW, Gen→ SCO transfer will be assumed as completed to stop air admission, which will be restarted say at –ΔP = -1.5 MW and to trip machine at -ΔP = -3MW, signifying failure of SCO mode.