A CASE – STUDY OF RUNAWAY – SPEED AT SANJAY-BHABHA – H.E.P. AND LATEST TREND IN PELTON TURBINE.

By. M.P. Shrivastava
Ex-B.H.E.L.
The Sanjay Bhabha Hydro Project (Sanjay) is having 3x40mw Pelton turbine, Head is 887.2 meter, speed is 500 rpm. This power house is situated in Satluj River in Himachal Pradesh and was commissioned in the year 1989. The Electro – Mechanical equipments were supplied by B.H.E.L Bhopal unit. The Power House is underground.

About 10 years back one unit of Sanjay Bhabha reached runaway speed due to the failure of the Electro-Hydraulic governor as well as failure of the emergency closing valve and total stator & rotor of Generator had been ruined.

Being High head machine, Penstock water pressure was used to close the deflector servomotor because this water pressure is considered most reliable source to close the machine. The Deflector servo – motor was designed in such a way that it opened under oil pressure of 40 kg/cm² and closed under penstock water pressure in 1.5 sec.

The diagram of control gear is enclosed as fig.1
Diagram of Control Gear
Governing system
where the Deflector Servo motor 1 No is opening through the oil pressure and this pressure is coming from H.M.C. of Governor (M.D.V.) and closing is done through the penstock water pressure. The penstock tapping is taken from penstock before M.I..V. through Duplex water filter (strainer).

Due to heavy silt in the river, duplex filter got fully chocked and water pressure was not available in deflector servo – motor. Due to this reason and because of failure of the Electro– Hydraulic governor and opening of the main Generating circuit breaker at that movement, the machine reached run-away speed and damaged the generator. MIV was closed manually to stop the machine.
1. In the Pelton turbine, the speed rise is less than 15% and closing time of deflector servo-motor is 1.5 sec. If deflector servomotor does not close in 1.5 sec, then there is a possibility that machine may reach over speed as well as run away speed. If deflector servomotor does not close within 10 sec, Bhabha unit may reach runaway speed. The electrical over – speed and mechanical over – speed relay are also working through governor and these devices had also not worked and Bhabha unit had reached run-away speed.

During run away speed, one of the rotor bolt got loose and fell down in the air gap between stator and rotor. Due to this, the complete stator winding as well-as rotor-poles got damaged. The machine was shut down for more than three months for rectifications.
2. Action: - After studying the above problems, B.H.E.L changed the deflector servomotor closing through oil pressure. Earlier it was closing under penstock water pressure and opening under oil pressure as mentioned above.

The revised scheme D.C.G. is enclosed as fig 2 & 3.
The modification in the Hydro – mechanical cabinet (H.M.C) of governor to suit the Main Distributing valve was also carried out as shown in figure -4

Modifications were done in all three unit of the Bhabha plant in the year 2000. After these modifications, the machines had been operating smoothly without any run-away speed and over-speed problem.

After this incidence B.H.E.L decided to provide closing of deflector by oil pressure and provide hydraulic over speed device in addition to electrical and mechanical over speed device.
(i). Internal nozzle servo-motors:- Earlier nozzles were fitted with external servo-motors and needle rod passed through the distributor and wye branch to control the needle movement. This needle in water passage is not desirable for high head turbines because water flowing across this rod give rise to vortices, loss in efficiency & humming sound in distributor.

Hence internal nozzle type servo-motors are used in pelton Turbine as shown in fig – 5.
Needle Servo motor de-assembly
(ii). Individual deflector and Deflector servo-motor are mounted on each nozzle and each deflector is controlled independently now a days. Both the deflector and nozzle servomotors are provided with disc springs to ensure emergency closure to avoid any chances of mishap as fig. 6.
(iii). Pelton Turbine have a part load low efficiency if all jets are put in service. Hence automatic jet selection features are provided in the governing & control system to overcome this problem. (As shown in fig. 7 & 8)
Individual needle and deflector servo motor
(iv). High oil pressure system above 100 kg/cm^2 are used in pelton turbine. This high oil pressure system help in reducing the size of hydraulic components e.g. Internal nozzle servo-motors, Deflector servo-motors, main distributing valve of governor and oil pipe line Etc.
Arrangement of PPSet
High pressure PPset
(v). Earlier the deflector was controlled as main control and needle control as follower through conjugation curve in the governing system. This control is obsolete in governing system because it is not direct control of water discharge in Turbine.

Now days, the nozzle – control is designed as main control and deflector control as follower through conjugation curve in the governing system.
(vi). Now a days hydraulic over speed tripping device is provided as positive control of any emergency tripping condition in addition to mechanical and electrical over – speed device (As shown in fig. 3)

**Conclusion:** The closing of the Deflector servo-motor through oil pressure system is more positive and reliable compared to penstock water pressure.
Thank You!