Speech – Load Characteristics

(Load Sharing between Two SynchronousMachines in Parallel)

Speed droop is a governor function which reduces the governor reference speed as fuel position (load) increases. All engine controls use the principle of droop to provide stable operation.

The simpler mechanical governors have the droop function built into the control system, and it cannot be changed.

Droop originates from the principle of power balance in synchronous generators. An imbalance between the input mechanical power and the output electric power causes a change in the rotor speed and electrical frequency. Similarly, variation in output reactive power results in voltage magnitude deviation.

The ability to return to the original speed after a change in load is called isochronous speed control. All electronic controls have circuits which effectively provide a form of temporary droop by adjusting the amount of actuator position change according to how much off speed is sensed. Without some form of droop, engine-speed regulation would always be unstable.

A load increase would cause the engine to slow down. The governor would respond by increasing the fuel position until the reference speed was attained. However, the combined properties of inertia and power lag would cause the speed to recover to a level greater than the reference.

Droop is a straight-line function, with a certain speed reference for every fuel position. Normally, a droop governor lowers the speed reference from 3 to 5 percent of the reference speed over the full range of the governor output. Thus a 3% droop governorwith a reference speed of 1854 rpm at no fuel would have a reference speed of 1800 rpm at max fuel (61.8 Hz at no fuel and 60 Hz at max fuel).

Most complex hydraulic governors have adjustable droop. In these cases, droop may beset between 0% and 5%. Droop is not adjustable in most mechanical governors,

Percentage speed regulation or droop

The value of R determines the steady-state speed versus load characteristic of the generating unit as shown in fig.5. The ratio of speed deviation ($\Delta\omega_r$) or frequency deviation (Δf) to change in valve/gate position or power output (ΔP) is equal to R. The parameter R is referred to as speed regulation or droop. It can be expressed in percent as

$$\%R = \frac{No\ load\ speed - Full\ load\ speed}{Full\ load\ speed} \times 100$$

$$\%R = \left(\frac{\omega_{NL} - \omega_{FL}}{\omega_{FL}}\right) \times 100$$

When two generating units are operating in parallel on the system, their speed-droop characteristics low load changes are shared among them in the steady state and to operate to a common frequency.

The changes in the outputs of the units are given by

$$\text{Unit-1, } (\Delta P_{G1}) = \frac{-P_{r1}}{R_{p.u1}} \times \frac{\Delta f}{f_r}$$

$$\text{Unit-2, } (\Delta P_{G2}) = \frac{-P_{r2}}{R_{p.u2}} \times \frac{\Delta f}{f_r}$$

Total load change in output

$$= \Delta P = \Delta P_{G1} + \Delta P_{G2} = \frac{-\Delta f}{f_r}\left[\frac{P_{r1}}{R_{p.u1}} + \frac{P_{r2}}{R_{p.u2}}\right]$$

$$\text{The system frequency change } \Delta f = \frac{-\Delta P . fr}{\frac{P_{r1}}{R_{p.u1}} + \frac{P_{r2}}{R_{p.u2}}}$$

$$\Delta f = \frac{-\Delta P}{\frac{1}{R_1} + \frac{1}{R_2}}$$

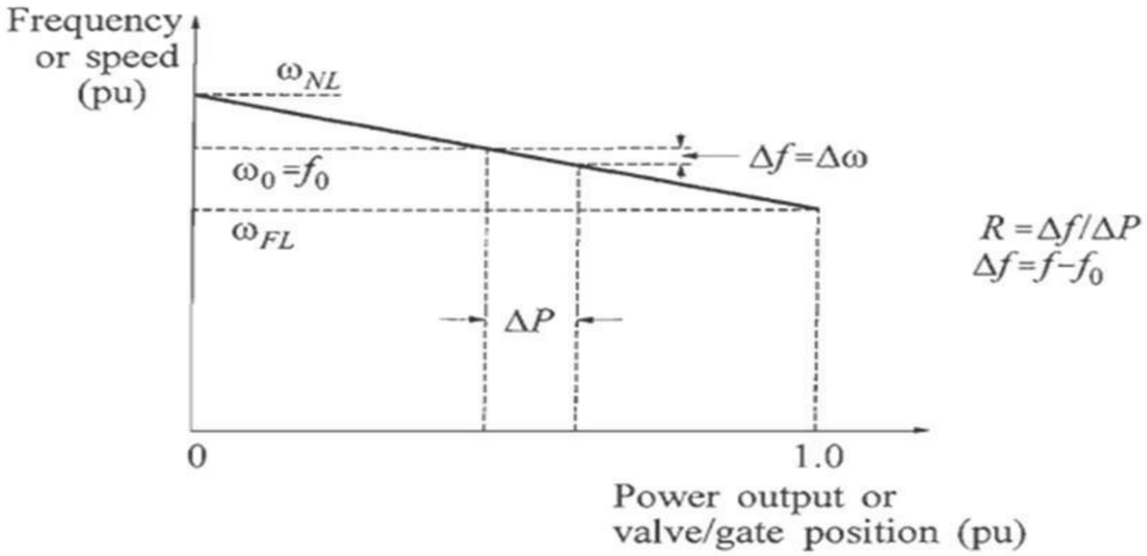
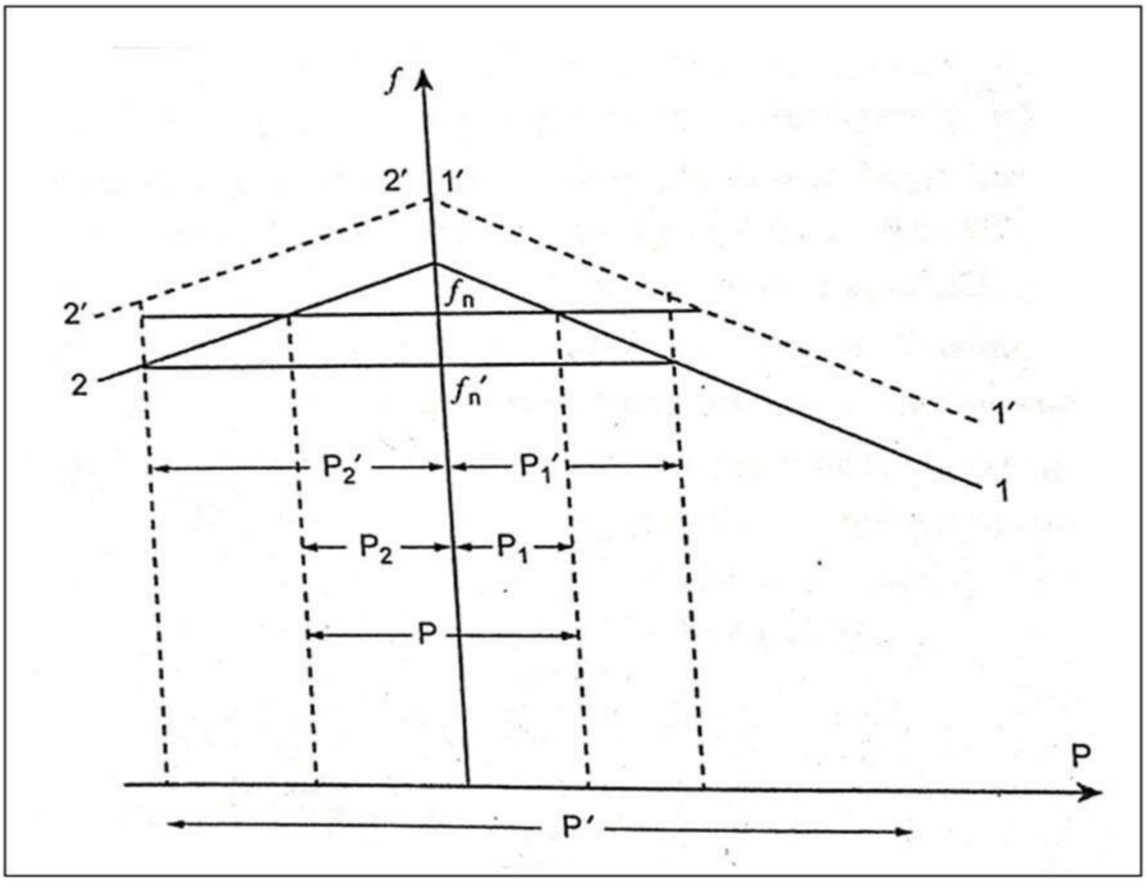


Fig.5 Ideal steady state characteristics of a governor with speed droop

Parallel operation of two alternators

Two different controls are carried out on the governor characteristics. The parameter R is adjusted during off-line condition of the unit to ensure its proper coordination with the other units, the second control shifts the straight line characteristic parallel to itself to change the load distribution among the generators connected in parallel as well as to maintain the system frequency.



The second control known as supplementary control. In Fig.7, the governor characteristics of two generating units are shown. Supposing if two generator units sharing the total load P ie. $P = P_1 + P_2$ and at constant frequency f_0.

Now if the total load increases by P', the frequency reduces to f'_0 then the two generator units increases their output by supplying kinetic energy which in turn reduction in speed. In order to maintain the system frequency, one of the generators or both the generator increase their output which is shown in dotted lines of the figure. Now the total load P' is hared by both the generators with increased output i.e

$P' = P'_1 + P'_2$.

It is to be noted that if the frequency of two areas are to be controlled, the static frequency drop is 50% of the isolated operation of two systems. Also, if there is changein load in any area, half of it shared by other area