(2) The flux produced by I_f should aid the residual flux. If the field wdg is connected in the reverse direction, the voltage will 'build-down' i.e. it becomes less than E_{res} (i.e. almost zero).

(3) The resistance of the field circuit R_f should be small enough to intersect the OCC in the saturation region. As R_f is made larger, the intersection moves down the OCC, fig. 8.8. The field resistance line that is tangent to the linear part of the OCC is called the critical field resistance, R_{crit} in fig. 8.8 :if R_f is increased further, there will be no build up. The critical resistance is higher for higher speeds (why?); the critical speed corresponding to a given field resistance is the speed at which the linear part of the OCC becomes tangent to that resistance. If the shunt generator fails to build-up at a certain speed due to large field resistance, it might build-up at a higher speed.

8.13 Compound Generator

A compound generator is essentially a shunt generator with additional mmf from the series wdg:

$MMF_{total} = N_f I_f \pm N_s I_s$ (8.10)

The compounding is cumulative if the series field aids the shunt field (plus sign in eqn 8.10); the compounding is differential if the series field opposes the shunt field (minus sign in eqn 8.10). For long shunt connection, fig. 4.3, $I_s = I_A$, and for short shunt connection $I_s = I_A - I_f \approx I_A$. If a diverter is used, fig. 8.2, I_s may be less than these values.

The OCC of a compound machine corresponds to separate excitation of shunt field alone. Dividing eqn 8.10 by the shunt field turns:

$$\frac{MMF_{total}}{N_f} = I_f \mp \frac{N_s}{N_f} I_s = I_{eq} \quad (8.11)$$

The term $(N_s/N_f)I_s$ is the series field excitation referred to the shunt field circuit; I_{eq} represents total excitation in terms of shunt field amperes, and can be read off or projected directly on the horizontal axis of the OCC.

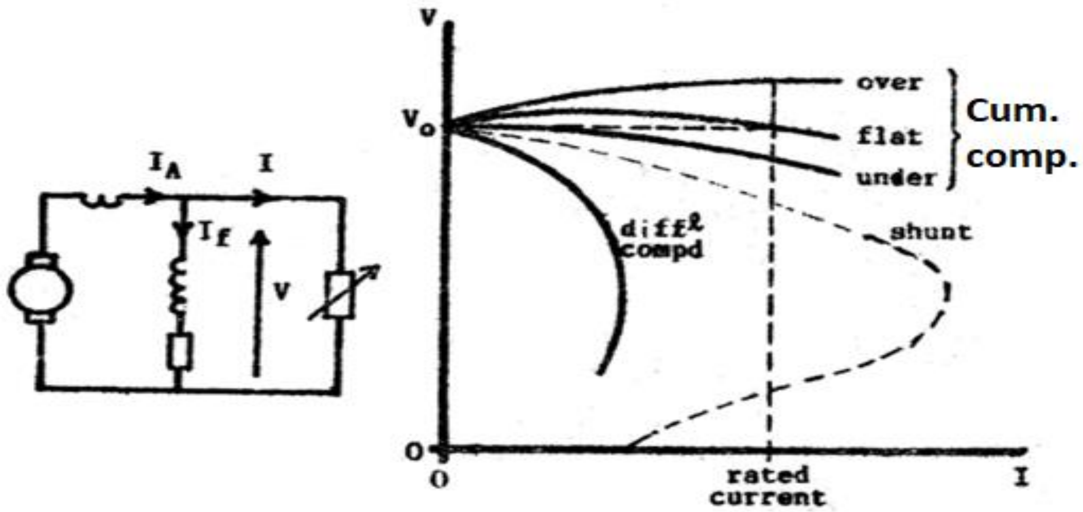

Fig. (8.9) Compound generator

8.13.1 Cumulative Compounding

As seen in section 8.4, the terminal voltage of a shunt generator due to ΔV and the reduction in E_{Aoc}. In a cumulative compound generator, the series field compensates for part or all of the drop.

The series field current changes with load (why?) so that the degree of compensation changes with load. The number of series turns N_s may be chosen such that the resulting series field compensates exactly for the drop at full load; the full load voltage is then equal to the no-load voltage (zero voltage regulation), and the machine is said to be flat-compounded (or level-compounded)-see fig. 8.9. If fewer series turns are used, we have under-compounding :the full load voltage is less than the no-load voltage (positive regulation), but still more than the shunt generator full load voltage. If more series turns are used, we have over-compounding :the full load voltage is greater than the no load voltage (negative regulation). It is also possible to choose N_s for over-compounding, and change the actual degree of compounding by means of a diverter, fig. 8.2.

8.13.2 Differential Compounding

When the series field opposes the shunt field, ineffectively increases the drops, the external characteristic is then below that of the shunt generator, fig. 8.9.

8.14 Series Generator

The OCC for a series generator, fig. 8.10, is obtained with the field supplied from a separate source (the armature is open circuited by definition). In normal operation, the field wdg is connected in series with the armature, and the terminal voltage V is less than the induced emf E_{Aoc} due to the drop ΔV; the external characteristic is thus below the OOC as shown in fig. 8.10. The rising part of the curve is not stable :a slight change of load resistance causes large changes in terminal voltage and current. In the saturation region, the OCC is almost horizontal, but ΔV continues to increase with I_A so that the curve is falling; the fall is sharp in series generator designed to have strong demagnetizing armature reaction.

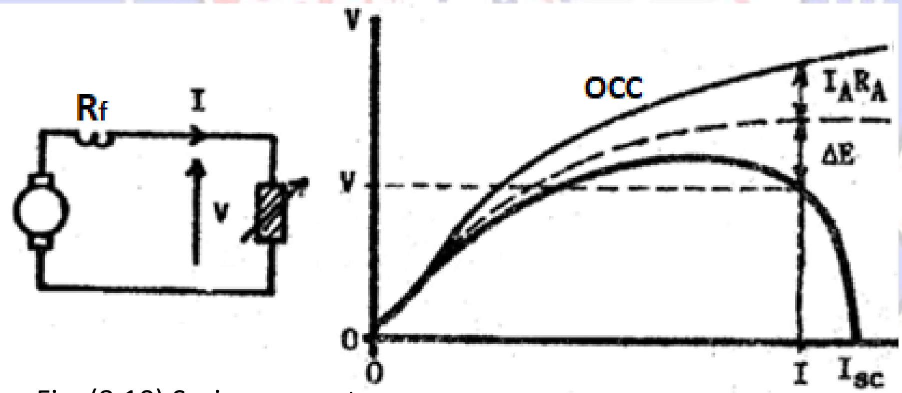

Fig. (8.10) Series generator

8.15 Applications

For dc power generation, the separately excited generator has acceptable voltage regulation, but has the disadvantage of requiring a separate source. The self-excited shunt generator does not require a separate source, but has poor regulation. The cumulative compound generator overcomes this problem; it can be designed to have zero regulation by suitable compounding. Modern generators are equipped with automatic voltage control, possibly solid-state, so that they have excellent regulation; the design of the control system is determined by the external characteristic of the generator. However, solid-state rectifiers are rapidly replacing dc generator in most applications; technological advances have made it possible to manufacture commercial solid-state components of high rating, i.e. components capable of passing high currents and withstanding high voltages. For example, the dc generator in the automobile has now been replaced by an ac generator (alternator)with rectifier.

The external characteristics of the series and differential compound generators make them unsuitable for dc power generation at constant voltage. The falling portions of their characteristics correspond to constant current operation over that range. The series generator has been used as a booster :it is connected in series with the line between a generator and its load; its rising characteristic compensates for the drop in the line.

8.16 Parallel Operation

Two dc generators, or a generator and a battery, may be operated in parallel to supply a common load. The over-all characteristic is obtained by graphical parallel addition of their external characteristics, fig. 8.11. The figure also shows how the two generators share the load current according to their individual characteristics.

When we intend to operate two generators in parallel, before closing the paralleling switch we must make sure that the voltages of the two generators are equal and have the same polarity; otherwise large currents may circulate between them.

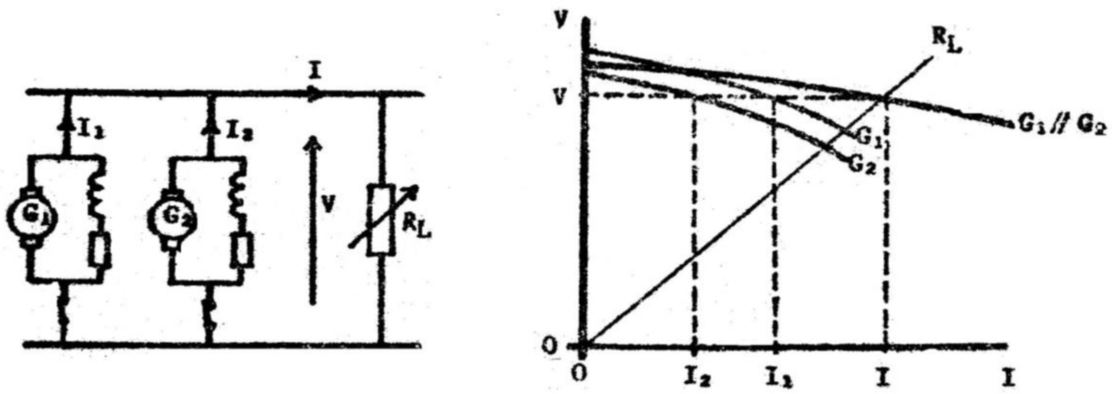

Fig. (8.11) parallel operation of shunt generators