Operating Characteristics of Alternator and their Ratings

External Load Characteristics:

If an alternator is running at constant speed with constant excitation, E_f=constant.

At no load I_a=0, so $E_f = V_t$, shown in fig. 1(a)

If the alternator is carrying a current I_a at lagging pf, then the terminal voltage V_t will be less than E_f, shown in fig. 1(b).

If the alternator is carrying a current I_a at leading pf, then the terminal voltage V_t will be greater than E_f, shown in fig. 1(d).

Terminal voltage V_t will be also less than E_f , if the alternator is carrying a current I_a at unity pf, shown in fig. 1(c).

Therefore the terminal voltage falls for unity and lagging pf load and rises for leading pf load.

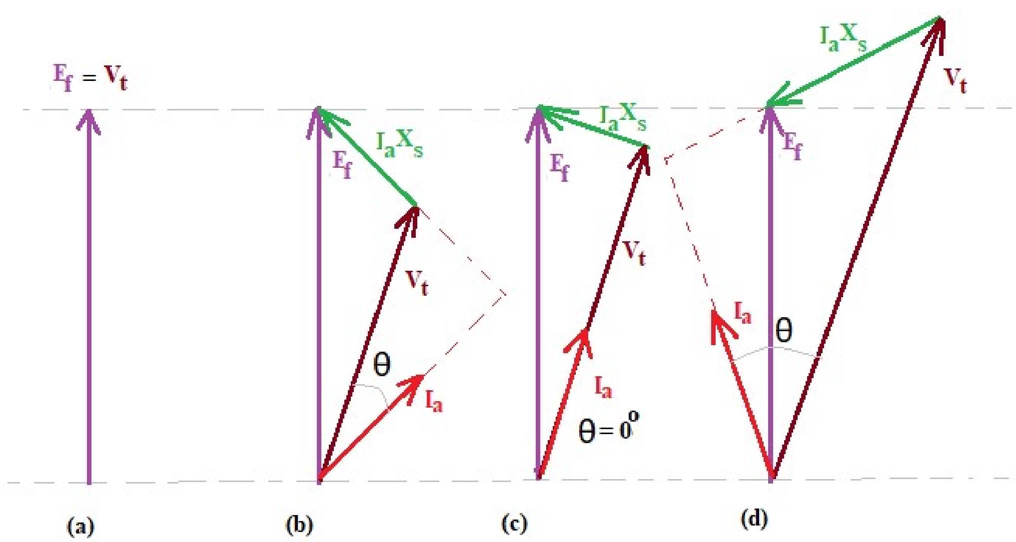

Fig. 1

If the field current is kept constant at a value such that rated voltage is obtained at rated load, the change in terminal voltage with load is shown in fig. 2. The no load voltage will be more than the rated voltage if the pf is lagging or unity. The no load voltage will be less than the rated voltage if the pf of the load in leading.

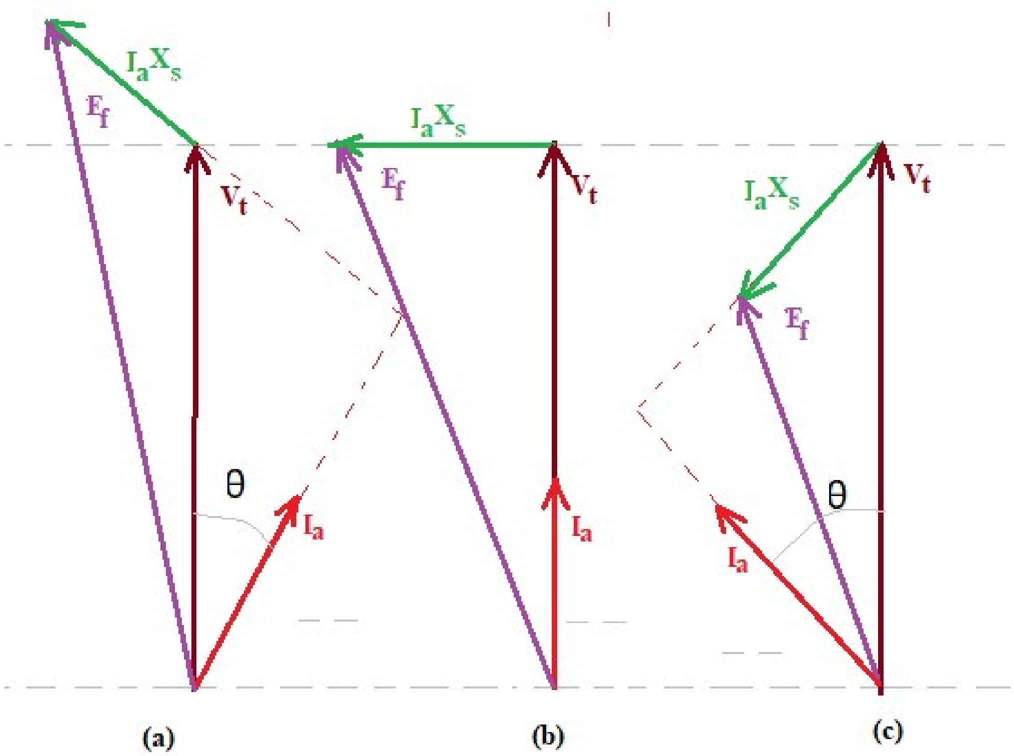

Fig. 2

The plot of terminal voltage vs. armature current is called the external characteristics.

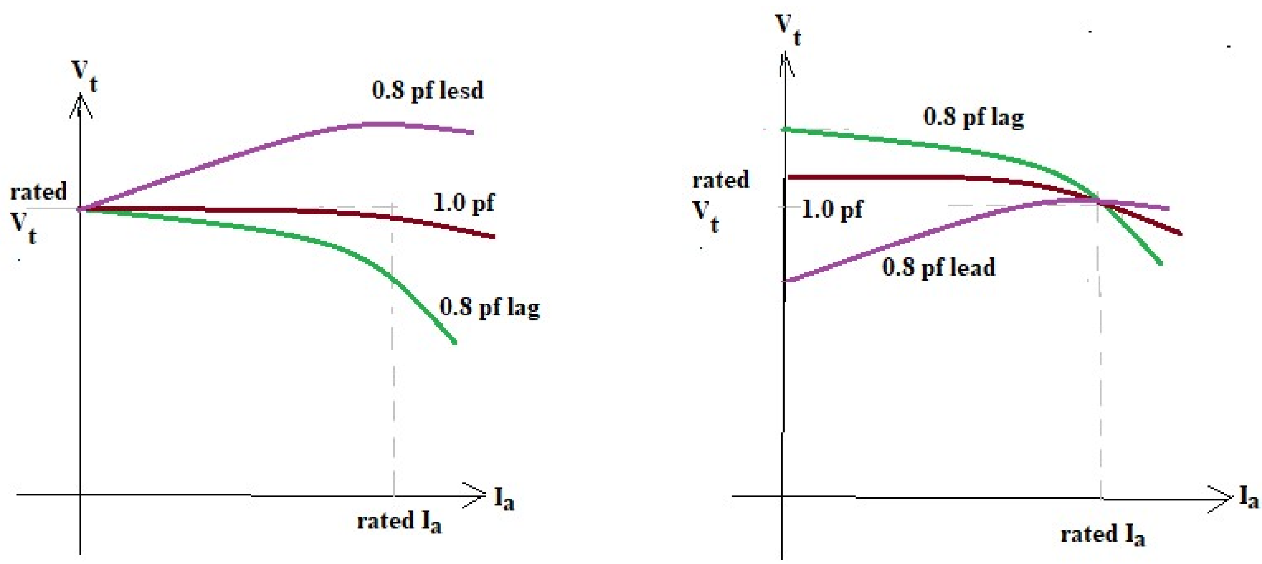

Fig. 3 External Characteristics

Alternator Compounding Characteristics

The above discussion shows that as the load changes, the field current should be varied to keep the terminal voltage constant. The terminal voltage is kept constant by automatic voltage regulator.

Form Fig. 2 , considering V_t = 1.0 pu, E_f is more than 1.0 pu if pf is lagging. E_f is slightly more than 1.0 pu for unity pf. And E_f is less than 1.0 pu if the pf is leading. So, to keep the terminal voltage constant, I_f should be increased for lagging pf load and I_f should be decreased for leading pf load. For unity pf increase in I_f with increase in I_a is slightly less compared with lagging pf load. Fig. 4 shows the compounding curves for an alternator.

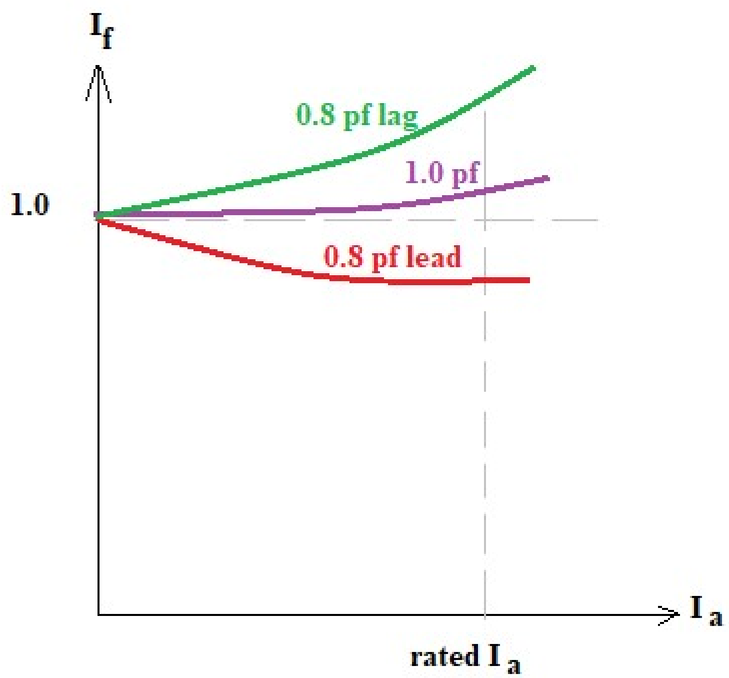

Fig. 4 Alternator Compunding Curves

Rating of Alternator:

The rating of any electrical machine depends on its heating and hence by its losses in them. The losses of an alternator consist of I^2R loss, core loss and windage and bearing friction loss. Windage and bearing friction loss is small and usually clubbed together with core loss. The I^2R loss depends on current and core loss depends on voltage, and this losses are not affected by the power factor. In view of this , the rating of an alternator depends on the volt-ampere of the load and not on the active power alone. However, the prime mover ratings are dictated by the active power. For example, for 100MVA load of 0.8 pf, the alternator, transformer and transmission line rating is 125 MVA, while the size of boiler, turbine and fuel requirement are decided by active power 100MW .

For an alternator the pf for which it is designed must also be stated on the name plate. Because an alternator designed for 0.9 lagging pf at rated load, requires more field current when operated at 0.8 lagging pf . More field current results in over heating of the field system. If on the name plate it is not mentioned whether the pf is leading or lagging, it should be taken as lagging, as for lagging pf the machine takes more field current.