Green Rameswaram - Energy Efficient Motors – II

By Dr.Ramaratnam, Basil Energetics

The last article described the issues involved in improving the efficiency of electric motors. Electric motors account for a significant portion of the overall electricity consumption. Generation & utilization of electric energy itself is a major contributor to the pollution, accounting for as much as 40% of the total green house gases produced globally. As the country progresses further on the development path, the per capita electricity consumption will go up on an ascending manner. Even to catch up with the rest of world, our consumption will increase around four fold. Unless we learn to use energy more efficiently our pollution levels will go up significantly and will not be sustainable. India is already the third biggest polluter of the world, after China and USA. With a lot of emphasis in getting a faster growth for the country to lift millions of people out of poverty, it is to be expected that our electricity consumption has necessarily to go up.

The energy intensity of our economy has to be brought down significantly. Unless this is done it will be difficult for us to meet the aggressive commitment that India has pledged to in the COP 21 agreement. The COP21 conference itself was held in Paris and recently India has put its signature on this in September. Electric motors, which account for around 60 - 65 % of the total electricity consumed, will have to be looked at critically in this regard. Energy efficiency of electric motors will play a crucial role in deciding the path in which we strive to meet the COP21 agreement norms in containing the production of green house gases.

Efficiency Issues of Electric Motors:

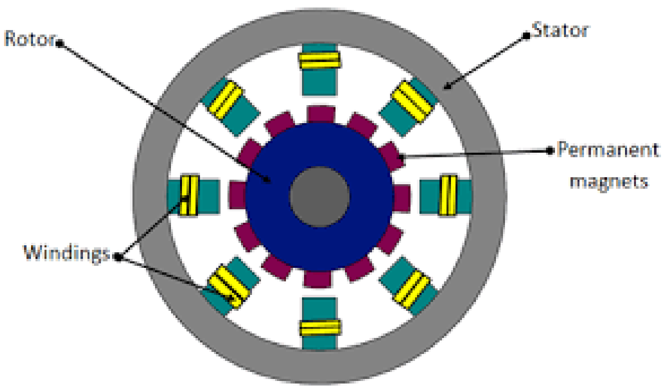
Presently most of the motors that are used in appliances and equipments in home, offices and industry are AC motors. These are called as Induction motors. They can be of single or three phase types. These induction motors have inherent characteristics that compromises their inefficiency. The bulk of them are also single speed type. Normally they are constant speed motors. While being very reliable and rugged these motors are invariably the work horses for the industry. The three phase motors are mostly used in industry while the single phase types in the small and fractional horsepower range occupy a prime place in the appliances used in home and office.

The AC induction motor, particularly in the small power range, has some inherent issues which makes it not very efficient. The basic objective a motor is to provide a rotation or movement of a mechanical object like fan blade, impeller of a pump, head stock or a chuck of a lathe, drilling machine and similar machine tools. A motor converts electrical energy into mechanical energy to provide the required motion. While doing so it will have to overcome the friction and the basic resistance of the load. It has to provide the necessary torque to move things and this has to be done at a desired speed.

The torque production in the electric motor happens due to the interaction between the magnetic field that exists and the current carrying conductor/winding. The basic laws of Physics enunciate the motion of the current carrying conductor in an established magnetic field. Normally in conventional electric motors the magnetic field is set by a current carrying winding placed in it. This is called as an electromagnet and while doing so expends some energy to set up the magnetic field. Secondly in the induction motor, the moving part, viz., rotor which has a short circuited winding within it has to necessarily rotate at a frequency which is somewhat lesser than the frequency of the input supply current fed to the motor. There will be no torque production if the rotor speed is equal to that of the input supply voltage and current. This difference in frequency between the rotor speed and the input supply frequency is called as slip. This also results in a loss of power which is proportional to the slip. Smaller and single phase motors have slip amounting to around 5 - 6 percent and this is a direct loss which is unavoidable.

These two components of an induction motor results in some inherent losses due to the basic principles of operation of such motors and are inevitable. The proportion of such losses in bigger motor will be much lower than that of a small motor. Thus it is the basic principle of operation the induction motor which makes small motors in the fractional horse power range intrinsically less efficient. As against the conventional single phase induction motor, with its inherent deficiencies, a new class of motors are now emerging. These new generation motors have inherently increased efficiency due to their basic operating principles, as described below.

Instead of an electromagnet needed to establish the required magnetic field, these motors use permanent magnets. These magnets arranged in specific order and form totally eliminate the need to have a separate windings with their attendant losses. In the last article more detailed description of such magnetic materials were given. Thus one part of the intrinsic deficiency is taken care of. The other issue is the necessity of an induction motor to operate at a definite slip. With the permanent magnet motor this is also overcome. The rotor, normally housing the magnets, can easily rotate at the frequency of the input power supply, i.e., both the rotor frequency and that of the input power supply are same. These motors are classified as Permanent Magnet Synchronous Motors or PMSM. Thus the PMSM does not have any losses in the rotor due to the slip.



The earlier type DC or synchronous motors normally needed carbon brushes and commutator or slip rings to inject current into the rotating windings. But the modern permanent magnet motors do not need the carbon brushes. These are brushless motors where the commutation is by electronic and static means. The permanent magnet motors do not have any windings in the rotor to which the current has to be injected. Thus the absence of carbon brushes riding on commutator or slip rings also reduces the frictional losses. Absence of wearable carbon brushes also increase the reliability of the motor.

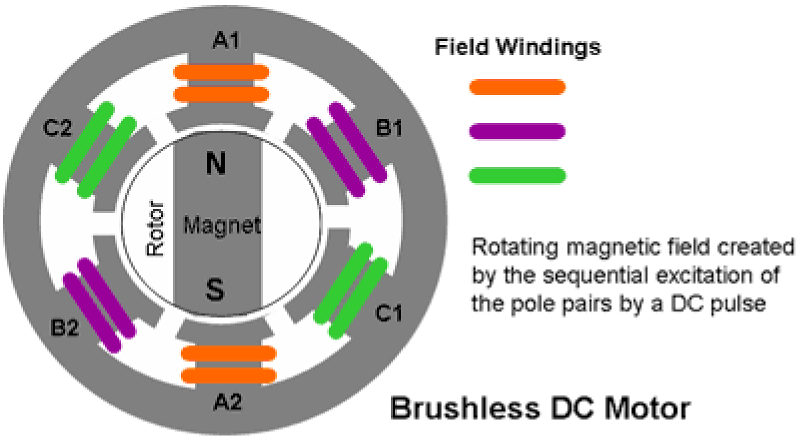
Another factor that is contributing to loss of efficiency in induction motor is the constant speed of operation of this motor. It is essentially a constant speed motor. In real life most of the times the load requires variable speed operation. In a vehicle, for example, during starting higher torque is required and the speed is low. As the vehicle picks up speed, the torque requirements comes down and we shift to higher gears. Likewise in most loads, the torque needed from the motor varies with speed. Even in loads like compressors the torque is constant but the speed can be varied.

For example in air conditioner or refrigerator the compressor has to run till the set temperature of the room or cabinet is attained. The compressor runs at full speed and cools the room or cabinet. Once the set temperature is reached, the compressor is switched off. Again after sometime when the room temperature increases due to heat loss or increased ambient, the compressor comes ON to effect further cooling. The compressor motor again operates at full speed to ensure cooling the room, It switches OFF again once the set temperature is reached. This process of switching ON and OFF continues.

As the compressor is a constant torque type load, i.e., the torque is constant irrespective of the speed and the input power varies with speed. Power is the product of torque and speed. Thus the air conditioner or refrigerator draws full power whenever it is ON. Compared to this a variable speed compressor will operate at full speed during starting like the conventional one. Once the set temperature is attained it switches OFF. But when it again start when the room temperature is more than the set value, the compressor is not run again at full speed but at a reduced speed. The speed is so chosen by a temperature control algorithm in such a way that just enough cooling capacity is given by the compressor to compensate for the insulation loss or increased ambient. Due to this variable speed operation, the power drawn by the motor is drastically reduced in subsequent cycles. The energy consumed by the air conditioner is also greatly reduced. Thus the overall energy consumption of a variable speed compressor is drastically reduced.

Similarly in the case of a fan or pump, variable speed operation of the motor reduces the energy consumption. The PMSM is very well suited for such variable speed operation. As there is already power electronic circuitry in the motor for making it brushless, the same can be used for speed control as well.

Thus the emergence of brushless permanent magnet motors with electronic controls for variable speed increases the efficiency of these motors significantly, when compared to single phase AC motors. The recent trend is to use such motors widely in small motors and reduce the energy consumption. Japan pioneered this concept in a big way and has been able to increase the energy efficiency in a significant manner over the last 10 - 15 years. Such motors also find widespread use in electric vehicles and are poised to play a major role in reducing the energy intensity in these sectors. The developed world is also following the same path in ensuring significantly increased efficiency for motorised applications including traction. This is the way forward for energy starved and infrastructure constrained nations like India.



In the next article real time examples of deployment of such motors in appliances will be indicated. The extent of energy savings will also be illustrated with specific examples of applications.

To be continued………