

load efficiency. For loads with greatly lower horsepower requirements at reduced speed motors can be furnished with minimum speeds of 25 per cent of maximum speed.

The curves of Fig. 5 indicate the performance of a typical wound rotor motor with various values of secondary or external resistance. With various values of resistance the motor will operate with different speeds below full load speed, depending on the load torque. By use of a suitable resistor the motor can be operated continuously at reduced speed.

Synchronous motors are ordinarily used where there is a need for or advantage in obtaining power factor correction and high efficiency, or where constant speed is necessary or where they have a lower first cost than other types of motors. They are especially applicable for large low speed reciprocating compressor drive in view of their lower first cost. It is necessary to consider each application as a special case, which must be individually engineered to correctly establish the combined moment of inertia of the compressor, compressor flywheel and motor rotor. Otherwise due to the torque pulsations of the compressor unsatisfactory operation will result.

Synchronous motors are frequently used for driving large direct connected, medium speed fans where continuous operation makes high efficiency and power factor of some value. Similarly they are being used for driving large high speed centrifugal compressors through speed increasing gears. On this type of compressor, the torque characteristics are the same as for a fan and each application is not a special case as is true for reciprocating compressors.

Other means of obtaining adjustable speed drives is by using a constant speed motor either induction or synchronous type, and an adjustable speed coupling. These couplings are available in both hydraulic and magnetic types, both of which are easily adjustable over a wide speed range with a variable torque load and a more moderate speed range with a constant torque load.

Enclosures

Motors are built in several types of frames depending on the particular application. Usually the open type of motor, meaning one with an open frame so that the windings are not too closely protected from ambient conditions such as dirt, dust, moisture, abrasive material, etc. is used. In case the motor is to be installed under dripping pipes, for instance, a drip-proof frame motor should be used and in case the motor is to be exposed to splashing water a splash-proof frame motor should be used. These types of frames offer more protection to the motor winding and consequently the winding experiences a reasonable life. Similarly if the motor is to be exposed to abrasive dust or explosive gases special enclosed or explosion proof frames should be considered. Such requirements as these are frequently encountered in certain industrial applications in which cases, it is necessary to select the motors from the viewpoint of service conditions as well as the required operating and temperature characteristics to meet the demands of the machines being driven and the surrounding ambient.

The general classification of motors used for heating, ventilation and air conditioning is shown in Table 1.

CONTROL EQUIPMENT FOR MOTORS

In selecting control for alternating and direct current motors it is necessary to determine whether the installation is to be operated by manual or automatic control. The available controls and the function of each group of apparatus may be outlined as follows:

1. Manual Control:
 - a. To establish current.
 - (1) Snap switch.
 - (2) Knife switch.
 - (3) Manually operated contactor.
 - (4) Drum switch.
 - b. Establish current and provide overload protection.
 - (1) Snap switch with overload element.
 - (2) Knife switch with fuse or thermal cutout.
 - (3) Manual contactor with overload protective device; also reduced voltage starting compensator.
 - (4) Drum switch with overload protection.
 - c. Establish current and provide overload and low voltage protection.
 - (1) Not used.
 - (2) Not used.
 - (3) Manual contactor or reduced voltage compensator with overload and low voltage release.
 - (4) Drum switch equipped with latch coil to give low voltage release.
2. Automatic Control:
 - a. To start on full voltage.
 - (1) Without overload device (used only on small fractional horsepower motors).
 - (2) With overload device.
 - (3) With combination overload device and disconnect switch.
 - (4) With combination overload device, disconnect switch and short circuit protection.
 - b. Reduced voltage starting with options, 2, 3 and 4, under full voltage control.
 - (1) Primary resistance type starter.
 - (2) Auto transformer type.
 - (3) Reactor type.

The present trend in practice is to include short circuit protection for the motor feeder and controller in the automatic starter either by means of fuses or breakers depending on the size and voltage of the motors, and the short circuit capacity of the feeders and source of power to which the motors are connected.

Most motors are mechanically and electrically designed for full voltage starting. Power companies have set up certain restrictions on starting motors on full voltage due to the necessity of maintaining voltage on their distribution lines within certain limits. Large motors on low voltage systems may cause serious voltage dips on starting, due to the high value of the inrush current. However, certain types of motors such as those with switches for changing the motor circuit during the starting period, may draw other high peaks of current as large or larger than the initial inrush, during the accelerating period which will also cause voltage dips. These voltage dips may cause light flickering, shortening of lamp