Motors are mechanical or electro-mechanical devices that convert energy into motion. Energy, in the form of electrical, hydraulic, or pneumatic, is converted to rotational or linear motion and then output to a shaft or other power transmission component where it provides useful work. Electrical motors include AC or DC varieties, which are further broken out by specific special purpose electrical motors, including gearmotors, stepper motors, servomotors, and linear motors. Hydraulic and pneumatic motors rely on fluid (oil, air) for their motive power. Chemical motors include outboard motors for use on boats and rocket motors, both of which use internal combustion and are often called engines. An electric motor used to propel small fishing boats is called a trolling motor.

Types of Motors

AC Motors
AC Motors are electro-mechanical devices powered by alternating current to produce rotational motion. The rotation provides mechanical work to drive other rotating machines such as pumps. Standard frame sizes are available over a range of powers to ease interchangeability. Enclosures can range from simple open designs to explosion proof, non-ventilated designs, with totally enclosed, fan cooled (TEFC) being common. An international rating system also prescribes the levels of cooling and protection. AC motors form a large portion of motors in use today and drive pumps, fans, compressor, etc. Sizes range from sub-fractional horsepower machines to 20,000 HP plus sized units with metric sized units similarly available.

DC Motors
DC Motors are electro-mechanical devices powered by direct current to produce rotational motion. The motion provides rotational work to drive other rotating machines such as hoists at varying speeds. Certain wiring arrangements can produce strong slow-speed torque, making them suitable as traction motors for locomotives. Standard frame sizes are available over a range of powers to ease interchangeability. Enclosures can range from simple open designs to explosion proof, non-ventilated designs. An international rating system also prescribes the levels of cooling and protection. DC motors have many applications in toys and consumer goods, and are used heavily by automakers. They find service on elevators, electric fork lifts, and conveyors, where constant-torque loads are normal.
**Gearmotors**

Gearmotors are electro-mechanical devices powered by alternating or direct current to produce rotational motion. The motion provides rotational work which is then stepped down through an integral gearhead to drive other rotating machines such as conveyors or packaging machines. Gearmotors are used anywhere a motor and speed reducer is required and the benefits of integrating the two outweighs any disadvantage from sourcing both components through a single vendor. They are not as common in very large motors but are quite common in fractional HP sizes.

**Stepper Motors**

Stepper Motors are electro-mechanical devices powered by alternating current to produce rotational motion and positioning. Generally, stepper motors do not incorporate a feedback loop as do servomotors, but instead achieve position control by turning the motor rotor a discrete number of steps. They are specific to motion control applications. Stepper motors are used in positioning applications where holding a position is important and are used on packaging machines, printers, etc., where loss of position due to overload isn't critical and where economy is important.

**Servomotors**

Servomotors are electro-mechanical devices powered by alternating or direct current to produce rotational motion and positioning. Servomotors make use of a feedback loop to control the radial position of the motor rotor with respect to its stator. They are specific to motion control applications. Servomotors are used in positioning applications where smooth, controllable motion is paramount, an industrial robot, for example. A packaging machine might use a servomotor to index a precise amount of packaging film into a forming zone, in a second example, where in the past such feeding might have been controlled with a motor driven mechanical indexer.

**Linear Motors**

Linear Motors are electro-mechanical devices powered by alternating or direct current to produce linear rather than rotational motion. The linear motion is useful in applications where an air cylinder might be used but where greater precision and positional feedback are needed, or where the motion can vary from stroke to stroke. Motor configuration and forcer/slider shape can be concerns, as well.Linear motors are used in packaging machines, assembly machines, material handling equipment, and in various applications in medical equipment.
Air Motors

Air Motors are mechanical devices powered by air pressure to produce rotational motion. The motion provides rotational work to drive other rotating machines such as take-up reels and tools. Air motors are used where a source of compressed air is available and where a steady torque regardless of speed is needed, such as the scrap take-up reel on a packaging machine. They are used in explosive atmospheres as well, where they are considered intrinsically safe.

Hydraulic Motors

Hydraulic Motors are mechanical devices powered by fluid to produce rotational motion. The motion provides rotational work to drive other rotating elements such as the drive wheels of a heavy-equipment excavator. Hydraulic motors are used extensively on construction machinery where rotary motion is needed from a compact device and hydraulic power is already available.

Applications and Industries

Among the motors, the AC, DC, gear, air, and hydraulic varieties provide rotary motion while stepper, servo, and linear motors provide positioning. An AC motor is the likely choice for driving a pump, a DC motor is a good match to drive a crane drum where variable speed is important, gearmotors fulfill the same duties as bare AC and DC motors except they come with integral gear reductions, and air and hydraulic motors fill similar needs in situations where electricity isn’t practical or suitable.

Positioning is the realm of the other three types, meaning that these types are used where machine elements need to be moved to exact locations. Where rotary motion machines cover the entire size spectrum from the very small subfractional HP units to the largest above-NEMA machines, stepper, servo, and linear motors usually top out at a few horsepower and excel in the smaller sizes.

AC induction motors are ubiquitous in industry. They employ wound rotors which induce magnetic fields in the pole windings which then interact with the magnetic fields of the stator windings to produce rotation. AC motor speed is a function of the number of poles and the frequency of the applied voltage, with 1800 and 3600 rpm being especially common. Actual speed lags slightly the nominal speed of the rotating magnetic field, or line speed, and varies with load. AC synchronous motors exactly match the speed of the rotating field, independent of load, but their application is generally limited to special cases where this is critical, in motor-generators, for example. AC induction motors are not intrinsically suited to speed control, although a number of methods both in the motor design and in the controller circuitry are available to make speed control possible. Multiple windings are one way to achieve multi-speed motors. Variable frequency drives are another. In between, a number of motor controllers are available for induction motors to help them in coming up to speed, so called soft starters being one such example.

DC motors, on the other hand, offer intrinsic speed control by virtue of their construction and reliance on non-frequency direct current for their motive power. A DC motor typically uses brushes to bring DC
current to the rotor. By controlling the level of DC voltage, an operator can directly control the speed of the motor. DC motors are used in automobiles and abundantly in small size applications. In their larger sizes they are used in applications where speed control is a must: hoists and cranes, machine tools, presses, etc. With the advent of stronger magnets, permanent magnet DC motors have become popular, which dispense with brushes.

Gearmotors are available as AC and DC units, generally in small size where close coupling of the motor and gearbox is practical. Gearmotors are available with a variety of gearheads such as parallel shaft, right angle, planetary geared, etc.

Stepper motors are for positioning. They rely on permanent magnets on their rotors which can be controlled in discrete intervals by energizing the stator field. A stepper motor needs a controller/drive to function. Steppers typically index 1.8 or fewer degrees of rotation for every step, but these can be further subdivided by the use of so called micro-stepping controllers. Stepper motors provide a relatively inexpensive way of mimicking servo positioning, though they generally lack positional feedback. Stepper motors can usually hold a load while stopped, a benefit for positioning applications.

Servomotors are true feedback positioners that incorporate encoders to report positional information back to their controllers. They control both speed and precision through the use of the feedback loops.

Linear motors are best considered as rotary motors that have been “unrolled” to create rotors that travel along linear paths. They are usually servo controlled and used for positioning and precise speed control that can’t be achieved through cheaper means such as air cylinders, etc.

Air motors are simply powered by air rather than electricity and typically found in air tools such as pneumatic wrenches, etc. Air motors are used where constant torque is required, such as on take-up reels on web handling machines. They are also used in explosive environments due to their being considered intrinsically safe.

Hydraulic motors are powered by hydraulic fluid and are typically found on the rotating elements of construction equipment, as wheel motors, for instance. They are powerful for their size, easily reversed, and speed controllable. They require sources of hydraulic power, which on engine driven construction equipment, usually comes by way of a hydraulic pumps/systems. Stationary plants are less likely to have hydraulic power available as utilities, as they would compressed air, but for these, so-called hydraulic power packs are available.

**Considerations**

AC and DC motors are available in standard NEMA frame sizes making the motors interchangeable in these sizes. These are sometimes called Integral HP units or, simply, medium machines. Motors also come as fractional HP units, dubbed FHP or, simply, small, and as non-standard designs beyond the
integral NEMA frames, sometimes called large machines. The IEC offers similar standardized metric sized motor frames and divisions.

Protection options are usually stated in one of two forms, a NEMA code and an IEC code. Most motors are of the totally enclosed, fan cooled ilk, abbreviated TEFC, but varieties abound from open, drip-proof (ODP) to totally enclosed, non-ventilated (TENV). The IEC code achieves similar classification through a two digit numeric code, the first of which specifies the enclosure protection from solid objects and the second digit the level of moisture ingress protection. For example, an IP67 motor is considered to be watertight and dust resistant.

These same codes can apply to other motor types as well, especially the gear, stepper, and servo motors.

Mounting options include base or foot mounting and face mounting. In the former options, motors are supported on their own bases—often sharing frames with the driven equipment, while in the latter option motors are attached to the housings of the driven equipment, an arrangement sometimes used with pumps.

Speed and power ratings are the main specifications for defining motors of the rotational variety. Number of phases is important too, normally one or three.

**Important Attributes**

**Motor Type**
For AC units, major choice is between induction and synchronous machines. Brake motors are induction machines that have integral brakes which can hold a loaded motor in position. For DC machines, the principal choices are between brushless units and those that employ brushes. Gearmotors offer many of these same choices.

**Industry Focus/Intended Application**
Many motors are designated as general duty while some incorporate special features or duty ratings fitting them to specific applications. NEMA defines a host of special purpose motors, including those for fans and blowers, woodworking machines, etc. Manufacturers will often classify their special purpose motors along these lines, i.e., farm duty, HVAC, washdown duty, etc. Motor specifiers can rely on these two attributes to narrow the choices when looking outside the range of general purpose motors.

**Shaft Rotation**
Generally, motors are reversible. Many can be made to run in the opposite direction by switching leads where they attach to the motor. Some motors, notably small synchronous motors used for damper controls, etc., are single direction but can often be specified as CW or CCW rotation. Motor rotation is usually determined as viewed from the drive end (DE), that is the end of the motor on the load, or coupled, side.
Motor Voltage
Medium voltage motors generally operate on 2300 or 4000 volts. Smaller general purpose three phase motors can run on 208-230 or 460 volt supplies. Single phase motors generally run on 115 or 230 volt supplies.

Nema Class Design Rating
NEMA maintains a number of ratings for motor design which specifies insulation and the temperature rise it must withstand.

Shaft Design
Motor shafts and can be ordered with keyways or flats for securing couplings, etc. They can also be shorter than standard shafts. Shafts can also be threaded to accommodate threaded fasteners.

Related Product Categories
- **Motor Starters** are electro-mechanical devices that provide starting and stopping of electric motors by means of manual or automatic switches, and provide overload protection to the motor circuits.
- **Electrical Contactors** are electronic or electro-mechanical devices used for switching electrical loads.
- **Protection Relays** are electromechanical switches used to protect various devices from voltage, current, or thermal overloads.
- **Shaft Couplings** are mechanical devices used to connect rotating shafts and absorb misalignments between them.
- **Motor Controllers and Drives** are electrical or electronic devices that regulate motor speed, torque, and position outputs.

Resources

General
AC Motors
DC Motors
Gearmotors
Stepper Motors
Servomotors
Linear Motors
Air Motors
Hydraulic Motors
http://www.eaton.com/Eaton/ProductsServices/Hydraulics/Motors/
Trade Associations
http://www.smma.org/
http://www.nema.org/pages/default.aspx
http://www.easa.com/
Glossary
http://www.reliance.com/prodserv/motgen/b9652new/b9652.htm

Manufacturers and Suppliers
http://products.autonicsonline.com/category/stepping-motors
http://baldor.thomasnet.com/
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