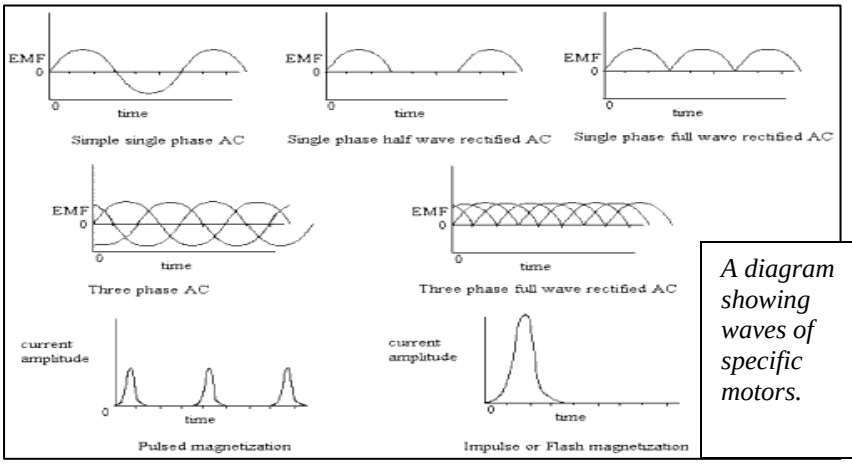
Powering the World: The AC Motor

Imagine if one day everything stops working. Airplanes lie still and lifeless. Cars become hulking masses left immobile in the streets. Buildings plunge into darkness and power lines exist only as abstract statues. No, this is not the premise of a science fiction novel, but rather a description of the world if it were missing a key component of electrical and mechanical engineering. This is what would happen if the world were without the Alternating Current (AC) motor. The AC motor is one of the most important machines in industry today and is often referred to as the machine that sparked the Second Industrial Revolution. The AC motor is used in many common devices such as washing machines, fans, and more importantly in power plants where it transfers power through power lines and into houses where it is harnessed to be used by household electronics. The AC motor has a truly essential part harnessing electricity, whose inner workings are both easy to understand and hard to perfect.

Alternating Current

The easiest way to understand how motors work is to start simply. The battery attached to a wire and sent through a light bulb represents a simple Direct Current (DC). The Direct Current is such because it only moves in one direction: from one pole of the battery to the other. Alternating current is similar to Direct Current, but instead of going in one direction, it *alternate*s between the two poles. More specifically, in an AC motor a magnetic field is set up in the center of a coil, or coils of wire. The object producing the magnetic field (a magnet or electromagnet) is rotated on an axis, a motion which produces an alternating current because the polarity (positive or negative charge) inside the wires change along with the polarity of the magnet to which they are closest. When the magnet is rotated faster, the alternating current becomes stronger because the current in the wires alternates at a greater frequency. This process coupled with using transformers to accelerate or decelerate the current makes Alternating Current capable of traveling large distances at extremely high voltages, then returning to low voltages to be used in household machines.

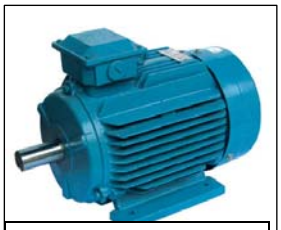


A diagram showing waves of specific motors.

A Brief Overview of Motors

The three most common AC motors are the permanent magnet synchronous motor, the induction (squirrel cage) motor, and the single phase motor.

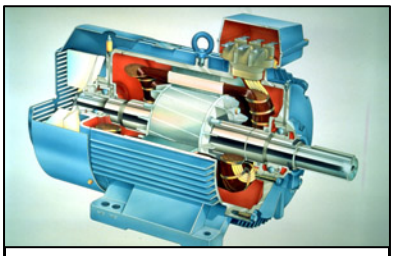
Permanent Magnet Synchronous Motor



A simple Permanent Magnet Synchronous Motor.

The Permanent Magnet Synchronous motor is a more compact motor than the induction or synchronous, and is able to run with less resistance. It also differs in that it has a rotor that is completely circular shaped, the two poles existing on the two opposite halves of the circle. Another important aspect of the permanent magnet synchronous motor is the fact that it has smooth rotation, eliminating the torque ripple which plagues other motors.

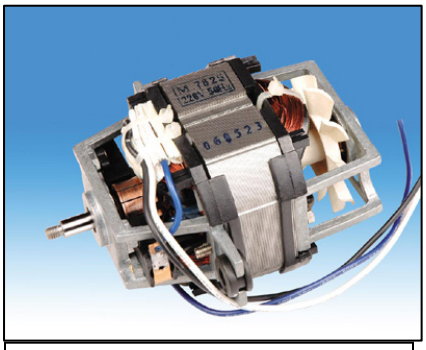
Squirrel Cage Motor



A Squirrel Cage Motor Cut-out.

The induction motor, or more specifically the squirrel cage motor, has a 'cage' shaped rotor from which its name is derived. This 'cage' has bars made of aluminum, which act as conductors for the motor. The squirrel cage is more versatile speed-wise, and can run almost as well on low speed as on high. It is also the most popular motor used in industrial machines today.

Single Phase Motor



A simple Single-Phase Motor.

The Single Phase motor exists as the predecessor to the Three Phase motor. With limited capacity for transmitting electricity it is not very efficient. It can be built with relative ease when compared to other motors and does not break as easily as Direct Current (DC) motors, but is known for its low control and low EMI. The single phase motor is used in many devices including fans, air conditioners, and some industrial machines.

AC/DC

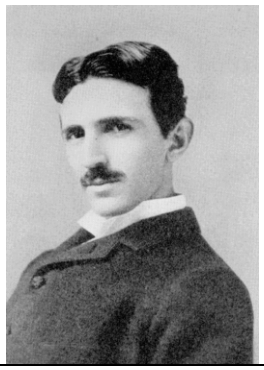
The universal motor is one of the simplest motors to date. While it is commonly classified under the AC motor category, it in fact is a bridge between Alternating Current and Direct Current because it uses aspects from both. While this motor was found to be too small to be practical during the early industrial age, it has found its niche within the smaller electronics of today's world. The Universal Motor is usually very small and relatively inefficient but is inexpensive to make in mass setting it as a necessity electronic appliances. It also has low reliability making it break easily, but can be reinforced to have longer use. Direct Current motors have both strengths and weaknesses compared to AC motors. AC motors, while being more reliable and cost efficient, do have their disadvantages. The most crippling of the AC motor's flaws is its inability to run at low speeds, making it unfit for more delicate operations, such as computer hard drives and early floppy discs. Also, the control of the AC motor is also expensive if precision is needed such as in the aforementioned devices. DC motors are in some ways the opposite of AC motors.

The DC motor has its own advantages. DC motors are commonly known to be easy to understand and easy to control. They also have the ability to run on slow speeds at high efficiency. The DC motor is not without its deficits. Despite its advantages the DC motor is considerably more expensive to produce and maintain mostly due to the 'brush', a coiled wire in the center of the motor which acts as an electromagnet and must be replaced periodically. The DC motor is also much larger than the AC motor and can be damaged when dust collects on parts of the brush and interior. Even though DC motors are less widespread than AC motors, they still are in use today. Now they are used in devices that require a steady low speed, and in some household appliances. DC motors work simply; they create an electromagnet which propels the motor. Because electricity today is sent away from power plants via AC motors, motor controllers are required to change AC power to DC power and vice versa. In fact, the popular band AC/DC got its name from the inscription on the back of some household appliances which indicates AC energy being changed to DC energy.

The logo of the late 1900's band, ACDC, which is also the symbol designating that energy produced from an Alternating Current is being converted to Direct Current.

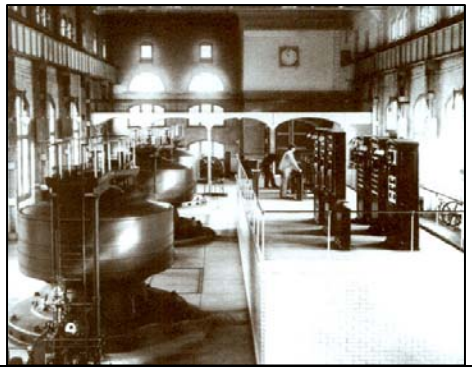
Refining the AC motor

Alternating Current is, to say the least, a marvel of nature. Alternating Current is essentially a current that alternates, as the name suggests. This current, called a Sine Current, fluctuates at an extremely fast speed and can transmit electricity through wires. It is then manipulated to be stronger or weaker through the use of transformers. AC was first used as in an application by William Stanley, Jr. who discovered how Alternating Current could be sent through coils of wire to create an early version of the transformer. AC power truly began its ascent into its use today in the late 1800's, when American inventor Nikola Tesla began harnessing this force. As Tesla and Alternating Current rose up to become the power transmission source for the world, another famous inventor started to preach Direct Current. This other inventor was none other than Thomas Edison. Their time period was aptly named the "War of Currents." Initially, Direct Current was the only means for electricity to be transmitted, mainly because no successful way to transmit AC had been created at that time. Then Tesla finally perfected his AC generator, the first devised way to transmit AC power. With this refined method of transmitting electricity, AC power became the generalized power supply.



A portrait of Nikola Tesla.

As the years rolled on into the modern age the demand for power grew and, as a result, the AC motor was optimized to have a greater electrical output. The speed of the motor is reliant on a few variables of the motor: the number of phases (magnetic poles), and the frequency of the power supply. The number of phases is determined by the type of motor; one-phase motors have one phase, and three-phase motors have three phases. The frequency of the power supply is increased by supplying the motor with a greater power source. For this reason the improvement in speed in AC motors is directly proportional to the improvement in energy creation. As the speed at which AC motors spun increased the motors had to be made out of more powerful material. Today most AC motors are made of a variety of metals from stainless steel to plastic, depending on the use of the motor.



The inside of the first AC Power Plant, the Adam's power station. Built November 16, 1896 at Niagara Falls.

Conclusion

The Alternating Current motor exists as a marvel of engineering. This motor forms the backbone of the energy transfer system used worldwide, without which the world would be set back to a virtual dark age. Even though some obscure parts of Alternating Currents remain a mystery, the overall design and functioning of AC motors is simple and easy to understand. And though it took hundreds of years to define a method of producing energy through these devices, the result is well worth the time and energy spent in its discovery. AC motors, apart from providing transfer of electricity throughout the planet, are essential parts of numerous household appliances. From small handheld electronics to large machines, AC motors help to power and run innumerable amounts of machinery without which the world would be an undoubtedly darker, and unpowered.

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