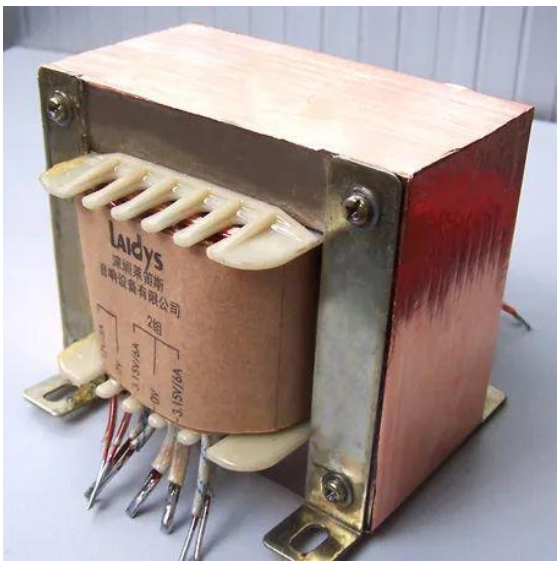
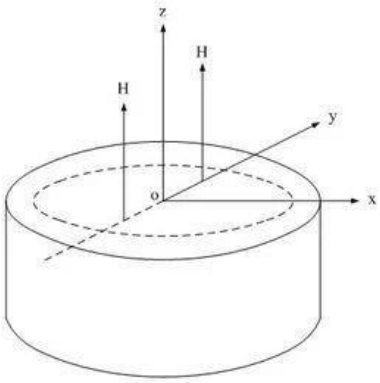
# Analysis of Silicon Steel Sheets for Transformers

Silicon steel sheet, commonly known as silicon steel or silicon steel strip, is a type of electrical steel with silicon content ranging from 0.8% to 4.8%. It is produced through a hot and cold rolling processes. With a thickness generally below 1mm, it is referred to as a thin sheet. Electrical silicon steel sheets exhibit excellent electromagnetic properties and are indispensable magnetic materials in the fields of electric power, telecommunications, and instrumentation.



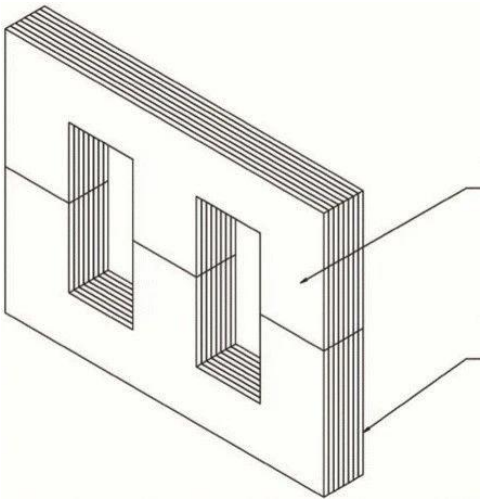

As we know, the actual transformer is always working in AC state, the power loss is not only from the coil resistance, but also generated in the core under the magnetisation of alternating current. Usually the power loss in the iron core is called "iron loss", iron loss caused by two reasons, one is "hysteresis loss", one is "eddy current loss".

Hysteresis loss is the core in the magnetisation process, due to the existence of hysteresis phenomenon and iron loss, the extent of this loss relative to the core hysteresis loop surrounded by the size of the area is proportional. Because the hysteresis line of silicon steel is narrow, it is used as the core of the transformer, the hysteresis loss is small, which can greatly reduce the heat produced through induction. Since silicon steel has the above advantages, why not use the whole silicon steel block to make the iron core? Why is it processed into sheets? This is because a sheet core can reduce another type of iron loss - "eddy current loss".




When the transformer is operating, there is an alternating current in the coil, which produces a magnetic field that is of course alternating. This varying magnetic field produces an inductive current in the iron

core. The inductive current generated in the iron core, perpendicular to the direction of the magnetic field in the plane of the circulation, so called eddy current.
Eddy current losses also cause the core to heat up. In order to reduce the eddy current loss, the core of the transformer is stacked with silicon steel sheets insulated from each other, so that the eddy current passes through a smaller cross-section in a narrow and long circuit to increase the resistance during the eddy current process; at the same time, the silicon in the silicon steel makes the material's electrical resistivity increase, which also plays a role in reducing the eddy current.



Usually, used as a transformer core, generally choose 0.35mm thick cold rolled silicon steel sheet, according to the required size, it will be cut into long pieces, and then stacked into the“core type or shell type shape. Following that reasoning, to reduce eddy currents, it is necessary to reduce the thickness of the silicon steel sheet, the thinner the splicing of the narrower the strip, the better. This not only reduces the eddy current loss, reduces the temperature rise, but also saves the material of silicon steel sheet.

In practice, however, when making silicon steel sheet cores, it is not necessary to start from the above advantages alone, because if the core is made only in the way described above, it will greatly increase the man-hours and reduce the effective cross-section of the core. Therefore, it is necessary to choose the optimum size after balancing the advantages and disadvantages of each case.

A transformer is manufactured based on the principle of electromagnetic induction. It consists of a closed iron core column with two coils wound on top: a primary coil and a secondary coil. When an AC voltage is applied to the primary coil, alternating current is generated in the primary coil, establishing a magnetic field potential. Under the influence of this magnetic field potential, the entire iron core produces alternating magnetic flux.

The reason why transformers can step up or step down voltage needs to be explained through Faraday's Law. The magnetic flux generated by induced currents always opposes the change in the original magnetic flux. When the original magnetic flux increases, the induced current generates a magnetic flux in the opposite direction to the original flux. In other words, the induced magnetic flux in the secondary winding opposes the main magnetic flux generated by the primary winding. As a result, the secondary winding produces a lower-level alternating voltage. Therefore, the iron core serves as the magnetic circuit part of the transformer.

(1) **Classification of silicon steel sheet**

**A. Silicon steel sheet can be divided into two kinds of low silicon and high silicon according to its silicon content. Low silicon containing silicon at 2.8% or less, it has a certain mechanical strength, mainly used in the manufacture of motors, commonly known as motor silicon steel sheet; high silicon silicon content of 2.8-4.8%, it has a good magnetic qualities, but is more brittle, mainly used in the manufacture of transformer cores, commonly known as transformer silicon steel sheet. There is no strict boundary between the two in actual use, commonly high silicon steel is used manufacturing large motors.**

**B： According to the production process steel can be divided further into two kinds, hot-rolled and cold-rolled, and cold-rolled can be divided into grain non-orientation and grain orientation of two kinds. Cold rolled sheet thickness uniformity, good surface quality, and high magnetic qualities, mean that with the development of the industry, hot rolled sheet has mostly been replaced by cold rolled sheet.**

（1） Hot Rolled Silicon Steel Sheet for Electrical components (GB5212-85) Hot Rolled Silicon Steel Sheet for Electricity production is made of soft magnetic ferrosilicon alloy with low carbon loss, and hot rolled into a sheet with a thickness of less than 1mm. Hot rolled silicon steel sheet can be divided into low silicon (Si ≤ 2.8%) and high silicon (Si ≤ 4.8%).

（2）) Cold rolled silicon steel sheet (GB2521-88) is made of silicon steel containing 0.8%-4.8% silicon, and is cold rolled. Cold rolled silicon steel sheet is divided into grain non-orientation and grain orientation. Cold rolled electrical steel strip has a flat surface, uniform thickness, high stacking coefficient, Good pressability , and than the hot-rolled electrical steel strip, high magnetic susceptibility, low iron loss. With cold strip used instead of hot-rolled strip in manufacturing of motors or transformers, weight and volume can be reduced by 0-25%.

If a cold-rolled oriented strip is used, the performance is superior. Substituting it for hot-rolled strips or low-grade cold-rolled strips can reduce transformer energy consumption by 45-50%, and the operational reliability of the transformer is enhanced. It is used in the manufacturing of motors and transformers. Typically, non-oriented cold-rolled strips are used in motors or welded transformers, while grain-oriented cold-rolled strips are employed as the core in power transformers, pulse transformers, and magnetic amplifiers. The steel plate specifications are as follows: thickness of 0.35, 0.50, 0.65mm, width of 800-1000mm, and length of ≤2.0m.