ELECTROMAGNETIC STIRRING IN CONTINUOUS CASTING PROCESS

Electromagnetic stirring, as a well established high efficiency technique, is possible to achieve effective and reliable stirring of the molten steel in the continuous casting process, which can meet the metallurgical objective of improving the quality and productivity of cast products. It has been widely accepted in the conventional practice to use the electromagnetic stirring in mold (M-EMS) in order to control the initial solidification so as to reduce various defects and increase the Equi-axed Grain Zone in the continuous casting of high carbon steel billets and slabs.

EMS Technology to improve the rate of slab equiaxed, fine solidification structure, reduce the inclusion content and to promote uniform structure, improve the internal slab, surface and sub-surface quality plays an important role.

Principle

The working principle of electromagnetic stirring works is very simple, as the two-phase or three-phase current-driven, alternating magnetic field can produce a linear induction motor. Current phase transition, the magnetic field from one pole to the other extreme, while the electromagnetic force generated the liquid steel to the direction of the magnetic field to promote the sport. This phase change can be selected by the current direction, current density and frequency can be adjusted thrust size.

When an electric current j(x,t) flows through a conducting body, whether solid or fluid, in the presence of a magnetic field B,(x,t), there is a force per unit volume (the Lorentz force)

\[ F = j \times B \]

that acts upon the conductor. In general, this force is rotational.

Due to the Lorentz force there is a generation of a torque that gives the liquid steel a rotational movement. The generated torque depends on the following factors (Intensity of supply current, Number of windings forming a coil, Frequency, System geometry). These parameters change depending on the stirrer type. Thus the magnetic field acts as a non intrusive stirring device and it can, in principle, be
engineered to provide any desired pattern of stirring. The stirrer design, size and position etc. depend on the continuous casting machine data, the steel grades to be produced and the casting parameters.

**Main component of electromagnetic stirring:**

- Equipments which are used in Electromagnetic stirring in continuous casting process are Cooling water system, Stirrer, Monitor/controller, Frequency Converter, Power pack including transformer, high and low voltage power distributor.

**Types of Electromagnetic Stirring Process**

1. Mold Electro-Magnetic Stirrer (M-EMS)
2. Strand Electro-Magnetic Stirrer (S-EMS)
3. Final Electro-Magnetic Stirrer (F-EMS)

**(Mold Electro-Magnetic Stirrer)M-EMS**

Electro-Magnetic Stirrer (M-EMS) is mainly applied to improve the surface quality, especially to avoid surface cracks and to ensure the skin cleanness of the slab. It is usually installed in the lower part of the mould for stirring of the liquid steel in the mould. It improves the solidification structure, reduces the surface roughness and increases the heat delivery rate.

**(Strand Electro-Magnetic Stirrer)S-EMS**

A Strand Electro-Magnetic Stirrer (S-EMS) is applied to enhance the internal quality of the slab. Nowadays three types of S-EMS are used in the slab continuous casting of steels, i.e. between-roll type (NSC), in-roll type (Rotelec), and box type (ABB). The merits of the S-EMS are to reduce the center segregation and/or porosity, to increase the equiaxed zone, and to decrease the susceptibility to internal cracking. As a result, the center quality of plate and the ridging defects of cold rolled sheet can be prevented.
Final Electro-Magnetic Stirrer (F-EMS)

F-EMS is particularly efficient when casting high carbon or high alloy steel grades. Also with the use of F-EMS, it is found that the solidification structure of the cast product is improved and there is increase in the ratio of the equiaxed structure and the inner porosity. The shrinkage is reduced, and the ratio of central carbon segregation is decreased. Further the secondary dendrite arm spacing (SDAS) is improved, and the ratio of central equiaxed grain is considerably increased, which results in finer grains. Therefore, the quality of the cast product is enhanced with the F-EMS.

Application of Electromagnetic stirring in continuous casting

- Surface & subsurface cracks
- Breakout reduction
- Solidification structure & internal cracks
- V segregation
- Pinhole and blowhole
- Centerline segregation