CC-EMS for flat products

FC Mold: Improved Coil Surface and Internal Quality for Conventional Slab Casting

ABB has supplied EMBR systems to more than 50 slab strands, worldwide.

The EMBR type FC Mold (Flow Control Mold) was developed jointly between JFE of Japan (formerly Kawasaki Steel) and ABB. The FC Mold is designed for conventional slab casting using normal to high casting speeds.

The FC Mold generates two independent static magnetic fields, one field at meniscus level to control the meniscus metal flow speed and turbulence while the second field at the bottom of the mold will control the penetration depth of the steel jets (see figures above). In effect, the higher the metal flow speed the greater will be the braking force and more turbulence will be subject to a greater damping effect. The results, as detailed in the center fold, are:

- Greatly improved end product quality; see example for rejections of deep drawing grades in the figure to the right.
- Higher casting speed can normally be used.
- Almost total elimination of mold powder entrapments resulting from correct meniscus metal flow speed.
- Reduced meniscus waving with a more even molten mold powder layer, resulting in reduced crack formations.
- Hotter steel at the meniscus.
- In summary, FC Mold will increase productivity and product quality while lowering operating costs.

The FC Mold can be combined with the EM Control to maintain a preset metal flow speed at meniscus when changing Ar amounts, casting speed etc.
FC Mold for improved coil surface and internal quality

Optimum casting conditions
The meniscus metal flow speed shall be kept within a certain interval, see figure to the right. Should the metal flow speed be lower, non-metallic inclusions will not be swept away but will get stuck in the solidification shell and, further, the hook depth will increase, contributing to an increase of subsurface inclusions. Should on the other hand the metal flow speed be higher, the risk for mold powder entrapments increases. Further, the penetration depth of the jets from the casting tube shall be as shallow as possible to enable inclusions to float up and get dissolved in the casting powder.

FC Mold controls the meniscus metal flow speed
The strength of the upper magnetic field of an FC Mold controls the meniscus metal flow speed, see figure to the right. Further, an EM Control system can be used to ensure that the meniscus flow speed is kept within the zone of operation for varying casting parameters, see separate leaflet.

FC Mold reduces the penetration depth
The lower magnetic field of the FC Mold is normally kept strong to minimize the down flow at the mold narrow sides and by that also minimizing the penetration depth of non-metallic inclusions, see figure to the right. This will facilitate for these inclusions to float up and get dissolved in the mold powder.

FC Mold decreases the reject ratio for inclusion sensitive grades
Manufacturing of 2-piece cans is very sensitive for smaller inclusions, as the minimum can thickness only is around 80 µm. Therefore, inclusions with 40 µm diameter can be detrimental for the process. An FC Mold will reduced the reject index for 2-piece can manufacturing as shown in the picture on the front page. Another example is ERW-pipes (Electrical Resistance Welding), where an FC Mold will decrease the reject ratio for ERW-pipes as is shown in the picture to the right.
**FC Mold for improved coil surface and internal quality**

**FC Mold allows normally a higher casting speed**

The use of a FC Mold results in the fewer mold powder entrapments and non-metallic inclusions and fewer blow holes and surface cracks.

The effect of a FC Mold on coil surface quality is shown in the first figure to the left. It is evident that the casting speed can be increased substantially without the normal drawback with deteriorated surface quality.

The effect of a FC Mold on coil internal quality is shown in the second picture to the left. As the penetration depth of the steel jets from the SEN still will increase with increasing casting speed, the effect here is not as clear as for the surface quality. However, there is a substantial reduction of defects compared to conventional casting without FC Mold. Consequently, a higher casting speed can normally be used for those grades where quality demands limit higher casting speed.

**FC Mold improves alumina clusters, mold powder entrapments and blow holes**

The braking of the steel jets results in that alumina clusters and blow holes floating up and to a much greater extent being separated at the meniscus. Simultaneously, the metal flow speed at meniscus is controlled, virtually eliminating mold powder entrapments. As seen in the figure to the right, all these defects are greatly reduced.

**FC Mold increases the meniscus temperature**

The braking of the steel jets results in:
- The turbulence in the steel is reduced and hence the heat transport to the solidification fronts is reduced, increasing the temperature of the melt.
- The penetration down of the hot steel from the SEN is decreased and then the hot steel is kept higher up in the strand increasing the meniscus temperature.
**FC Mold electrical connection**

The FC Mold generates two static magnetic fields in the mold. Each field is generated by two part coils with iron cores, one at each of the mold wide sides, see figure to the right. The upper part coils are electrically series connected and fed by a DC electrical current from a thyristor converter. The lower field is independently controlled and fed from a second converter.

A yoke closes the magnetic path form the upper to the lower fields, see red arrows in the figure to the right.

**External solution, normally used for new casters.**

The movable part coils with cores and yokes are mounted on a non-oscillating manipulator. In a front (casting) position, these iron cores fit in through “windows” in the mold water jacket. These “windows” are slightly bigger than the cores to allow for the mold oscillation.

At mold and segment exchange, the iron cores are retracted, see the figure to the right, and the mold and segments can then be lifted out of the caster. When the new mold has been mounted in the caster, the iron cores are pushed forward into the “windows” in the water jackets. In this way, the part coils remain connected in the caster during mold exchange. Another advantage of the window method of installation is to minimize the weight on the oscillation table since the cores and yokes do not oscillate.

In an alternative solution the part coils with cores and yokes are fastened on and oscillate with the mold. At mold exchange these items are loosened from the mold and retracted, see the figure to the right.

**Internal solution, normally used for existing casters.**

The part coils and the magnetic cores and yokes are mounted on the mold and go in and out of the caster with the mold during mold exchange. This method of installing the EMBR will add to the oscillation weight.