Automatic Control of Molten Metal Flow for Improving Casting Performance
Among all available technologies for improving casting quality, automatic level control is one technology that will improve several quality factors when casting slabs (rolling ingots).

Examples:
- Reduce shell zone,
- Prevent butt curls and cracks
- Repetitiveness through automation
- Optimization through traceability
- Operator safety
Presentation content

- Metal level and flow control equipment
- Quality factors
- Safety
- Plant examples
Metal level and flow control equipment

- Level sensors
- Flow control actuators
- MLC-system
- Furnace control
- Automatic dams
Availability
Automatic mould level control is available from most suppliers today when installing a new casting line or casting machine.

Investment
For some companies, especially smaller producers, this may lead to heavy investments in replacing all (or parts) of their equipment in their casting line.
Cast house implementation

Implementation alternatives

What everyone might not be aware of, is that some of the benefits from new casting machines can be achieved with less investment and without replacing any of the existing equipment.

By retrofitting your casting machine with products for molten metal level control some of the benefits from new equipment are achieved with increased casting quality as a result.
Quality factors

- Low metal head
- Fill rate control
- Variable levels during cast (parameter scheduling)
- Mould metal distribution
- Metal transfer and flow control
- Traceability and repeatability
Quality factors – Low metal head

Low metal head (right side) avoids the reheating effect caused by the air gap between mould and ingot side (high metal head on left side).
Quality factors – Low metal head

Plant example:

Upgrading from Spout and float to automatic controlled spout and pin with MLC-system.

Shell zone reduced from roughly 12-15 mm down to 2-5 mm.

Except for the use of a new pin and spout the casting machine remained the same. The improved casting quality was achieved using the same launder system and the same moulds etc. The control equipment (sensors and actuators) was retrofitted on the existing casting machine keeping the investment to a minimum.
Quality factors – Low metal head

Plant example:
Analysis of the ingots showed a significant reduction (~10mm) of the shell zone.

<table>
<thead>
<tr>
<th>Original setup before upgrading:</th>
<th>New setup after MLC-control:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spout and Float (manual).</td>
<td>Spout and pin (automatic level control).</td>
</tr>
<tr>
<td>Metal head: 70-75 mm (+-2.5 mm)</td>
<td>Metal head: 55 mm (+-0.3 mm)</td>
</tr>
<tr>
<td>Scalping needed: 15 mm</td>
<td>Scalping needed: 5 mm</td>
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</table>
Quality factors – Fill rate control

By controlling the actual fill rate of the mould, the initial filling of the moulds can be optimized to suite the alloy behavior and the cooling efficiency of the moulds.

This will help to reduce material tensions and stress that causes cracks and butt curls.

When the perfect fill rate for that specific casting condition is found, the MLC-system casting recipe makes it possible to store and repeat this through every cast.
Quality factors – Fill rate control

Plant example:

One example of reducing cracks by fill rate control is a slab casting plant in the UK. After upgrading from level control by steady eddy to an automatic level control system, the amounts of cracking slabs was reduced from 10% to 5% (casting their most difficult Alloy).

By elaborating and adjusting the mould fill rates differently depending on mould sizes (and types) and alloys, the plant managed to reduce the material tensions and stress created at the start of cast.
With a Metal level control system the metal head can be adjusted during the time of casting. The metal level in the moulds can be controlled by following a predefined level curve. This level curve is scheduled by time or cast length.
Quality factors – Variable levels

By doing this the metal head level can be optimized and changed automatically for different casting speeds and cooling characteristics. Once again, this will reduce shell zones and metal tensions.
Quality factors – Mould metal distribution

Getting rid of floaters and/or mechanical devices inside the melt will reduce turbulence and distribution disturbance. A typical pin and spout setup with combo bags will provide optimization of the metal distribution in the moulds.

Pin and spouts are well combined with digital camera laser sensors and pin position actuators to control the level without any turbulence or fluctuation.

With the measuring accuracy below 0.1 mm the level can be controlled inside 1 mm (+- 0.5 mm) or better without any contact with the molten metal.
Metal transfer to the casting machine is one further area where metal quality and conformity can be affected. Any cascading or turbulence of metal will create a rupture in the protective aluminium oxide surface layer. With automatic level control the metal flow can be controlled all the way from the furnace to the mould to ensure a laminar, non turbulent flow.
Quality factors – Traceability and repeatability

Automatic level control enables recording of the information regarding metal levels and metal flow for analysis and improvements. This will help to identify the optimal control settings that suit the specific casting process the best.
Safety

Safety has been an important issue in the metal industry for a long time. By making the casting process fully automatic, the operators do not have to be in the machine area during casting.

By monitoring the process from a designated and safe area, operator injuries can be avoided. Failsafe design and automatic shutdown in event of any abnormal situation also minimizes the risk of injuries as well as equipment damage.
Safety

Plant example:

A slab casting plant in Sweden has reduced the risk of operator injuries during casting to close to zero.

The operator(s) are monitoring and operating the complete casting process from inside an operator room. All tasks involving close contact to the molten metal during casting have been automated. After installation and commissioning they have had no reports of casting related accidents or injuries.
Safety

Brief casting sequence:

- Operator selects casting recipe
- Operator completes all “before cast preparations”
- Operator starts the cast by pressing the start button from inside operator room
Safety

Brief casting sequence:
- Metal flow from furnace starts automatically
- All moulds are filling up identically using fill rate control
- Drop of the casting table is done automatically according to recipe
- Mould level is controlled according to specified level curve during the complete cast
- Metal flow is stopped automatically in order to reach the given ingot length
- Casting table is stopped and the remaining metal is automatically drained to designated location
- Finally the casting system is “dry” from molten metal and operators can enter the casting area for “after casting procedures”
Safety

Failsafe design

In any abnormal situation or loss of electricity, the system will immediately:

- stop the metal flow into the moulds
- stop the feeding of metal into the launders
- automatically drain the remaining metal to a designated location.

The operators do not in any case physically interact to stop or start the metal flow.
Conclusion

The process of DC slab casting is an application that will gain a lot from automatic metal level control.

If the casting line is old or new doesn't matter. Upgrading a plant by retrofitting, or by replacing existing equipment, with products for automatic level control will for sure improve productivity by the factors described in the quality and safety sections.

Automatic level control on a DC slab casting machine gives higher recovery through reduced butt curls, reduced cracks, less scalping, less downtime due to accidents and the repeatability of quality.