MOULD METAL LEVEL AUTOMATIC CONTROL SYSTEM and OPERATIONAL RESULTS

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There are 2 continuous radial casting machine in SARTID a. d. Steel Plant. Until December 1998, mould metal regulation has been manual, in March and November 1999, there was automatic mould level control with software manufactured in former Cegelec-Acec company (Alston) and since December 1999, there is automatic mould level control with software for regulation and control and supervision “ACA-SUPER” manufactured by Aleksandar Duric.

In manual regulation mould level oscillation is about ±13 mm although a man is maximally lumped for that few minutes (Figure 1), but in reality when casting duration is few hours level oscillation are about ±50 mm!!!.

With Cegelec-Acec automatic level control oscillation are from ±3 mm to ±15 mm,
With “ACA-SUPER” automatic level control oscillations are from ±1.1 to ±3.5 mm, but in rarely, extremely bad conditions up to ±5 mm.

Because of big and uncontrolled level oscillations in manual level control there was a plenty of problems such as:
- inconsistent slab quality because of human factor,
- big percent of very bad slabs (about 1 to 5 %), which contain a slag inclusions on surface,
- rough slab surface with deep and injust lines on slab surface which is potential surface lakes,
- enormous score of break outs,

There was also a problems like:
- only a 4.5 heats per tundish,
- a small casting speed (up to 0.9 meter/minute)
- impossibility to overlook any disturbance in casting.

Essential parts of system for automatic control of mould metal level:

1.) NKK level meter with sensor head:
Producer: NKK, Nippon Kokan K.K, Nireco Corporation, Japan
Function: measuring mould metal level with Eddy-Curent principle, i.e.
one coil emit 50 kHz magnetic field and makes eddy-current on metal surface which induce a new alternate magnetic field which magnitude measured with second and third coil in sensor head define a distance of metal surface from the sensor head.
This system is fully immune to slag and powder over the metal!!

2.) Robot:
Producer: Premier Refractories (Belgium) S. A. rue de la Rivierette 100 B-7330 Saint-Ghislain
Function: To put and remove sensor head in a mould. Robot is powered with air or nitrogen.
3.) SERT motor (actuator):
Producer: SERT  Parc ‘Les Pivolles’-3 avenue de l’Europe, 69150 Decines(Lyon)France
Function: To move stopper rod i.e. to control metal flow through ceramic pipe. It is powered with 48 V DC.

4.) plant console
Function: It is a men-machine interface. It’s contains of couple numeric displays, push buttons, light and noise alarms, emergency-STOP button etc.

5.) Programmable Logic Controller and Supervision Control and Data Acquisition with “ACA-SUPER” software inside:
Hardware: MCI-a and ALSPA 8035 PLC’s plus one pentium PC (200MHz, 64 MB RAM, 1.9 GB hard disc, 1.44 MB floppy drive) plus RS232-RS485 convertor.

Software named “ACA-SUPER”
Producer: Aleksandar |uri| (A. Duric), B.Sc. Electrical Engineer,
Function: This is a brain of whole system. “ACA-SUPER” consist of subroutines for:
- compensation a lost motion of stopper rod mechanism which enable us to use a very bad and low cost stopper rod mechanism without decreasing a performance of level control,
- reduction of steel sticker occlusion,
- reduction of tundish nozzle abrasion,
- detection a dangerous incidents (such as break out) and appropriate automatic action,
- self detection of system malfunction,
- recording whole casting for a subsequent analysis,
- auto-marking all points where some disturbance happened such as: big level deviation, inroad the junk of Al₂O₃ or powder in metal, enormius casting speed derivation etc.
The part of ACA-SUPER software package is also an C++ program for easy and quick determining what slab is fully OK. This prediction is very important beyond for a hot strip mill. Depend of that information some slabs will be designed for fine sheets.
With automatic mould level system with ACA-SUPER software we gain a plenty of upgrades from manual level control and Cegelec-Acec automatic control:

1.) *We decrease a hapening of break outs for 80 % !!!* (before about 1 break out per 150 heats, but today 1 break out per 750 heats i. e. 4 break outs per 3000 heats). It shall notice all that 4 break outs happened in period 18.-20. february only because of using a fully wrong and bad powder!

2.) *Up to 25 times less slag inclusions on slab surface!!!* When level was manualy controled percentage of slag inclusions was 1 to5 % (2 % average) (this is a ratio between slabs with at least one inclusion and whole production in that period). Since “ACA-SUPER” was installed *that percentage is average 0.3 % (Figure 2)*. Notice that in january and february 25 % casting was manualy because of problem with equipement for automatic level control In december 99 and march 2000 when about 95 % castings was fully automatic we acquire a record: 0.14 % and 0.08 % (almost 20-25 times less regarding to manual level control) !!! Program which predict a possibility of arasing a slag inclusions have 100 % regularity until now !!!

3.) *Incrising a number of heats per tundish.* We steel research all capabilities, but at this moment we can say with no doubt that *is posible to increase a number of heats per tundish about 30-40 %*. Its attained with ACA-SUPER software subroutines which make: quick and strong fluctuation of metal flow through tundish nozzle which neutralize sticker occlusion, high precision software indicator of nozzle occlusion and software for moving a slag level by means which optimally dispose a nozzle abbrasion. *Its interesting to mentioned that Cegelec-Acec software decrease a number of heats per tundish about 20 % regard to manual control.*

3.) *Incrising casting speed 10 –15 % i. e. we increase10 to 15 % a casting capacity of our’s radial machines. Notice that we decrease number of break outs for 80 % although we increase a casting speed for 15 %!!*

4.) Improvement of working condition and decreasing a number of workers on the plant about 30 %

**EPILOGUE:**
Automatic mould level control with Cegelec-Acec software have unacceptante oscilations in metal level and some others shortages so it isn’t much better then manual level control in real working conditions, because it’s dependent of very modern stopper rod mechanism
In the other hand software ACA-SUPER performance all neccessaries in any condition.

To solve a complicate problems in automatic regulation Aleksandar Duric used a literature:
Figure 1-Comparison between automatic and manual mould metal level regulation

- quality of stopper rod mechanism
  very bad (big lost motion)

- mould dimensions 2050 mm x 200 mm
- casting speed 0.8 m/min
Figure 2-Percentage of slabs with slag inclusion on surface

<table>
<thead>
<tr>
<th>Month</th>
<th>Percentage</th>
<th>Comment</th>
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<tbody>
<tr>
<td>Aug-98</td>
<td>1.22%</td>
<td>manual level regulation</td>
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<tr>
<td>Sep-98</td>
<td>1.45%</td>
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</tr>
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<td>Oct-98</td>
<td>1.06%</td>
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</tr>
<tr>
<td>Nov-98</td>
<td>2.18%</td>
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</tr>
<tr>
<td>Dec-98</td>
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<td>Jan-99</td>
<td>1.38%</td>
<td>manual level regulation</td>
</tr>
<tr>
<td>Feb-99</td>
<td>2.15%</td>
<td>manual level regulation</td>
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<tr>
<td>Mar-99</td>
<td>1.50%</td>
<td>Cegelec-Acc automatic level control</td>
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<tr>
<td>Nov-99</td>
<td>1%</td>
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<tr>
<td>Dec-99</td>
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<tr>
<td>Jan-00</td>
<td>0.47%</td>
<td>75% &quot;ACA-SUPER&quot; automatic control and 25% manual control because problem with equipment</td>
</tr>
<tr>
<td>Feb-00</td>
<td>0.63%</td>
<td>75% &quot;ACA-SUPER&quot; automatic control and 25% manual control because problem with equipment</td>
</tr>
<tr>
<td>Mar-00</td>
<td>0.08%</td>
<td>&quot;ACA-SUPER&quot; automatic control</td>
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Programable Logic Controlers with “ACA – SUPER” software inside.

Supervisory Control and Data Acquisition with “ACA-SUPER” software inside.

Figure 3 –System dynamic chart