Steel Works Description

The steel plant is equipped with 5 Continuous casting machines. Turnover reached 5 Billion Euros in 2007 with EBITDA of 700 Million Euros. Production ranges from High Quality Steel Pipes X 70 X 80, used for Submarine high pressure Gas transport to Automotive users such as FIAT, BMW, and SEAT.
At a Glance

The need:

To create a system that identifies and maintains operational and maintenance procedures with the objective of reducing the occurrence of strand cracking that appears in various forms at a number of possible locations. Quality defects lead to costs and delay in the production stream.

Our approach:

All the operational procedures have been identified and reviewed. A new system to control effective operation has been implemented.

The result:

Significant increase in the ratio of “Quality free slabs”, and the level of slabs that had to be downgraded was reduced by more than 20 %.

Raw Numbers

- Production capacity: 11.5 Million Tonnes
- Direct employment: 13,000 people
- Contractor: 2,500/3,000 people
- Internal Railway: 200 KM
- Internal Road: 50 KM
- Raw Material: 20,000,000 Tonnes/year
Context

Initial Situation:

Crack-free slab production is an important key to success. To achieve this objective the Client’s requirement was for slabs with a higher surface and internal quality. This meant that more slabs of better quality needed to be ready for hot-direct charging in the rolling mill heating furnace. To reach the optimal level it is mandatory to develop strict casting procedures and maintain equipment in line with specifications.

One of the major concerns for caster operators and process engineers is surface cracking especially in these steel qualities of:

- Aluminium and Silicon killed steel
- Micro-alloyed steel grades
- Peritetic steel.

These particular grades are known to be ‘surface critical’. The quality of the steel is determined by the conditions existing during the steelmaking process, in particular the cooling and solidification area. If the steel has corner cracks, it is necessary to undertake surface grinding or scarfing to improve the steel’s quality which is costly and interrupts the production route.

During the continuous casting process main defects can be classified such as:

- Longitudinal cracks that have been detected for sensitive steel grades.
- Transverse surface cracks are another type of defect that are often seen in the continuous casting process.
- Other possible defects are smaller cracks which are usually located in the vicinity of the slabs’ oscillation marks.
Our Approach:

It is hard to be sure why surface cracking occurs. Even for a metallurgical Engineer who is highly experienced in this field, it is difficult to come forward with a straight resolution to this problem. Although we might know the main reasons for the corner cracking, because we cannot always be sure we have to conduct careful investigations before we can suggest a final solution.

Another method of trouble shooting the problem of corner cracking is to approach the subject in a highly disciplined way similar to a scientific analysis in a laboratory.

1. Technicians agree that transverse cracking is initiated and propagated along the continuous casting machine.
   The possibility of alleviating the problem by careful analysis of the steel chemistry is limited, but it should still be carefully investigated.

2. Transverse cracks may develop in the slabs during the unbending process. Metallurgical investigations and tests at elevated temperatures have shown that grain refined and micro-alloyed steels have significant reduction in hot ductility between approximately 900°C and 700°C. The extent and severity of the ductility drop are dependent on the steel chemistry. This needs to be carefully considered to avoid surface quality problems. It is necessary to straighten the slab outside this temperature range. That is, to avoiding straightening in the ductility trough associated with Peritetic and micro-alloyed steel grades.

3. The methods for controlling transverse cracking have included the following:
   • control of the oscillation mark such as oscillation practice and mould powder selection
   • minimization of bulging
   • control of reheat both within, and at the end of, secondary cooling.

   Tensile strains could develop in the surface of the strand because of poor machine alignment in the critical temperature range. This aspect will initiate cracking in the surface. Also, sub-surface metallurgical structure is susceptible to propagating cracks once initiated.

   That is the case for those grades we have previously called ‘surface critical’.
A detailed description of an application to trouble shoot corner cracks:

1 Problem

Each steel plant needs to establish criteria as regards what constitutes a surface crack. A system needs to be established for investigating whether surfaces have cracking. Here is a real example from a major steel plant in Europe.

Most steel grades were produced crack and defect-free but in a few specific grades a pseudo-transverse crack oriented across the width of the slab and corner cracks were a problem. Discussions among production and engineering personnel were held early in the project to discuss together the whole process. The discussion was mainly focused on Peritetic and Micro-alloyed steels.

2 Plant installation

The continuous caster was a curved type machine. There were two strands able to cast different formats of slab. Weights ranged up to:

- 2500 kg/m
- Width ranges from 1080 x 243 mm to 1360 x 243 mm.
- Tundish capacity of 40 tons with a protected stream casting
- Secondary cooling consisting of an air-water spray cooling system with different types of nozzle.

3 Steel Grade

The steel grade chosen by the client was a typical mid-carbon Peritetic steel. It was aluminum-killed and micro-alloyed with niobium and titanium.

4 Define the objective

The objective of the project was to develop a surface and sub-surface metallurgical structure more resistant to surface cracking in the direct charge process route.
5 Steps to solve the problem

To achieve the objective of a reduction in surface cracks, several steps were requested in the first part of the project:

- Evaluate the actual industrial situation in order to establish a detailed knowledge of the actual industrial practice
- Evaluation of the influence of the casting parameters on the surface quality
- It was established that a new thermal pattern needed to be applied in the strand in order to achieve the surface quality
- It was agreed that the actual industrial practice and steel analysis needed modifying
- The surface and internal quality achieved was discussed in detail

6 Chemical Analysis before Steel Hub Intervention

Data from the client about surface and internal quality obtained at the beginning of the project as follows:

<table>
<thead>
<tr>
<th>Width</th>
<th>N° SLABS</th>
<th>S.P.FAILURE</th>
<th>INSPECTED</th>
<th>OK</th>
<th>OK After Cut + Grinding</th>
<th>Downgraded</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCO - A</td>
<td>1100</td>
<td>426</td>
<td>29</td>
<td>297</td>
<td>53</td>
<td>47</td>
<td>397</td>
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<td></td>
<td>6.8%</td>
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<td>13.4%</td>
<td>11.8%</td>
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<tr>
<td></td>
<td>1280</td>
<td>46</td>
<td>4</td>
<td>32</td>
<td>7</td>
<td>5</td>
<td>44</td>
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<td></td>
<td></td>
<td>8.3%</td>
<td>72.7%</td>
<td>13.9%</td>
<td>11.4%</td>
<td></td>
</tr>
<tr>
<td>TOT</td>
<td>474</td>
<td>7.0%</td>
<td>74.6%</td>
<td>13.6%</td>
<td>11.8%</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>

7 Slab rejection after Steel Hub Intervention

All the slabs were inspected for the transverse/intergranular surface and longitudinal cracks. This approach has shown the benefit of the project and the table below shows the improved performance.

<table>
<thead>
<tr>
<th>Width</th>
<th>N° SLABS</th>
<th>S.P.FAILURE</th>
<th>INSPECTED</th>
<th>OK</th>
<th>OK After Cut + Grinding</th>
<th>Downgraded</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
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<td>178</td>
<td>249</td>
<td>175</td>
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<td>570</td>
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<td></td>
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<td>23.8%</td>
<td>43.7%</td>
<td>30.3%</td>
<td>26.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>TOT</td>
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<td>23.8%</td>
<td>43.7%</td>
<td>30.3%</td>
<td>26.0%</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>
Final Results

These are the results after Steel Hub’s intervention:

a) The ratio of "Quality free slabs" increased from 43.7 % to 73 % (weighted value).

b) The level of slabs that had to be downgraded was reduced from 26.0 % to 11.4 % (weighted value).

c) The level of slabs that had to be downgraded owing to Baumann’s failure was reduced from 23.8 % to 7% (weighted value).

Picture 1: Examples of corner cracks observed in the top surface of the cooled slab

Picture 2: 45° degree cut corners; leads to a loss of weight and consequent cost to remove the corners cracks.