1.32 Mty greenfield turn-key plant for High Quality Steel Grades at Interpipe

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Abstract
Interpipe Steel plant is the biggest facility for high quality round billets and blooms production in Eastern Europe, with 1.32 Mt/y nominal yearly production, supplied by Danieli as a turn-key greenfield plant.
Interpipe Steel product range includes high quality grades like wheel steels which are about 25% of total production and are cast in CCM 2 4-strands bloom caster. The other caster (CCM 1) is a 5-strands billet caster having Φ 150 mm as most produced section, which is reliably cast at 3.5 m/min for low C grades.
The plant is located inside the Dnepropetrovsk city (Ukraine), so several solutions like EAF dog house or paintings on the external walls have been adopted in order to limit the environmental impact.
Key words: RAILWAY WHEELS, SEAMLESS PIPES, ROUNDS, EAF, CONTINUOUS CASTING, HIGH SPEED

Introduction

Key reasons for Interpipe steel plant project have been the reinforcement of vertical integration of the group, increase in billet/bloom productivity and economic and environmental advantages of the route electric arc furnace + continuous casting versus previous open hearth furnace + ingot one.

Danieli has successfully started up Interpipe minimill in 2012, reaching high productivity coupled to high quality level, regardless the wide production mix, not only as grades but also as round diameters (9 sizes, from 150 to 470 mm rounds).

The achievement of these results is even more remarkable due to the challenging compact layout chosen (one EAF feeding 2 CC casting simultaneously, each of them having lower productivity than EAF), which proved to be a proper balance between investment cost and productivity.

This paper is focused on the description both of the mini mill equipment and on quality and productivity achieved results.

2. Plant Features

2.1 Layout

Interpipe Steel is a 3 bays plant with one EAF, one LF twin, one VD twin tank, two CCMs and 2 billet/blooms yards. Scrap yard has a single bay and (see ***figure 1)*** this layout allows a future expansion, with a longer scrap yard, an additional EAF and LF plus 6th strand on CC1.

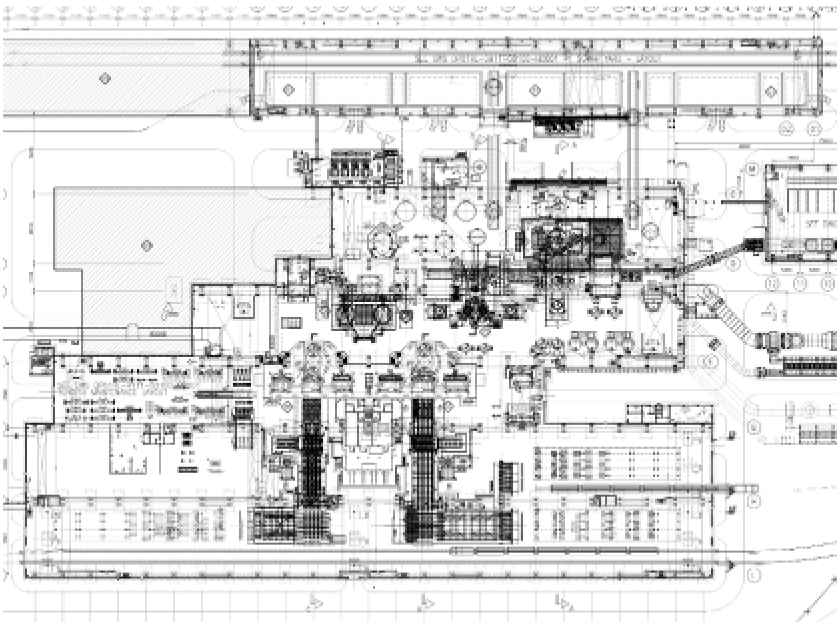


Figure 1. Interpipe meltshop layout

A very peculiar feature of this plant is the presence of 5 large scale permanent masterpieces by Olafur Eliasson, with the aim to form special attitude of employees to their work,to make the plant more friendly to local community and to highlight low environmental impact of meltshop, which is located not far from residential areas. Here below (**figure 2**) the 'Your heat murals', a group of giant thermal images on factory sidewalls.

Figure 2. Interpipe melt shop front view

2.2 EAF

Interpipe EAF is a 7.5 m EBT, with a 140 MVA transformer. It works keeping a hot heel of 26 t and is designed for a rated tapped size 160 t. The nominal tap-to-tap time is 50 min in order to achieve 192 t/h of productivity. It is remarkable that power on time (34.5 minutes) is significantly lower than contractual figure with 100% scrap (38 min).

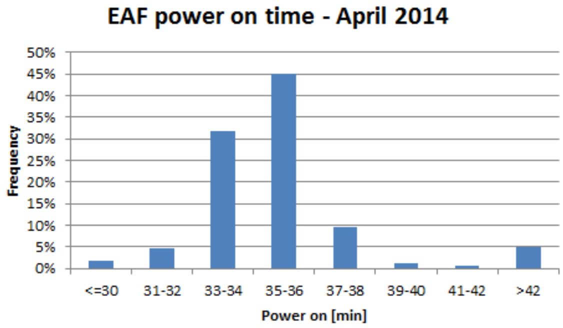


Figure 3. Interpipe EAF

2.3 LRF twin

In order to have a fast treatment and a buffer able to match the different EAF and CCMs productivity, it has been designed an LRF twin with 28 MVA transformer and electrode conductive arms, which allowed to reach 5.6 °C/min as heating rate, significantly higher than guaranteed 4.7 °C/min.

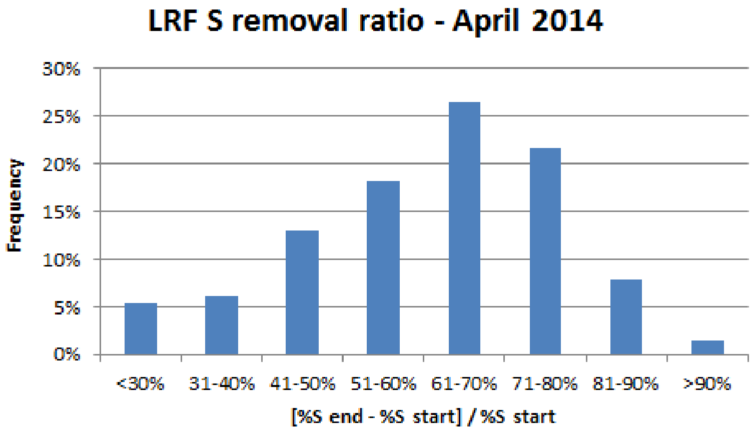


Figure 4. Interpipe LRF

Both LRF positions are equipped with 4-strands wire feeder machine, emergency lance for stirring, semi-automatic steel and temperature sampling, batch hopper.

One of the key drivers for internal quality is S content, therefore Interpipe developed a LRF practice aiming to an LRF final S content below 80 ppm, reaching 63% average LRF S removal ratio, including Si-K grades.

2.4 VD twin

A vacuum degassing station with twin tanks and single cover have been installed close to LRF, both in order to be able to fulfill the strict requirements of some of grades mainly cast in CCM2 and - in case of both CCMs casting together – in order to have an additional buffer for EAF and LRF.

The VD station is equipped with a new 400 kg/h 4-stage steam ejector pump, whose design has been performed based on consolidated Danieli experience in this field.

Since one of the main risk for wheel steel rejection are hydrogen flakes, it was defined a practice aiming to very low hydrogen, reaching 0.80 ppm as average figure after 22 minutes average degassing time, almost half of guaranteed figure (1.5 ppm).

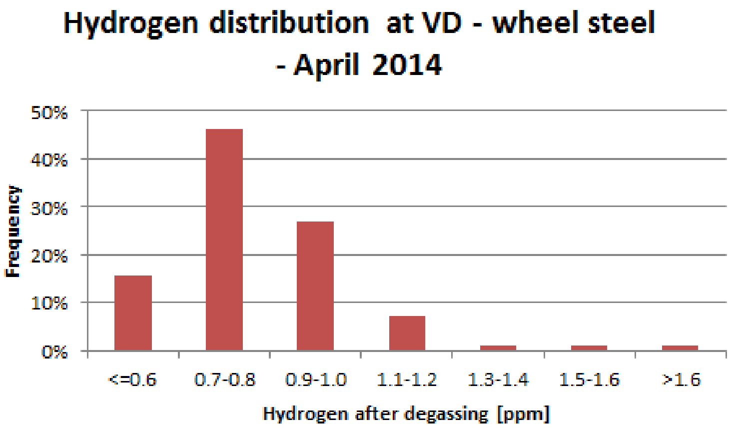


Figure 5. Interpipe VD station and hydrogen distribution after vacuum for wheel steel

2.5 Billet continuous caster (CCM 1)

Interpipe billet continuous caster (CCM 1) has a 5 strands configuration, rigid dummy bar, two unbending points and 12 m radius, in order to share same platform level with CCM2.

Tundish is not symmetric due to the option for additional 6th strand and reaches 35 tons capacity. The flow of liquid steel through the tundish to the mold is controlled by stopper rod system. A hydraulic oscillating table guarantees a tight control of the mold movement as well as the chance to adopt particular oscillation laws aiming at optimizing the billet lubrication and surface quality.

The mold is curved, 780 mm long type with parabolic taper and steel level is measured by a conventional radioactive system. This project was the first one where Danieli adopted a new taper with parabolic shape to overcome the typical issues of small round casting (longitudinal cracks), even reaching very high casting speeds.

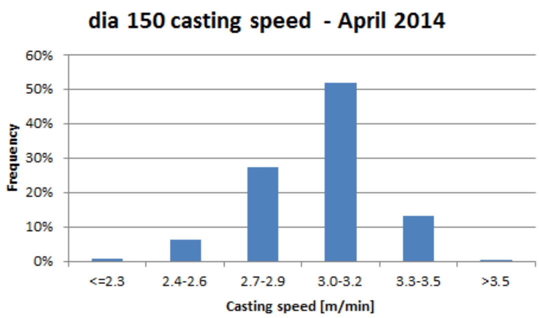
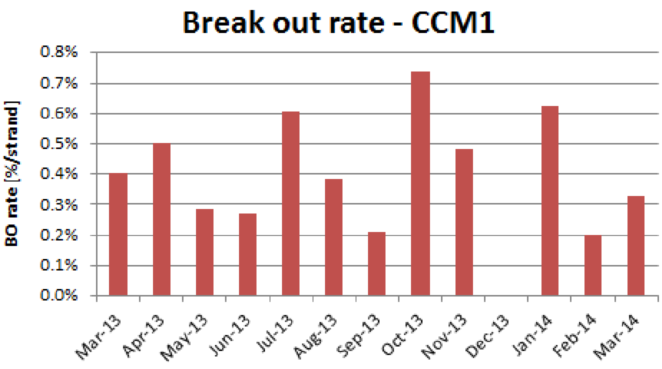


Figure 6. Interpipe CC1 and casting speed distribution for dia 150

Maximum average steady speed achieved in CCM1 for dia 150 has been 3.7 m/min for 10Y, 15GY and 20Y grades, which is significantly higher than 3.4 m/min guaranteed speed. Even casting at very high speeds, CCM 1 proved to be reliable, reaching a low BO rate, which manly (55%) depends by problems during first heat in sequence. The air-mist secondary cooling as well as 5-pinchrolls withdrawal and straightening modules forces have been optimised in order to have low porosity (average 0.8 as per OCT 14-1-235-91).



Interpipe Break-out rate

Interpipe CC1 air mist sprays

Figure 7a

Main products obtained from CCM 1 billets (*Φ* 150-290 mm) are seamless tubing and line pipes according to API 5CT, API 5L. Fot this product interpipe melt shop product mix has 60-114 mm diameters range and 4.8-6.9 mm thickness range, with final quality checked with tight limits at US test.

Figure 7b. Interpipe CC1 dia 150mm sampled at 3.35 m/mi and Seamless pipes from CCM 1

2.6 Bloom continuous caster (CCM 2)

CCM2 has a four strands configuration, flexible dummy bar, three unbending points and 12 m radius. The strand distance is 1.8 m.

Tundish capacity is 30 tons and its design has been optimized through a CFD study (**fig. 8b**), which showed – for the configuration chosen - that maximum inclusions size going into from tundish to mould is 120 μm and that the maximum speed at tundish meniscus level is well inside the 0.20 m/s limit, thus preventing slag entrapment.

Fig. 8a. CCM2 side view

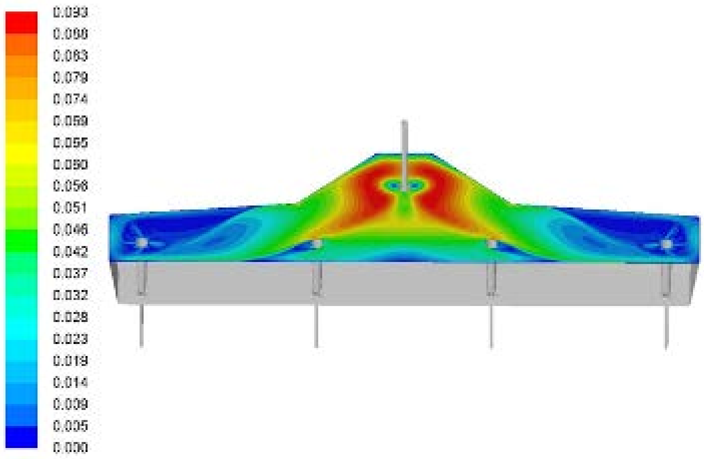


Fig. 8b. Tundish meniscus speed

The flow of liquid steel through the tundish to the mold is controlled by stopper rod, as for CCM 1. An SES avoids the reoxidation of liquid steel, allowing the chance of performing fly-tundish practice, with is commonly performed for wheel steels with a 41 heats as longest sequence achieved.

A hydraulic oscillating table guarantees a tight control of the mold movement and the mold is curved, 780 mm long type. Steel level in mold is measured by a conventional radioactive system and automatic powder addition is performed in order to avoid powder entrapment (see **figure 8c**), which may lead to defects.

The internal quality of as-cast rounds has been improved through the proper set up of two stirrers (M-EMS and F-EMS), which are very important in case of wheel steels, due to the tough request of subsurface and center quality. In this plant, it was decided to apply an innovative approach for the FEMS regulation, aiming to reach the highest stirring intensity without white band: FEMS current/frequency and mode (continuous or alternate) is changed based on the lifetime speed (see **figure 8d**).

Figure 8c. Mould powder automatic addition

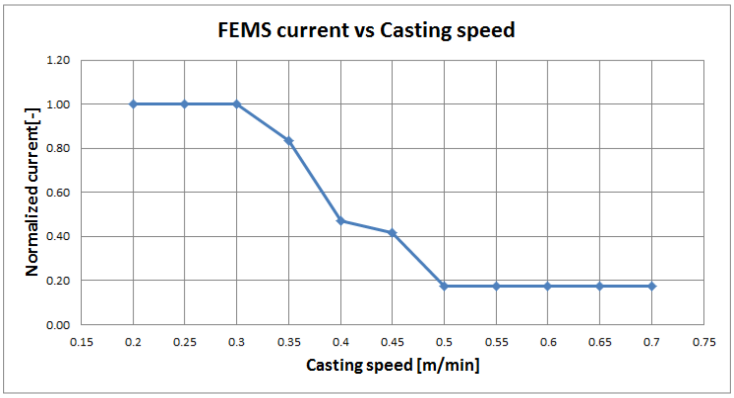


Figure 8d. FEMS dynamic set up

The very low centre porosity coupled with absence of white band was confirmed not only by as-cast macros, but also by the achievement of the same wheel microstructure from CCM and ingot (see **figure 9**).

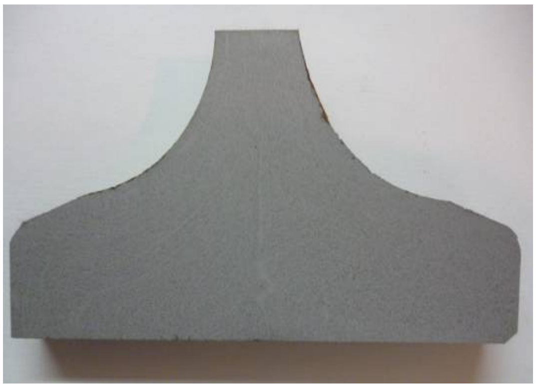


Figure 9a. Wheel section produced by EAF+CCM2

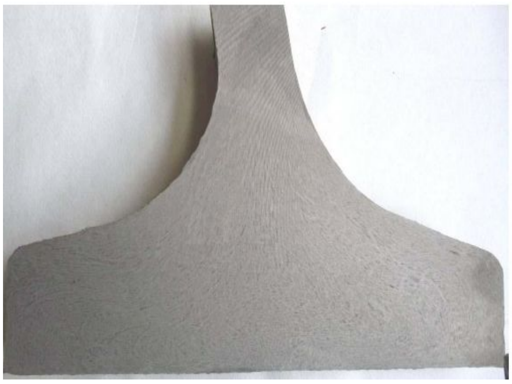


Figure 9b. Wheel section produced by OHF+ingot

Blooms are moved from cooling bed by crane to bloom cooling area. In order to improve quality of some grade crack sensitive, some additional slow cooling areas have been installed.

It was performed a thorough-process analysis from LRF to Interpipe rolling mill in order to improve the understanding of the key parameter allowing CCM2 to cast wheel steel 0.60%C □450 at 0.37 m/min, while keeping porosity not higher than 2.0 for 90% of samples and average wheel rejection rate below 5% with 2 mm US test limit. This result is in full agreement with guaranteed speed and internal quality for wheel steel.

3. Productivity trend and production mix

On January 17th and on February 7th, 2012 first cast respectively at bloom (CCM 2) and billet (CCm 1) caster have been successfully performed. After a steady increase in production levels from plant start, 115.000 ton/month have been achieved during 6 months (march-august 2013).

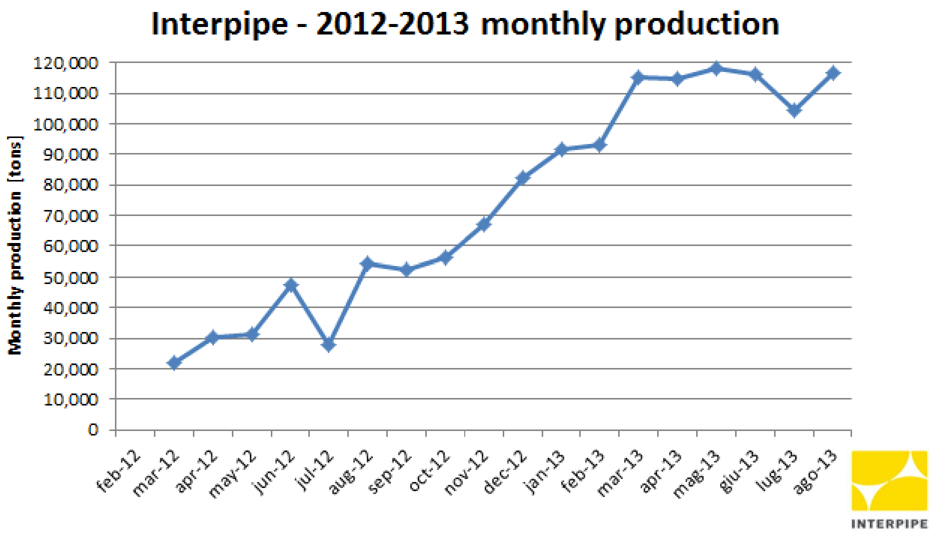


Figure 10. Interpipe monthly production

Running at 70-90.000 tons/month allows Interpipe to cast 15-19 heats/day, i.e. to run at approx. 100-130 ton/h, which is feasible running only one caster, going for fly tundish for CCM2 or starting the other caster just before beginning of restranding, without having any buffer or EAF stop.

Running at 115.000 tons/month requires Interpipe to cast 25 heats/day, corresponding to approx. 170 ton/h. This figure can be reached only with the two casters simultaneously casting for most of the time.

Melt shop production mix is quite wide and is currently mainly focused for CC1 on low C grades for pipes and for CC2 on railway wheel steel grades (see ***figure 12***) with 3% production dedicated to export. Aim for next future is to bring this figure up to 15%, starting to produce for Europe, North and South America markets.

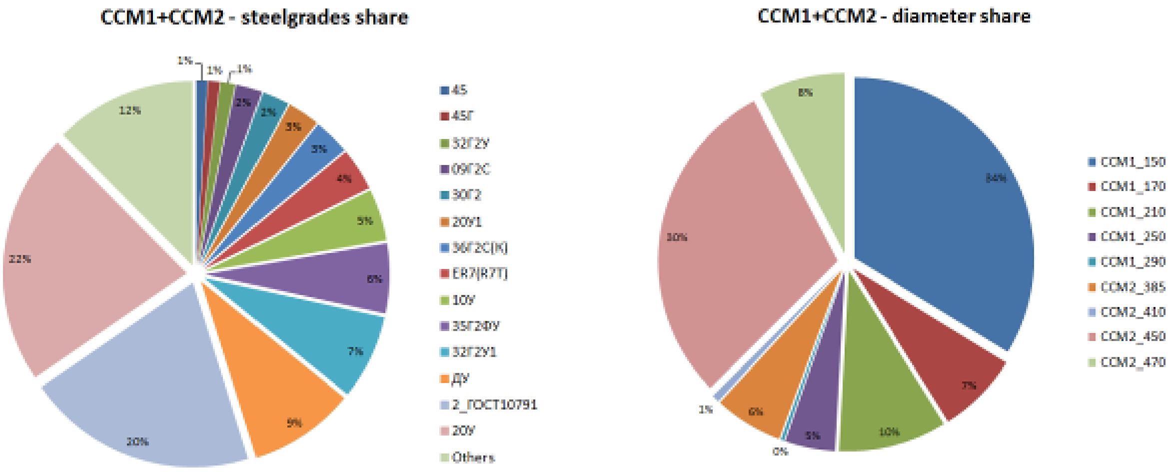
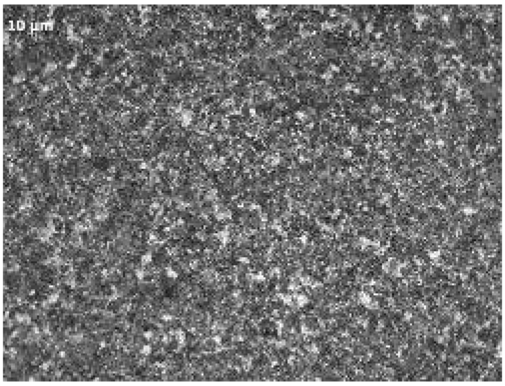


Figure 12. 2014 Interpipe production mix

New steel grades have been recently tested in order to enlarge production mix. Some of the most challenging are 28Х3СНМВФ (0.3%C, 1%Si, 3% Cr, 1% Ni, 1%Mo, 0.07%V), P23HBB (0.25%C, 0.9%Cr, 0.2% Mo, 0.02%Nb, 0.02%Ti, 0.09%Al) and 18Г2У1 (0.2%C, 0.02%S, 0.035% Al). In parallel, a continuous improvement is on-going, ISO 9001-2009 certification has been reached and some of the top Oil & Gas companies have approved the steel manufacturing plant of Interpipe Steel for production of steel billets for use in rolling of casing and tubing.

Currently one the most important products for Interpipe melt shop are railway wheels blooms, which are rolled not only within Interpipe group (mainly 2_ГОСТ10791 grade, with outside diameter ranging from 650 to 1269 mm) but also in external mills (like ER7, 0.50%C alloyed with Cr).

Φ 957mm wheel - steelgrade 2



Rolled wheel steelgrade 2 - homogeneous ferritic-pearlitic structure

Figure 13

Regardless new tougher limits for internal defect through US test (2 mm vs. previous 3 mm) of railway wheels have been requested by Ukrainian standards since January 2013, it was achieved a 2% improvement in rejected wheels compared to 2012 OHF + ingot casting route. This result, coupled with higher metallic yield of CCM compared to ingot casting, allowed a significant cost saving with higher quality for this product.

Next challenge is to move to 1 mm as US test limit, increasing as much as possible metallic yield.

4. Conclusions

Interpipe Steel minimill has reached after one year of operation the project quality and productivity goals, starting from a greenfield plant built on a turn-key base by Danieli

The achievement of these results is even more remarkable due to the challenging compact layout chosen and due to the quality level required by final end users, which include Oil & Gas companies as well as railways wheels producers.

The plant is located inside the Dnepropetrovsk city, so several solutions (i.e. EAF dog house, paintings on the external walls, etc.) have been adopted in order to limit the environmental impact.

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