New coating technologies to fight wear and corrosion on key steelmaking components

Many steelworks components suffer wear and corrosion due to working in hot, corrosive and dust-laden environments. Refurbishment with weld overlay rebuild and coating materials are traditional well-established processes using a range of established alloys and welding procedures. To meet the ever-increasing demands to improve performance and cut costs, Castolin Eutectic, a global leader in developing and manufacturing innovative new alloys for welding, thermal spray and laser applications, is continually improving its products. Some of these will be described.

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The typical steel plant represents an aggressive environment in terms of wear and high temperature corrosion of components in contact with the steel or used in the processing of the steel. The many forms, sizes, designs, makes, etc. of steelmaking equipment, together with the diversity of steel components and operating regimes, gives rise to a broad and complex range of wear/corrosion problems. Some major problem areas typically found are:

- Continuous casting units: rollers and slab, billet and bloom moulds
- Steel component handling: guides and rollers
- Sinter plant: hot sieves: transport/processing of raw materials
- Arc furnaces: hoods and ducting

Traditionally, many of these components have been refurbished with weld overlay rebuild and coating materials using traditional, well-established processes. The industry has developed a range of established alloys and welding procedures to address these wear areas and the choice is made not just regarding cost or performance, but also maintenance planning and onsite protection requirements that best fit the plant operator.

Today, with the constant pressure on production and steel tonnage costs, all plant managers are under pressure to improve the economics of their plant and are looking at a) reducing maintenance costs and outages, b) generating more steel with the same plant (increased performance and longer availability) and c) maintaining optimal operation conditions to sustain high quality and avoid scrap or reworking.

To these ends, refurbishment coating quality and performance, coating cost, reduction in downtime to apply coats on site, new parts vs onsite repair of worn parts, etc. are now becoming critical issues in the economics of many steel plants.

New alloys and protective coating systems are available and can be used to extend the life of existing solutions, at reduced total cost, to meet planned major overhaul scheduling.

CURRENT AND NEW SOLUTIONS TO WEAR

There are various philosophies for reducing wear to acceptable levels in key steelmaking components. These include design, operating temperature and work flow modifications, or component material changes (which can be expensive and usually mean sacrificing other properties). As wear/corrosion is only a surface attack phenomena of an otherwise mechanically functioning component, many steel producers have preferred some form of protective surface treatment/coating approach. Traditional methods available include weld overlay, use of ceramic tiles, thermally sprayed coatings and chromising.

The typical characteristics of thermal spray coatings are that they are thin (0.3-1.0mm), are fast to apply, can have unique chemistries and can be applied like sprayed paint to complex shaped parts, including worn rollers. Recent development has focused activities to produce new coating technologies and new coating materials combined to give new surface coating solutions.

The spray processes that have been used in the steel industry are: flame combustion (with powder or wire), electric arc wire, air plasma, high velocity oxygen fuel (HVOF), spray and fuse and painted coatings of inorganic ceramic-based compounds (slurry coatings).

Today, all these thermal spray solutions are still being ▷

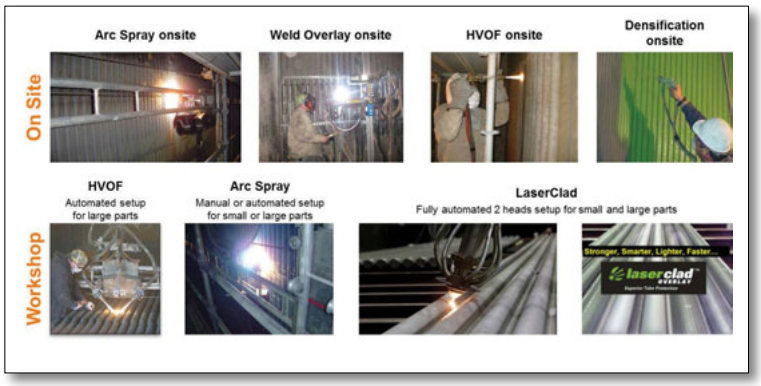

Fig 1 **Overview of coating technologies in the workshop and in situ**

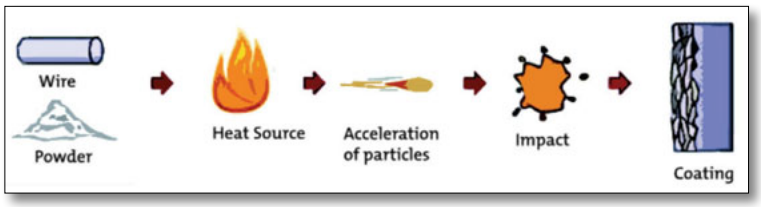

Fig 2 **Schematic of the thermal spray process to produce coatings**

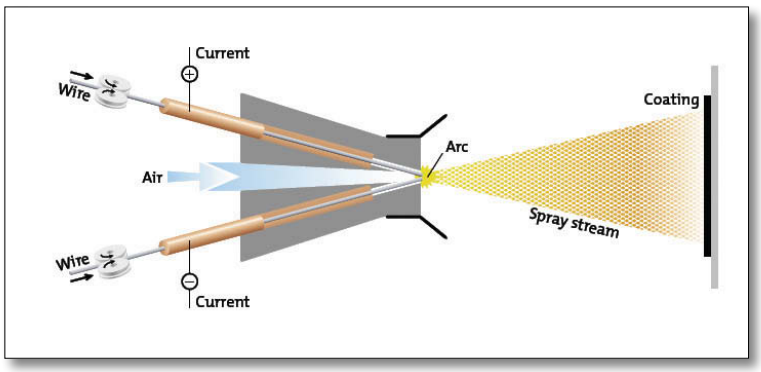

Fig 3 **Schematic of arc wire spray process for coatings on large surface areas**

Fig 4 **Arc wire spraying equipment**

used as each process and its associated optimised alloy has found niche success in terms of performance, price and practicality.

Through numerous development programmes, Castolin Eutectic continuously improves its technologies. Examples include optimisation of processes, densification technology, new alloys, on-site automation and laser cladding. Today with our global workshops and on-site service teams Castolin Eutectic can offer economical solutions to solve its steel customers' problems. An overview of the technologies is shown in *Figure 1*.

THERMAL SPRAY COATINGS AND PROCESS TECHNOLOGIES

In thermal spraying, the protective materials, which comes in the form of wire, powder or ceramic rods, are melted in a gas flame, electric arc or a plasma jet. The melt is atomised into a gas or air stream and then sprayed towards the object to be coated (see *Figure 2*). Metals, ceramics, carbides and plastics are examples of coating materials that can be applied by thermal spraying.

Arc spray Arc wire spraying is a simple, cost-effect solution for large surfaces and can be done on site. The special feedstock is in the form of two wires, which are short-circuited to melt the wire tips. Compressed air is used to atomise the molten tips and propel the droplets towards the substrate. The spray rate can be up to 20kg/hr and the process is used both in workshops and on-site (see *Figures 3 & 4*).

The characteristics of the arc wire spray coating are that it has a rough surface but good adhesion (usually above 35MPa). Its porosity content is typically below 2% when spray parameters are optimised.

High Velocity Oxygen Fuel (HVOF) HVOF spraying is a relatively new process giving the densest (less than 1% porosity), hardest coatings with very high bond strength. During HVOF spraying, an ignited kerosene/oxygen mixture produces a hot gas stream into which powder is injected (reaching velocity up to 800m/s). This creates high-impact energy particles and the highest quality coating. It can also spray very hard tungsten carbide coatings having hardness of more than 1,300HV.

Densification Castolin Eutectic has developed a proprietary process that densifies the thermally sprayed coating (arc wire and HVOF), which effectively blocks all the paths in the coating that would allow the corrosive species to reach the steel substrate. A thermochemical reaction between the densification component and the applied coating alloy creates this exceptional barrier against corrosion. It is used mainly in combination with ▷

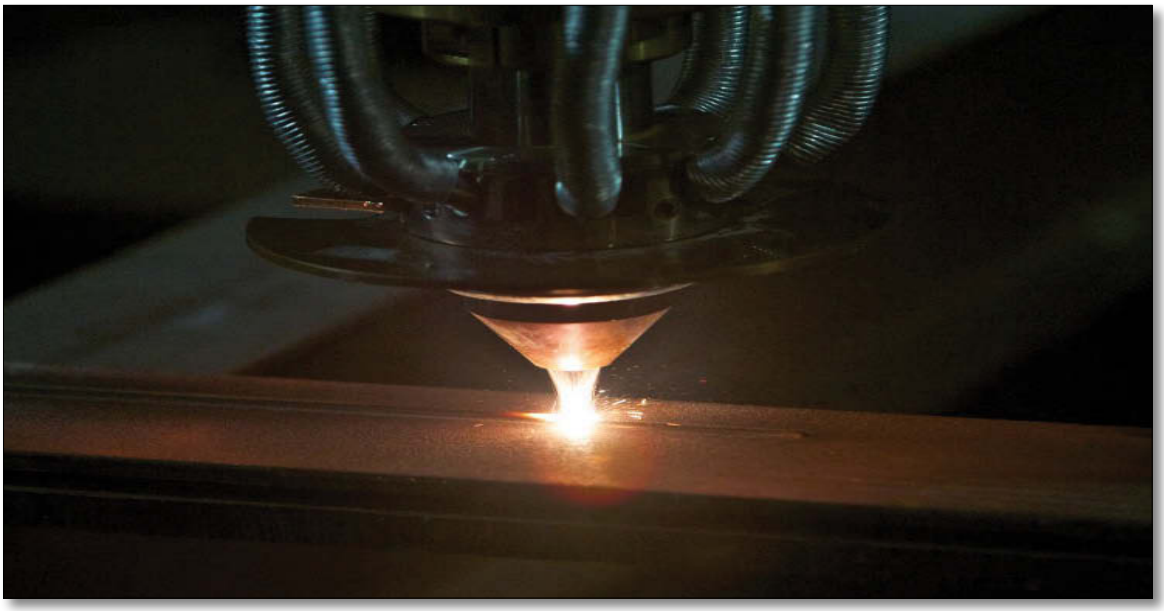

Fig 5 Laser cladding process on a single boiler tube at workshop

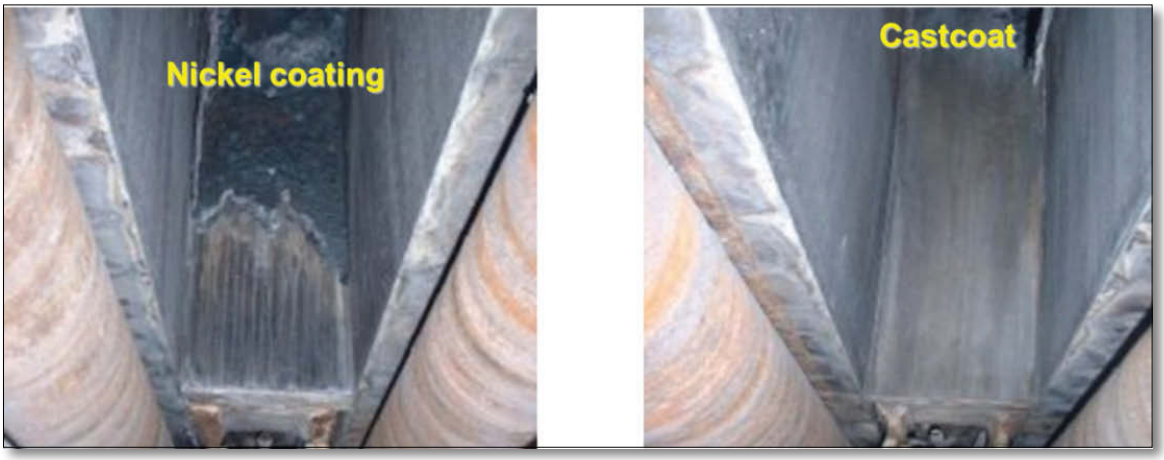

Fig 6 Comparison of Ni and CastCoat coatings on a single mould trial after casting 70,000 tonnes steel

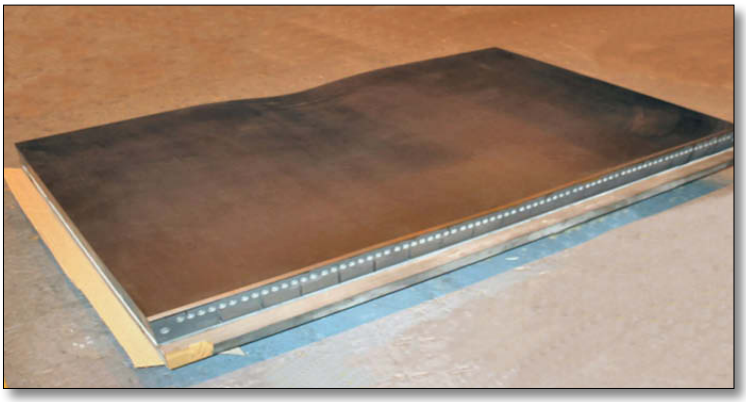

Fig 7 Funnel mould broad plate CSP thin slab mould coated with CastCoat

Fig 8 Examples of bloom and billet moulds protected with XuperCOAT where the smallest internal size is 160mm

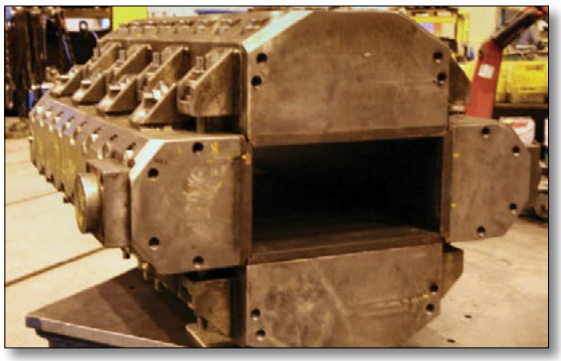

Fig 9 **Bloom mould coated with CastCoat**

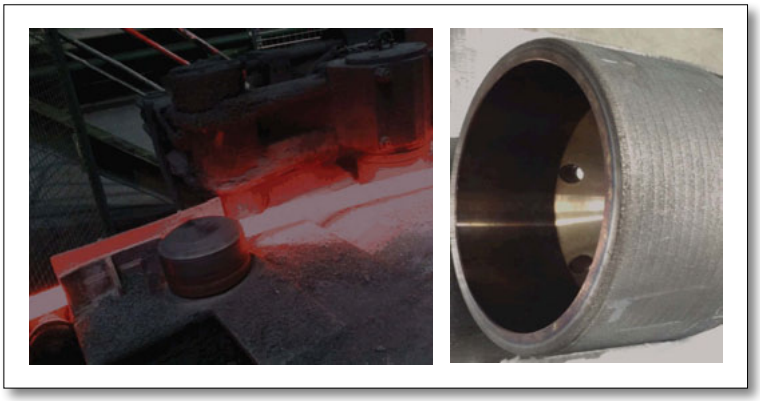

Fig 10 **Wire rod mill guide laser clad with NiCrBSi with WC particles**

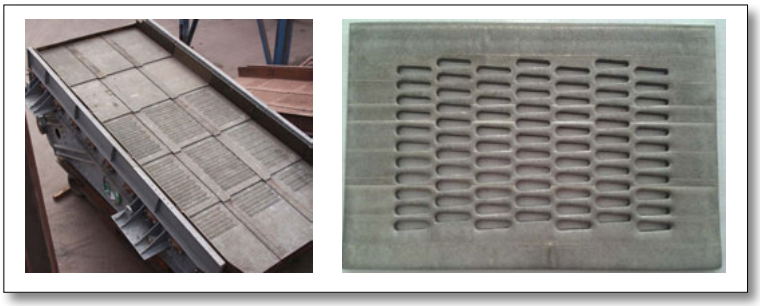

Fig 11 **Section of sinter plant strand and grate**

our optimised arc spray coatings (ChromeClad), but can also be used on HVOF coatings (XuperCOAT).

Laser cladding The advent of High Power Diode Laser (HPDL) technology has allowed the previously promising, but expensive, laser cladding technology to become a cost-effective corrosion solution for large boiler surface areas. This state-of-the-art process allows efficient cladding of steel components in our workshops and competes well against traditional weld overlay while giving better properties, such as a lower dilution, a smaller heat-affected zone and smooth coating surface and longer lifetimes and thinner coatings. An example is shown in *Figure 5*.

We use laser cladding machines, which are coupled with diode lasers up to 8kW and the high deposition speed and coating thickness flexibility finally allows these excellent coatings to be competitively priced for steel producers.

NEW ALLOYS AND COATING SYSTEMS

Castolin Eutectic is a global leader in developing and manufacturing innovative new alloys for welding, thermal spray and laser applications. Some of these new alloys will be shown in the examples below.

The processing parameters must be optimised for each process/alloy couple in order to get the best properties from all these coatings. This is achieved using our own specialist on-site equipment and consumables that are manufactured internally under tight specifications. Our automated systems help reduce the operational costs while keeping the coating quality at the highest level.

PRACTICAL RESULTS AND EXPERIENCE IN STEEL PLANTS

The Castolin Eutectic Group has been involved in the development of wear- and corrosion-resistant protective coatings for the steel industry since its creation in 1906. Most recently, the acquisition of Monitor Coatings Ltd in the UK has added several new coating solutions for the steel industry.

CONTINUOUS CASTING PLANTS In continuous casting plants, there is major wear in the copper moulds so the standard nickel coating protection solution has been superseded by advanced ceramic-based, thin thermally sprayed CastCoat coatings applied by HVOF, which give 3 to 5 times lifetime wear. Trials are also underway of a novel XuperCOAT coating for bloom moulds with inner dimensions (square and round) down to 160mm. *Figure 6* compares mould wear of nickel coated and CastCoat moulds based on the practical experience in many plants under conditions of up to 70,000 tonnes cast. *Figure 7* shows a thin slab caster CSP mould coated with CastCoat, *Figure 8* a selection of coated billet and bloom moulds, and *Figure 9* a bloom mould coated with CastCoat.

Some plant examples and life improvements achieved are shown in *Table 1*.

Steel component handling Laser cladding coatings of a NiCrBSi matrix alloy blended with very hard tungsten carbide (WC) particles have shown dramatic life improvements in components used in the transport of steel products in mills and factories, including pulleys, cooling bed rolls, profile rolls (diabolo or similar), roller table rolls, pushing rolls, driving rolls, guiding rolls, spooler rolls, loop lifter rolls.

The wear life of the wire rod guide shown in *Figure 10* increased from 3 to 9 weeks for instance.

Transport/ processing in the sinter plant In the hot sinter plant, the strand grates (see *Figure 11*) are subject to high temperature abrasion from the sinter, and the grate hole geometries can lose their dimensions quickly due to wear. Weld overlay and plasma cutting of holes is the standard procedure to repair these, but the use of laser cladding and novel profiling processes gives a dramatic performance improvement.

The sinter or 'star' crusher (see *Figure 12*), is also subject to high temperature abrasion, and a new solution based on traditional weld overlay, but using novel 'nanostructured' and WC-containing alloys have given dramatic wear life improvements.

ARC FURNACE HOODS AND DUCTING

In electric arc furnaces and BOF hoods, the cooled tubes that make up the structure are subject to high erosion and corrosion at elevated temperatures, due to the flow of the hot gases containing erosive particles. This leads to thinning of the tubes and bursting. Here, our patented wire BTW 66 (erosion-corrosion) and other wires have been both arc sprayed and densified in situ coatings and in our workshops (see *Figure 13*). Lifetime extension is a factor of three times.

CONCLUSIONS

- Novel thermal spray coatings systems have dramatically improved the wear life of continuous casting plant slab moulds and are being tested in small bloom moulds.
- Laser cladding of key guide plates and rollers gives significant lifetime increases in wire processing and beam handling.
- New alloys give increased performance of sinter crusher star and breaker bars.
- The lifetime of arc furnace hoods and ducting can be dramatically increased by spraying with thermal sprayed coatings, on site or in the workshop. MS

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Country	Machine type	Plate type	Max mould life improvement
South Korea	Thick slab	Narrow faces	X 2.5
Belgium	Thick slab	Full mould	X 2
Canada	Thin slab	Narrow faces	X 6
USA	Thin slab	Narrow faces	X 6
USA	Thin slab	Full mould	X 2
USA	Medium slab	Narrow faces	X 4.5
Belgium	Thick slab	Narrow faces	X 2

Table 1 **Examples of CastCoat coatings applied by HVOF**

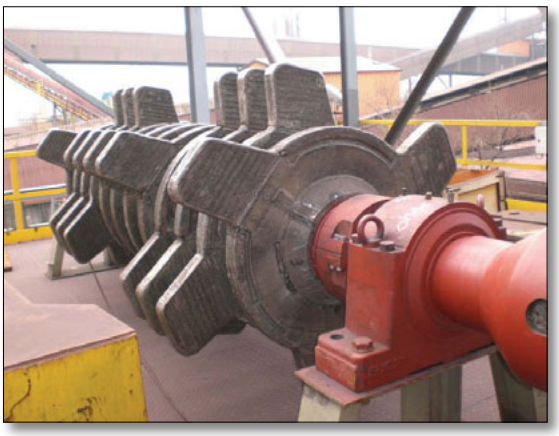

Fig 12 **Sinter or star crusher**

Fig 13 **Spraying of EAF gas ducting**