Materials Science Forum *Submitted: 2015-10-14*
ISSN: 1662-9752, Vol. 854, pp 255-259 *Revised: 2015-12-21*
doi:10.4028/www.scientific.net/MSF.854.255 *Accepted: 2015-12-22*

Online: 2016-05-17

Continuous Casting and Rolling Technology at MKM Mansfelder Kupfer und Messing GmbH – Optimisation of the Surface Quality for Conti-M® Strip

Klaus-Dieter Palm[1, a], Hendrik Busch[1, b *] and Axel Dusdorf[1, c]

[1]MKM Hettstedt GmbH, Lichtlöcherberg 40, D - 06333 Hettstedt, Germany

[a]Klaus-Dieter.Palm@mkm.eu, [b]Hendrik.Busch@mkm.eu, [c]Axel.Dusdorf@mkm.eu

Keywords: Copper, Continuous Casting, Surface Inspection, ISRA Parsytec

Abstract. Using Conti-M® which is a globally unique technology for producing cast-rolled copper strips, MKM has been able to link and optimise the continuous casting and rolling process together with the surface quality of milled strips. The last 15 years have seen many targeted projects for process, product and quality development. In this article, the process related challenges to optimise the surface quality of casting strip will be highlighted. We will present a process control system and the impact it had in the optimisation of the surface quality.

Introduction

For more than 100 years MKM Mansfelder Kupfer und Messing GmbH in Hettstedt has manufactured semi-finished copper and copper alloys. Privatisation in the mid-90's paved the way for the fast technical and technological modernisation of the production line. MKM focused on strengthening the capabilities of continuously operating casting plants, and in 2000 the Conti-M® technology for producing cast and rolled copper strip was commissioned. Typically copper strip is made from vertically cast slabs that are hot and then cold rolled or by rolling from a near finished dimension to the final size. Conti-M® is a new and innovative concept, which uses a continuous mold rather than a fixed or oscillating mold. Compared with established casting processes the continuous casting mold increases the casting speed by 2 m/ min, which means a ten-fold increase in production. After the assessment of the available casting concepts, MKM favoured the Hazelett twin-belt casting technology [1].

Until the successful commissioning of the fully automatic optical surface inspection system from ISRA Parsytec behind the horizontal mill beginning in 2009, the surface monitoring was limited by a purely visual inspection and therefore highly subjective. Since that time the fully automatic light optical system has allowed a fully comprehensive and complete surface inspection.

The Conti-M® Technology

The Conti-M® system (Fig. 1) forms the beginning of a modern technological process chain for manufacturing copper strip in a 360 m long hall. With a maximum casting width of 1290 mm and a melting capacity up to 70 t / h different copper qualities (ETP-Cu, DLP-Cu, DHP-Cu, HCP-Cu, OF-Cu and OFE-Cu) can be continuously produced via a continuous casting and rolling technology in one casting period. A characteristic feature is the technological link between the process steps melting, casting, hot rolling, cooling, surface milling and coiling. These milled copper coils produced by the Conti-M® technology are made not only with shorter lead times of about 2 hours, but also with higher energy efficiency compared to conventional technology.

Fig. 1: Conti-M® Plant (source: MKM)

The technological scheme at Conti-M® (Fig. 2) is designed to completely separate the slag coming from the molten metal provided from the ASARCO melting furnace in front of the casting system. Subsequently, the liquid metal feed is carried out in the twin-belt caster in which the copper solidifies in a mold which is turning in circles, existing of two water-cooled steel belts and laterally arranged damblock chains.

With a thickness of 45 mm and a maximum casting width of 1290 mm, the strip runs in a equalizing furnace arranged behind the casting machine, in which the strip temperature is kept constant (± 20 °C) before the next step of hot rolling. A reduction in thickness of 45 mm to a minimum of 12 mm is achieved in a quarto hot rolling mill. This is followed by a cooling chamber, leveling machine, surface milling machine and then shearing and coiling facilities. The resulting coils weigh approx. 25 t and are then used for further processing to reach the required final size [2]. This unique concept for producing copper strip integrates and improves industrial systems into one optimal process.

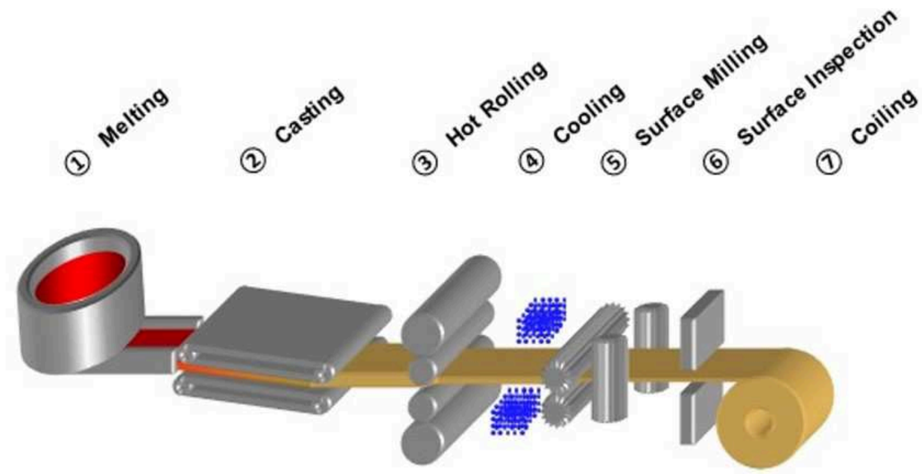

Fig. 2: Scheme of Conti-M® technology (source: MKM)

ISRA Parsytec – Computer Aided Surface Inspection

Parsytec is a computerized surface inspection system from ISRA Vision Parsytec (Fig. 3), which allows surface defect detection and defect classification – such as chips, scale residues and surface defects. It consists of one lighting and camera unit, which are aligned on the top and bottom of the strip surface. The lighting unit consists of several LED modules that operate within the infrared range. The camera units detect defects based on gray value differences from the images. The detected images then pass through a classifier which then assigns the defect to a particular category. This classification process needs to be periodically renewed and optimised to ensure the best possible outcome.

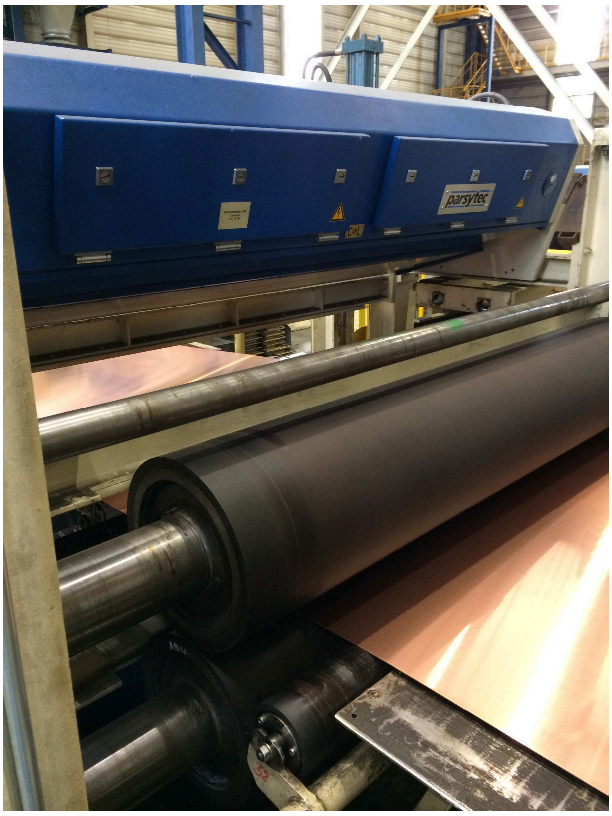

Fig. 3: ISRA Parsytec-system at a slitting and cut-to-length line for copper strip at thickness of 2 mm (source: MKM)

The detected surface failures are stored with relevant tracking information such as location in the coil, size, failure class, periodicity, etc. and can be displayed in a failure screen, together with any other detections in a coil map. Thus, an overview of all potential surface defects in the coil can be represented. A total of 16 critical (e. g. cracks) and 3 non-critical (e. g. stains) defect classes are stored in the system.

Prior to the integration of the surface inspection system in the Conti-M® line, comprehensive tests for detection of different classes of failures for such as scale, chips, scratches were carried out in ISRA's laboratory by optimisation the brightness of the incident angle and the adjustment of the camera sensitivity. The camera adjustment meant that the typical milled surface finish with a slightly rippled surface did not cause issues with the failure detection, and was not recognised as an issue to be flagged up.

During in-line milling, the edges of the rolled strip are milled up to 10 mm per side and the surface of the belt up to 1 mm on each side to remove the oxidation from the surface of the hot rolled strip ready for the subsequent cold-rolling process. The light-optical surface inspection system has an error resolution of at least 250 microns at the maximum milling speed of 6 m / min, and the ability to store data for about 4 weeks. After this period, the data will be saved for archiving on a separate SQDS server. Any coils - that have not been milled are put on the decoiler surface milling lines – whilst in off-line mode the milling operation is carried out separately from the casting and rolling process. At the downstream cutting and furnace lines a further cross process surface inspection is undertaken for assessment at a strip thickness from 2 mm using a plant specific extension of the ISRA Parsytec system. On this basis, within the process chain variations in the surface structure can be clearly tracked and mapped (Fig. 4, Fig. 5).

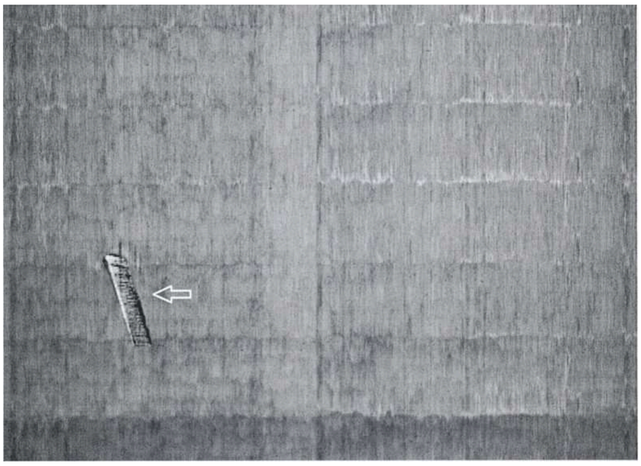

Fig. 4: Spill mark in the edge area (20 mm) after in-line surface milling (source: MKM)

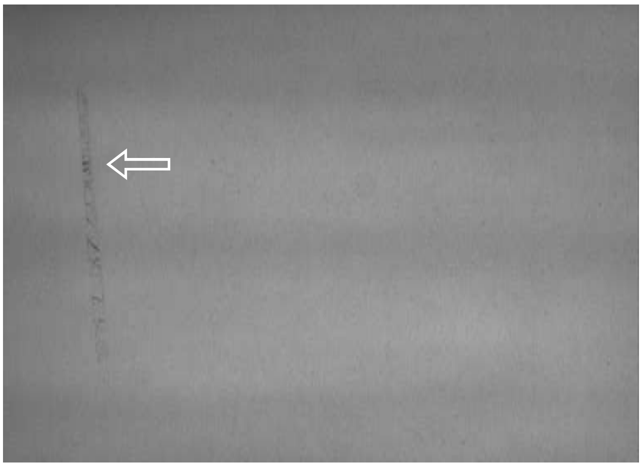

Fig. 5: Same spill mark in the edge area (20 mm) after cold rolling at 2 mm (source: MKM)

The key to good continuous process monitoring is the continuous optimisation of the classifier classes to recognise unique feature variations. As a result, the process control in continuous casting and rolling operation can be actively altered and on the type of surface deviations, immediate parameter changes can be made to the appropriate machines (caster, rolling mill and milling). By optimising the failure detecting an increase in productivity by reducing the depth of chip removal during milling operation is connected. Through optimisation of failure detection, an increase in productivity can be realised, for example by reducing the depth of chip removal during the milling process.

By comparing the downstream ISRA Parsytec installations conclusions on the detection performance of individual facilities may be linked and further optimised. We were able to eliminate a specific fault caused by the cutter shafts and from that we were able to derive targets for the change frequency of the cutter shafts.

The surface inspection system from ISRA Parsytec is a complete, fully comprehensive quality testing system for the surface of strip (Fig. 6, Fig. 7), which is the evidence of process safety in the continuous casting process. This ensures that the milled surface is free from failures in the subsequent process chain when passing through.

Fig. 6: Cast-rolled copper strips from Conti-M® (source: MKM)

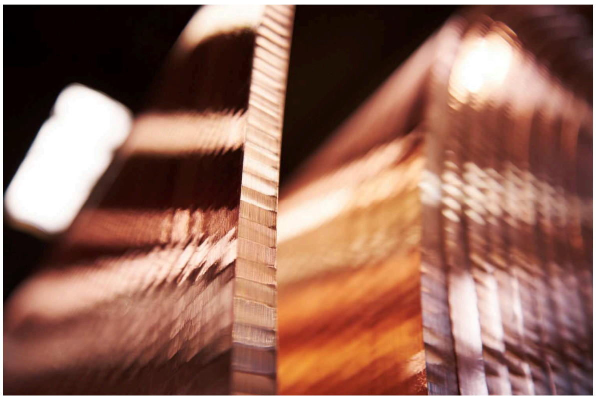

Fig. 7: Milled strip edge (source: MKM)

Summary

Since 2003, MKM has been successfully using the fully automated surface inspection system from ISRA Parsytec for the processing of copper strip. In 2009, for the first time the results were collated and categorised allowing the monitoring of Conti-M® process to be continually improved. This integration of computer aided inspection systems allowed full and transparent process monitoring in the complete process chain for strip production. The result of this process optimisation was significant and sustained improvement in yield, coupled with a significant increase in plant availability. The Conti-M® technology is constantly evolving to meet new and challenging market requirements. As one of the largest semi-finished copper manufactures in Europe, MKM has led the market in developing Conti-M® technology and is focused on further innovation and growth. The Conti-M® technology is the ultimate guide for the cost-effective and innovative pre-rolled strip production in Europe and worldwide.

References

[1] H. Bebber, G. Phillipps, Das MKM-Contistrip-Ofenkonzept, Sonderdruck aus „Giesserei“ 88 (2001), Seite 38-41, Giesserei-Verlag

[2] K.-D. Palm, A. Dusdorf, Modernes Gießwalzen von Kupfer in der MKM Mansfelder Kupfer und Messing GmbH, Vortrag zur MEFORM 2003