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ROLL CASTING IN IMPOL d.d. FOR FOIL STOCK AND FOIL PRODUCTION

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ABSTRACT

The main purpose of R&D work was optimization of the thin gauge twin-roll casting parameters, the alloy composition and the downstream processing parameters for the alloys 1050, 1200, 8011 and 8079. For casting trials, JUMBO 3CM with a roll width of 1800mm was used. Typical casting gauge was 6mm. The influence of the various processing steps on the kinetics of recrystallization, microstructure,, formablity, anisotropy, mechanical properties and surface quality was investigated. The main line of action was focused on the development of a processing schedule for the fabrication of thin gauge foil stock and foils with standard (EN546 1-4) quality.

Keywords: thin gauge twin-roll casting, downstream processing, foil-stock and thin gauge foils production

1. INTRODUCTION

Continuous cast aluminium strip accounts for 19.5% of the worldwide production of aluminium strip and rolled aluminium products, and the share is steadily increasing with an annual growth rate of 3 to 6%. In 1990 the total tonnage of aluminium cast strip produced in the world was 4 million, in 2000 more than 6 million and it is expected to double over the next 15 years. The major advantages of continuous casting in comparison to hot rolling of strip from non-continuous cast slabs are lower production costs, smaller initial investment and the possibility of modular growth of production volume. The basic market niches for continuous cast Al strip are: construction and civil engineering foil and can production, and the automobile industry. In the year

2000 the worldwide demand for Al foil was more than 2.2 million tons. From 2002 to 2005 the global demand for Al foil will increase at 3.8 % per year. In East European countries the expected growth is 4.4-5.5%. Accordingly, production capacity will go up at approximately the same rate (3% per year). Lower risk and other advantages will make continuous casting technology one of the most suitable ways of increasing present production capacity, namely by founding mini rolling mills.

Impol is aware that its hot rolling mill is going to shut down, therefore it is desirable to manufacture products which do not require a hot rolling mill. The aim of our rolling modernization programme is to focus production on making tread plate, circles and foil. Foil is a high added-value product if manufactured from in-house raw material. That is why Impol has opted for foil production based on cast strips with broad width as raw material. This technology is completely new to us and not frequently used in Europe.

Upgrading the hot rolling mill would require an investment of 130-140 million ECU with a minimum production for profitability of 200,000 tons per year, which greatly exceeds the planned production capacity.

In response to the identified problems and challenges Impol has decided to invest in a continuous caster, which will yield yearly 11,000 tons of final foil products. The remaining portion of raw material – foil stock strip for foil production - will be purchased at Impol Seval in Serbia.

In other respects as well, such as input raw material prices and the other advantages of »mini rolling mills« (lower capital investment by an order of magnitude, possible modular growth concept, lower production costs, reduced energy consumption and minimal negative environmental effects), the future trend of foil production and some other more demanding rolled products indicates a transition from the existing technology of hot rolled thin strip, made of slab, to new continuous casting technology for thin strip and foil production. This is why, along with buying a share in the Seval company, the management of Impol has decided to invest in a cast strip production line, which means a changeover to continuous cast strip as foil production raw material. This investment is part of Impol's investment into upgrading its cold rolling mill.

An additional production unit for cast strip manufacture has been built next to the rolling mill. The first part of the new unit contains casting furnaces and the second the caster. Continuous cast Al strip technology is very demanding. In order to achieve the desired quality of cast strip and process economy, several technological requirements must be met. Investment implementation began in the year 2002. Trial production is planned at the end of the year 2003, and foil production based on cast strip in the beginning of the following year.

As part of the restructuring of roll casting technology we had at first planned to modernize our cold rolling mill and two foil rolling mills. We realized though that the accomplishment of this task would be time-consuming

and less rational. We would have been sure to lose customers and fail to maintain the present quality of rolling. We also realized that it would be wise to think about relocating our foil production and purchasing new foil rolling mills. One of the decisive factors was probably the fact that there is a lot of competition and supply in selling this kind of machinery. Consequently we managed to secure an appropriate contract for the purchase of three new rolling mills with the representatives of the Achenbach company in Germany. The same sum that would be needed for modernization, sufficed for the purchase of a new cold rolling mill and two foil rolling mills which can roll strip of maximum width of 1500 mm. This is compatible with cast strip production and the hot rolling mill in Sevojno, which also makes it an optimal production solution. Of course some additional equipment for foil production had to be bought as well, such as doubling machine, separator, shears, a furnace...

By 2005 we will in all probability be the only company in Europe to own a completely new foil rolling mill. In terms of quality this will also permit us to rank among the top aluminium foil producers.

2. BRIEF DESCRIPTION OF R&D PROJECT PHASE

Continuous twin-roll casting is economically very efficient as it combines two types of technology; continuous casting and hot rolling. Because molten metal cools relatively rapidly in comparison with casting on conventional casters, the technical properties of the product are different. Recently the major trend has been downstream processing of cast strip, which further increases the efficiency of such production technology.

The process discussed involves feeding the molten metal through a tip into the gap between two rolls which revolve in opposite directions. The two internally water cooled rolls reduce the heat of the metal sufficiently for it to solidify and thus emerge from the rolls in the shape of a strip. The roll surface must be constantly greased with graphite grease which prevents the strip from sticking to the rolls and also regulates heat transfer between product and roll.

Continuous casting of aluminium and aluminium alloy strip is technologically challenging in two ways: (1) it requires mastery of the continuous casting parameters which affect cast strip quality and (2), product quality should be equivalent to rolled products manufactured from hot rolled strip. In other words, molten metal must first be made into high-quality cast strip which in turn must be worked into foil stock for foil production, the quality of which should not differ from the quality of foil (by European standards EN546 from 1 to 4) manufactured from hot rolled strip. The latter is technologically quite a demanding task.

In the next production stage the cast strip is reshaped into foil stock for foil production where many properties of the cast strip are methodically changed, such as microstructure (grain size and grain size distribution, ratio between

length and thickness of grains, volume fraction of intermetallic phases), formability (thin gauging, ductility, deep drawing), anisotropy, mechanical properties (tensile strength, ratio between formability and tensile strength), thermal conductivity, corrosion resistance, surface quality (roughness, aluminium oxide concentration, graphite concentration) etc., which is achieved by recrystallization, changing the phase composition and strength hardening.

The basic project goals are: (1) to restructure Impol's existing rolling technology by changing over to in-house continuous cast strips as raw material in foil stock and foil production, (2) to master continuous casting of 6 mm gauge strips on the basis of 1xxx and 8xxx alloy series, and (3) to master foil stock production for foil manufacturing.

In connection with the planned changeover to continuous cast strips as a substitute raw material for Al foil stock production, the following activities have been foreseen as part of the project: (1) applicative industrial research, which will help implement the technology of continuous strip casting and working cast strip into foil stock suitable for making standard quality foil; (2) development of a virtual environment for cast strip and foil stock production which will provide adequate IT support and the possibility of modeling technological production parameters; (3) study of the technical feasibility of manufacturing continuous cast strips and Al foil stock for foil production; (4) preparation of investment documentation for the program of restructuring rolling technology and the actual execution of investment in Impol d.d.; (5) setting up a continuous casting production line for strip and foil stock and implementing prototype production; and (6) production technology implementation involving start-up and regular production of cast strip and foil stock.

The results we achieved with this project are: (1) implementation of production technology for continuous strip casting and rolling strips into foil stock suitable for making standard quality foil, (2) optimization of production parameters and the technological properties of continuous cast strip and foil stock by developing a suitable virtual environment, (3) implementing the investment by setting up a production line, and (4) regular production of continuous cast strip (ca. 15.000 tons per year) and foil stock for foil production (ca. 14.000 tons/year).

In terms of increased competitiveness our company expects the following results:

- foil stock for producing 0.6 mm gauge foil which is made of cast strip is ca. 70 ECU (17%) cheaper than foil stock made of hot rolled strip,
- the price of converting foil stock intended for foil production into foil is 18 ECU (12%) lower than the price of converting foil stock made from hot rolled strip into foil of the same quality range.

With a targeted production of 11.000 tons per year the changeover to cast strip (i.e. substitution of hot rolled strip by continuous cast strip) means a saving

approximately one million ECU a year. The actual savings are much bigger (ca. 2.5 million ECU/year) when the market price of foil stock for foil production is considered.

Due to the new investment in restructuring rolling technology the gross added value should rise by at least 21% (in comparison with the gross added value per employee in Impol in 2002 of 37.000 ECU/employee).

Other factors in product competitiveness include the fact that investment in continuous strip casting plants (»mini rolling mills«) is an order of magnitude smaller than investment in a new hot rolling mill, and that continuous strip casting technology enables greater flexibility of product range composition and allows multiple modular growth of production capacity in accordance with market growth.

It is foreseen that by the year 2007 the Impol rolling mill will have at least 80% of its foil production based on its own foil stock for manufacturing foil from continuous cast strip – which corresponds to a 24% market share in the total product range.

The goals of this applicative industrial study are a comparative analysis of the microstructural, chemical and mechanical properties of in-house cast strip (alloys 1xxx and 8xxx) and cast strip from several commercial suppliers, characterization of the microstructural, chemical and mechanical properties of in-house foil stock for foil production, made from Impol's cast strips (alloys 1xxx and 8xxx), characterization of the microstructural, chemical and mechanical properties of 8 μm gauge foil made using familiar technology and in-house foil stock for foil production on the basis of Impol's cast strip, and determining the quality parameters of semi-products - continuous cast strip - for manufacturing the final product, namely 8 μm gauge foil made of aluminium alloys 1xxx and 8xxx.

The results will direct technological parameters both in the phase of continuous casting (primary crystallization, distribution of intermetallic phases, segregation, surface quality), and subsequent cold rolling with intermediate annealing (time and temperature of homogenization and recrystallization annealing, reduction levels) with the aim of achieving a fine grain structure with evenly distributed intermetallic phases, which is essential in obtaining the required physical and chemical foil properties.

The virtual environment of cast strip and sheet production is concerned with numerical modeling of casting and rolling and numerical modeling of heat treatment.

The study of the technical feasibility of producing continuous cast strip and foil stock for foil production involves preparing in-house prototypes of continuous cast strip from aluminium 1xxx (AA1050, AA1200) and alloys 8xxx (AA8011, AA8079) for foil production, studies of annealing and cold working of in-house continuous cast strip into foil stock for foil making, and the

manufacture and quality analysis of foil made from prototype in-house continuous cast and cold rolled strip.

The activities which ware necessary in implementing production technology, start-up and execution of regular cast strip production and foil stock include production worker training, mastery of casting parameters, development of microstructure, phase composition, formability, mechanical and other relevant technological properties of cast strip in the phase of regular production start-up, quality monitoring of manufactured cast strip, regular production of foil stock on the basis of in-house cast strip, and an acceptance test for the production of in-house cast strip, foil stock and foil.

3. CONCLUSION

The introduction of a new cast strip production line will enable a yearly production of 14.500 tons of foil stock for producing foil at a price which is ca. 16 ECU/ton lower than the price of hot rolled foil stock. On a yearly scale this means saving 1.9-2.6 million ECU.

In terms of immediate company development we will have a completely new and highly competitive foil rolling mill. In Europe there are a few competitors who have 10-30 years old plants for producing continuous cast strip and foil stock for foil production. In the long term all other European foil producers plan to introduce updated technology as well, so that Impol now has the opportunity to be among the first to enter the market with a completely new foil rolling mill and cast strip production line.

At Impol we are aware of the need for new types of technology or new products to raise the level of technology and increase the company's competitiveness, especially in the field of rolling technology. By investing in a caster, new cold rolling mill and two new foil rolling mills and by buying the Seval Company in Serbia, rolling technology will gain new dimensions and make Impol one of the leading European producers of rolled products.