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Melting and casting line for rolling ingots from 100 % secondary aluminium

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Melting and casting line for rolling ingots from 100 % secondary aluminium

The recovery of aluminium by means of recycling scrap from the production process is very important for meeting the demands. The production of secondary aluminium which is qualitatively absolutely equal primary aluminium is the main target. Therefore the production of high-quality aluminium products from 100 % scrap, old and waste material will gain further significance. The process of a complete melting and casting process line for rolling ingots from 100 % scrap is topic in this article. Especially measures for low energy consumption in melting processes (heat recovery) and measures to increase the quality of aluminium products (gas treatment) are described.

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Introduction

The recovery of aluminium out of recycling scrap from the production processes has become undispensable towards the demand of Aluminium. The remelting of such scrap results in secondary aluminium. Effective processing measures guarantee that secondary aluminium is qualitatively absolutely equal to primary aluminium.

In principle, construction units from aluminium can arbitrarily often be melted for the production of new products. In Europe are at present about 35-40 % of the total requirement of aluminium available by remelting of aluminium scrap. The increased demand for aluminium products and the political and economic orientation to the recycling economy requires the advancement of the remelting processes, since more and more scraps (contaminated aluminium scrap) arrive in this cycle.

Since the energy needed to produce secondary aluminium is only about 5 % of that for primary aluminium and the specific capital investment in a secondary smelter is only a small part of that for a primary smelter, there is an incentive to collect and use as much scrap as possible. The high material value of aluminium scrap contributes to cover the logistical and processing costs, making it possible to set up collection and processing systems with no need for subsidies.

Secondary aluminium with a high degree of purity is like primary aluminium and the raw material for the production of most diverse aluminium and cast alloys. The melted metal becomes in the foundry according to the demanded specifications:

- alloyed (brought to the required composition by addition of alloying elements)
- cleaned by filtering (salt, filter etc.)
- degassed
- cast into pig or else into specified formats
- as liquid metal commercially exploited

Format is the collective term for

- rolling ingot to DIN EN 487,
- extrusion billet to DIN EN 486 and
- forging ingot to DIN EN 604.

Rolling ingots are the basis for the production of high quality foils for industrial use and household. In a remelting plant in Berlin rolling ingots with highest quality will be produced by 100 % aluminium scrap. The Jasper GmbH acted as general coordinator to retrofit the existing plants respectively has established a new melting furnace for this process. The description of the production process of rolling ingots from 100 % aluminium scrap is topic in this article.

Production of rolling ingot

Description of the production process:

- melting of scrap respectively contaminated scrap in a MultiMelter©
- transport to the casting and holding furnace
- treatment of the liquid aluminium in the Casting Furnace (alloying and cleaning)
- casting process includes further treatment by gas
- vertical casting plant

MultiMelter© furnace and application

The MultiMelter© is a three chamber furnace with an integrated pyrolysis process. The field of application is the economical and ecological melting of aluminium scrap heavily contaminated with organic coatings and inlets (**Fig. 1**).

The Multimelter© consists of:

- a heating chamber (1) to melt clean scrap, ingots etc. and to heat the bath of liquid aluminium
- the pyrolysis chamber (2) to pyrolyse the organic components of the scrap into fuel gas and to melt the decontaminated scrap
- the pumping chamber (3) with the function of circulating the liquid aluminium (bath) and to melt turnings and chips

The heating chamber (1) and the pyrolysis chamber (2) are equipped with

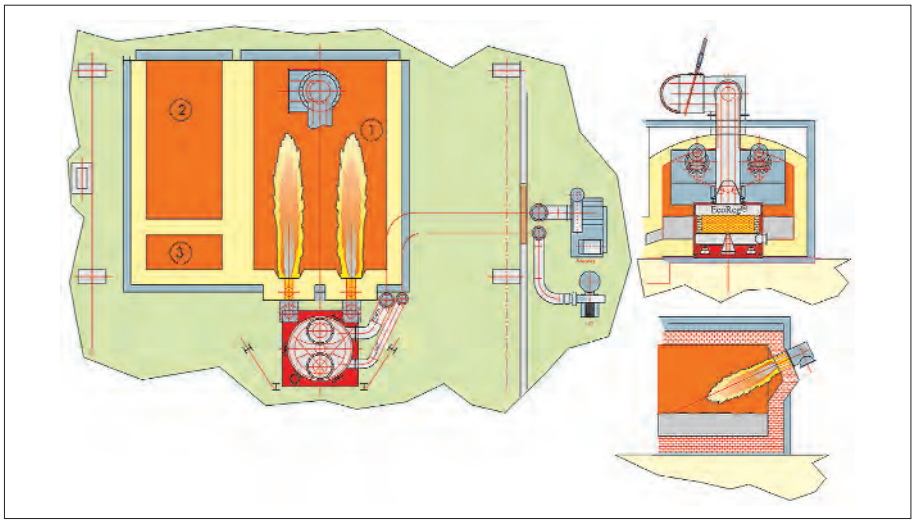

Fig. 1: MultiMelter© - Regenerator melting furnace

low NO_x burners with SFI-technology (Selective Fuel Injection). The SFI-burner technology, specially developed by Jasper GmbH allows the co-utilisation of the pyrolysis gas with respect to all German and European emission limits [1]. As a minimum standard all burners are built to the German "TA-Luft" requirements with the following values: NO_x < 350 mg/Nm^3 and CO < 100 mg/Nm^3 (5 % O_2). The installation of a special burner type depends on the application of the melting process. The burner systems are regulated by oxygen content. The pyrolysis-gas replaces to a part the main fuel in an efficient and economic way. Different ways are possible to use the pyrolysis gas as substituted fuel. On the one hand it can be directly burned in the heating chamber and on the other hand it can be completely burned with the natural gas within a special burner system.

The pyrolysis gas is formed in the pyrolysis chamber (2) (scrap chamber). After charging the scrap is lying on a bridge. The chamber is heated with a HiTAC-burner (High Temperature Air Combustion) and the convective heat transfer is responsible for the first thermal treatment of the scrap. The organic adhesions releases immediately with a temperature above of 350 °C during the heating process and the srap is preheated before it slides into the bath. The scrap chamber (pyrolysis chamber) is loaded several times per hour due to a uniform heating. Further, this thermal treatment has the effect of decreasing the metal loss due to a minimized oxidation of the aluminium scrap [4]. The volatiles release and the formed pyrolysis gas is transported into the heating chamber (1). It must be assured that all organic gaseous components are completely burned in the heating chamber (1).

The EcoReg®-regenerator is used for a central heat recovery in powerful furnaces and replaces the classic recuperator. The air piping can be connected to an unlimited quantity of burners. The flue gas temperature amounts between 1200 °C to 1400 °C. This results in an average combustion air temperature of approximately 1060 °C to 1275 °C (in the high temperature version up to 1400 °C). The exhaust gas of the rotating regenerator (heat exchanger) has a temperature of 140 °C up to 210 °C, which is suitable as filter inlet temperature. The energy saving amounts up to 62 % in relation to a burner system for cool air with a flue gas temperature of about 1400 °C.

A continuous optimisation of this rotating regenerator system EcoReg® and a multitude practical applications in the aluminium and steel industry were the reason for further development concerning exhaust air purification. In frame of a research project in 1998 the exhaust air purification was successfully proven concerning dioxin (quenching of dioxin). This outstanding effect of the dioxin reduction during simultaneous high heat recovery is an environment friendly and financially attractive solution for the use in melting furnaces. The Furnace is equipped and controlled by Siemens S7 [5].

Transport by crucible from MultiMelter© to the casting furnace

The liquid aluminium is casted from the MultiMelter© in a 10 – 20 t crucible and is transported by this to the Casting Furnace (**Fig. 2** – left side).

Holding and casting furnace

Tiltable furnaces (converter) will be used as melting and casting furnace (**Fig. 3**). In these furnaces the correction of the alloy composition is made. For better and faster distribution a gas treatment with lances and AluTreat©-system is used. On the one hand a better distribution of the additives and on the other hand a better distribution of the temperature is reached. After this treatment the liquid aluminium is heated up to the required temperature.

In 2002 all converters in the mentioned remelting plant were reequipped from cool air burner to regenerator burners and from oil EL to natural gas for

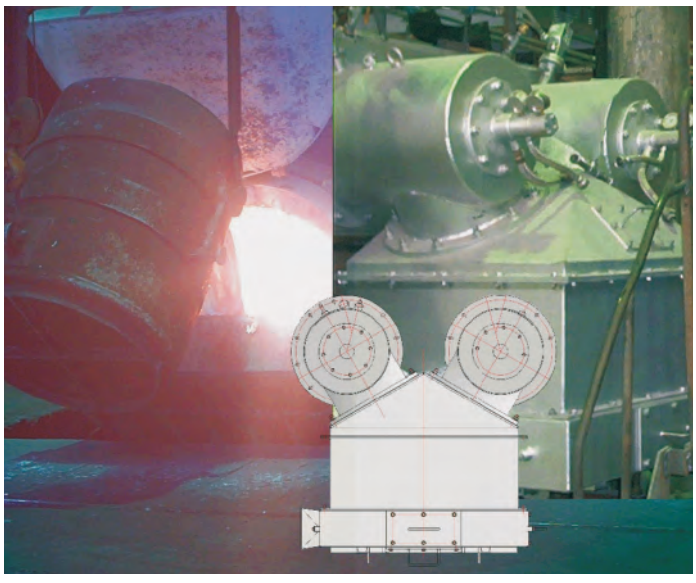

Fig. 2: PulsReg© regenerator with two burner heads

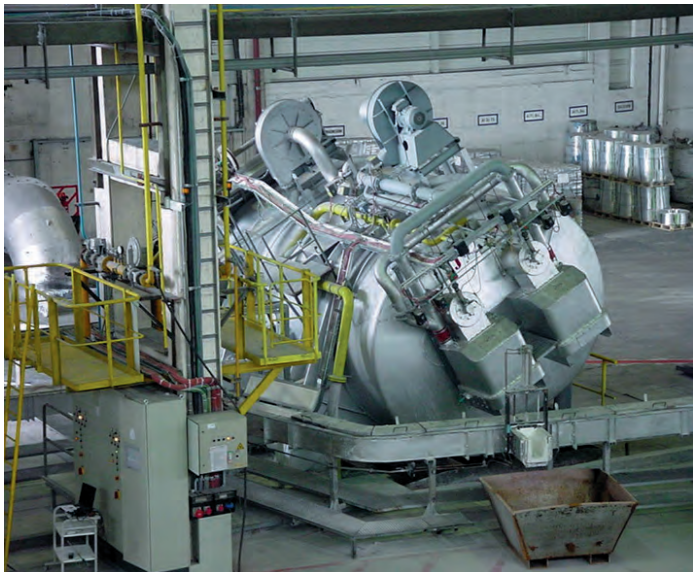

Fig. 3: Tiltable melting and casting furnace

economic and ecological reasons. By the use of regenerator systems the energy consumption decreases and thus the CO_2-emissions substantially. Firing sys-tems with regenerator burners are comparable with oxygen burners with regard to the energy consumption. But with regard to several years regenerator systems are cheaper and more environmental since the energy expenditure is void by the liquid air separation. A process cycle arise with regenerators, which use the combustion air (= 79 % nitrogen) for an effective heat recovery. In the remelting plant in Berlin two different kind of regenerator systems are installed – the rotating bed regenerator and the PulsReg®-system. This type is the classical regenerator burner design, consisting of 2 regenerators with assigned burner heads. During the heat up phase of one regenerator the exhaust gas is sucked off over the other burner.

The special characteristic is that the construction of the furnace permitted only burners with short flames. In order to be able to achieve the demanded power of the burners, each of the regenerators was equipped with two burner heads (Fig. 2 - right). Both of the burner heads from one regenerator are burning at the same time. This results in short flames, radiating on a large bath surface in the furnace. The gas/air ratio of each burner head is ensured. First, the burners were supplied with oil EL as fuel and then reequipped for the natural gas application. In the result of the changing measures both capacitive and energy saving effects were reached (**Fig. 4**) [2]. The obtained savings in the energy consumption are completely substantial and justify the associated investments fast.

AluTreat© - System

For increasing the productivity all converters are equipped with the AluTreat© - system (**Fig. 5**). A porous fireproof and aluminum-steady stone is built into the furnace soil. The porosity of the stone is so constituted that no liquid aluminium can invade. On the cold side of the stone is the gas pipe installed. The cleaning gas is coming from a special gas control system and will be introduced into the porous stone and comes out of the stone on the hot side as finely distributed gas bubbles. The gas flow determines the result in the furnace. Three modes of operation can be summarized:

- degassing = small gas flow for the reduction of hydrogen in the bath.
- mixing = large gas flow for an intensive mixing of the bath.
- cleaning = high gas pressure for the periodically cleaning of the stone.

Occasionally, the furnace can be operated without cleaning gas. Nevertheless, the restart of the porous stones is possible without problems. Mostly, argon is used as a cleaning gas. Nitrogen as cleaning gas is possible, if a nitride formation (e.g. with magnesium) is not to be feared. A treatment with chlorine is performed when inadmissible Magnesium/Calcium contents in the bath are existing. The result is an outstanding aluminium quality in foundry and wrought alloys. The advantages are:

- cleanness and homogeneity of bath contents are substantially improved
- typical is a density index value of approx. 1,5 and beside that a reduction of other inclusions (STIC) over approx. 80 %
- temperature differences over the bath height are minimized
- the furnace performance is increased
- a temporary operation of the furnace without cleaning gas is possible
- outstanding durability of the stones

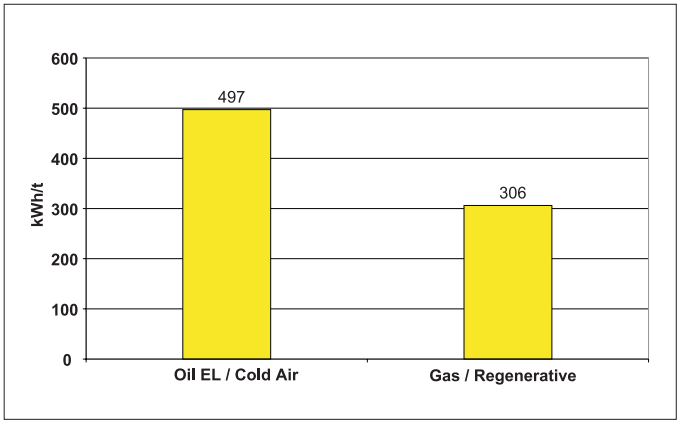

Fig. 4: Average specific energy consumption in a casting furnace

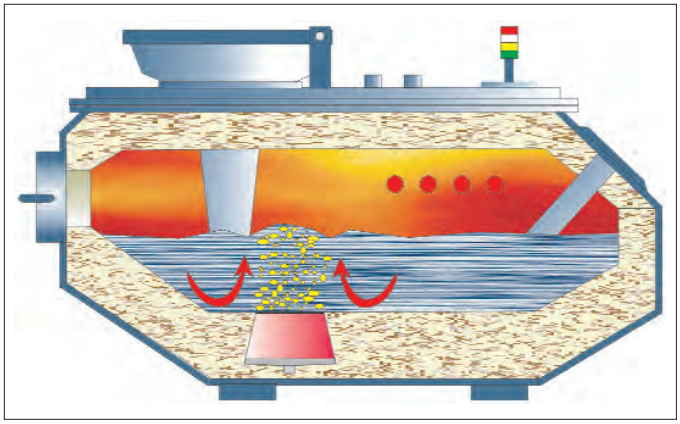

Fig. 5: AluTreat© - system

Fig. 6: Cleaning box

For a further treatment of liquid aluminium a clean box is integrated in the casting line (**Fig. 6**). The aim is a further reduction of hydrogen and other impurities in the metal (oxides).

Vertical (quadruple) continuous casting plant

The casting of rolling ingots takes place in a vertical (quadruple) continuous casting plant. The quality is determined by casting speed and cooling of the developing rolling ingots. These depend on the dimensions of the rolling ingots as well as the casting technology. The rolling ingots can be casted in different dimensions (length, width and height).

In the course of a quality with regard to the chemical composition and mechanical condition in this procedure the waste of rolling ingots is below 0,5 %.

Conclusion and Outlook

The production of high-quality aluminium products from 100 % scrap, old and waste material will gain further significance. The process of a complete melting and casting process line with all its components is described in this article.

The MultiMelter© reach high melting capacities with a minimum of melting losses. An extreme decrease of energy consumption is reached by an effective heat recovery due to the rotating regenerator system (ECOREG®) and the substitution of natural gas through pyrolysis gas. The reducing of metal loss by the pyrolysis process and the energy saving through an effective heat recovery by the Regenerator results in a short time of return of investment. In this combination the MultiMelter© is the profit generating melting furnace for secondary aluminium smelters by using contaminated scraps.

In melting and casting furnaces the alloy composition is made. An AluTreat©-System provides even distribution of the additives and temperature in the bath. Beside that, an increased productivity is obtained. Low energy consumption takes place by an effective heat recovery by means of PULSREG® regenerator systems.

The treatments by the cleaning gas (AluTreat© system) is a necessary component to release impurities in the bath and for an optimal distribution of the alloy with regard to chemical composition.

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