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Efficient drying of aluminium swarfs

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The recycling of aluminium from scrap, old and waste material as well as resulting scrap from production (swarfs, cast boss etc.) is of great importance. The product out of remelting of these scraps is secondary aluminium. As a result of effective and most modern procedures the quality is absolutely equal to primary aluminium, but it requires much less energy per production unit. In the recycling process the directly remelting of aluminium swarfs which contain water and oil is on the one hand dangerous and on the other hand often economically insensate. The most frequent disadvantages are extended melting times, because of the swarfs immerse scarcely under the bath surface, steam explosions due to the water content and raising melting losses of the swarfs. A thermal treatment (drying process) is a solution to achieve an economic and environment-friendly recycling of aluminium swarfs. In cooperation of Jasper GmbH and Aluhut a.s. a conventional swarf drying plant was rebuilt and modernized according to today's “state of art” techniques.

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Introduction

Aluminium swarfs represent a valuable resource which can be recovered by recycling. These swarfs are partially wet, polluted with oil or grease, partly also woollen and in balls. The swarfs contain iron, beside other solids, which has to be removed to avoid enrichment with iron during the remelting. When the swarfs are wet, clotted and woollen it is not possible to separate the iron by magnetic separators.

Accordingly aluminium swarfs have to be prepared and/or dried. Woollen swarfs must be cut up and/or broken at first. The drying process of aluminium swarfs has more significant advantages. Steam explosions, squirting aluminium and pollutant formation can be minimized or avoided completely when a melting furnace is fed with dried swarfs.

This kind of important thermal pre-treatment of aluminium swarfs requires a certain complexity of work and energy. It is necessary to combine old well-known processes with procedures which correspond to today's “state of art” technique in order to accomplish this thermal process economically and environment-friendly.

In cooperation of the company Aluhut a.s. in Dobris (Czech) and Jasper GmbH in Geseke (Germany) a conventional swarf drying plant with rotary drum and thermal post combustion was rebuilt accordingly to today's “state of the art” techniques. Additionally it was equipped with a regenerative heat recovering system.

This article describes the construction and the operating mode of this swarf drying plant as well as it presents first operating results regarding the energy consumption, operational data and emissions.

Construction and operating mode of the swarf drying plant

Aluminium swarfs exist in most different forms. They are wet, polluted with oils and grease and have mostly different sizes. If these swarfs appear in "wool balls" it is necessary to use a mechanical crushing. Furthermore unwanted components - e.g. shell moulds - have to be separated out by a shaking screen.

The swarfs (**Fig. 1**) which fell through a shaking screen are transported to a hopper unit (1). This hopper unit provides a material buffer to guarantee constant operation of the system. The swarfs are carried out of the hopper unit into a vibration launder which feeds the rotary drum (2). This transport is automated, variable and primarily depends on plant conditions. In the rotary drum the swarfs are heated by regenerative burners.

In order to be completely dried as well as free of oil and grease the residence time of the swarfs in the rotary drum has to be sufficient. The swarfs arrive at a magnetic separator (4) by a vertical vibratory feeder (3) and a conveyor belt. The iron containing swarfs are separated from the aluminium swarfs in the magnetic separator (4) and both swarfs are supplied to different containers (5).

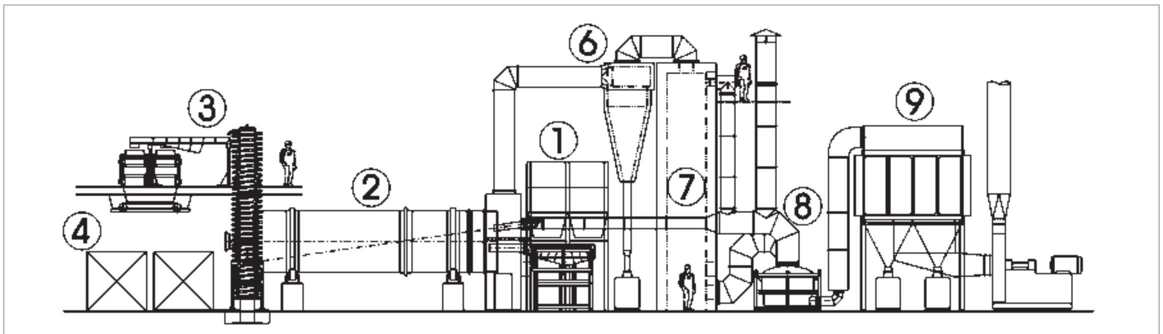

Fig. 1: Overview drying swarf plant

Same important as the drying process in the rotary drum is the thermal process on the other side. The arising waste and pyrolysis gases in the rotary drum have to be treated in the thermal post combustion. A suction fan behind the filter system (9) ensures the feeding of the waste gases by way of a cyclone (6) to the thermal post combustion (7). A regenerative burner in continuous controlled operation ensures a complete combustion of the waste and pyrolysis gas. The complete hot waste gas out of the thermal post combustion (7) is conducted through the rotary regenerator (EcoReg®) (8). The waste gas temperature behind the (EcoReg®) is clearly below 200 °C and can be supplied without additional complex cooling to the filter system (9). Additional measures to reduce the different kinds of emissions are not necessary. The waste gases can be fed directly to the chimney (10).

Many different kinds of measuring procedures are used for monitoring, regulation and automation of the plant. The level measurement of the hopper reservoir and the containers is done using ultrasound. Thermocouples are installed in all realms of the plant. The rotary drum is equipped with contact thermocouples which send the values of the wall temperatures of the whole drum to the central processor. Accessorily an O_2-measurement respectively a control system is provided at the plant behind the thermal post combustion. The waste gas is taken off after thermal post combustion by a measuring gas pump, cleaned in a wash bottle and an additional filter, cooled down and the oxygen content in the waste gas is determined using the paramagnetic principle in the analyzer.

Fig. 3:
Heat recovery behind the thermal post combustion by an EcoReg®

Direct heating of the swarfs in the rotary drum

Direct heating of the swarfs in the rotary drum (**Fig. 2**) is a challenge for process engineering. In their size and contamination aluminium swarfs are characterised by a strong inhomogeneity. During the thermal treatment of the swarfs oils and greases are emitted as pyrolysis gases. For security reasons it is necessary to avoid unwanted reactions like inflaming of these gases and/or explosions and to suppress a burning of the swarfs. It is necessary to control the temperatures of the waste gas and at the rotary drum exactly. An essential requirement to the burners at the rotary drum is a large range of control. Furthermore the dosing of the swarfs and the rotational speed of the drum must be adjustable quickly. As far as possible "homogeneous" kinds of swarfs have a positive effect to regulation and production. A further reduction of the energy consumption is accomplished by swarfs which are contaminated with oil. Then it is possible to operate the burners in part-load mode or even fed only preheated air from the regenerative heat recovery behind the thermal post combustion into the rotary drum. However swarfs with high water content require a higher energy input during this process. This can be prevented, as the swarfs get moistened with oil or water oil emulsions in the vibration launder in front of the drum.

Fig. 2:
Rotary drum of the drying swarf plant

Thermal post combustion and heat recovery

Before the pyrolysis gases of the rotary drum are emitted to the filter system or into the environment they have to be treated. A continuously operating regenerative burner with a large range of control provides a complete burning inside the thermal post combustion at temperatures between 800 °C and 1000 °C.

The hot waste gas is supplied to a heat exchanger – in this case the rotating regenerator (EcoReg®). Continuous operation is the main criterion for the choice of a suitable heat recovery system. The decision runs between a classical recuperator and a rotary regenerator.

In principle the two regenerators of a classical regenerator system are summarized physically in one rotating regenerator. The bottom part and upper part of the regenerator are fixed. These parts have, in each case, two chambers flown by the cold/hot exhaust gas and/or the cold/hot combustion air. The middle section is rotating between the lower and upper part and is divided into several segments. The sealing of the centre section is done by sealing strips

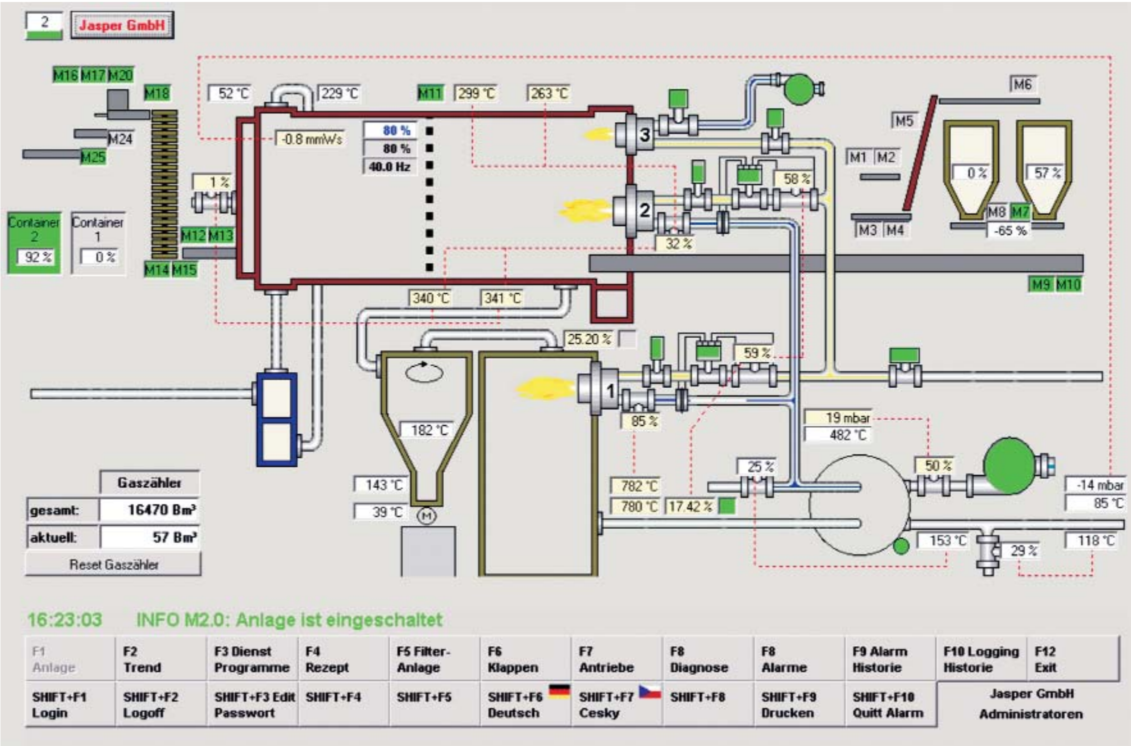

Fig. 4:
Flow sheet of the drying swarf plant

made from steel and/or ceramic. The hot flue gas passes the segmented heat exchanger filling while the middle part is rotating. It takes out the heat energy from the exhaust gas and stores it. During the further rotation of the middle part the hot segments come into the area of the cold combustion air. The filling transfers the heat energy to the combustion air. The temperature in these segments decreases and these segments continues turning into the hot area again, where a new heating takes place (**Fig. 3**).

The efficiency of the heat recovery is in average more than 80 % related to the inlet temperature of the flue gas. Depending upon dimensioning, the waste gases which leave the EcoReg® still have an outlet temperature of about 150 °C to 220 °C and can be supplied to the filter system directly.

Corresponding today's “state of art” the rotating regenerator has a further extremely valuable advantage. This regenerator can be used for the reduction of dioxin too. Dioxins (and furans) are not intentionally fabricated. They unintentionally arise during the combustion process, e.g. by reason of the presence of plastics (chlorine and bromine) in scraps [1].

For dioxin-reduction by water injection a temperature reduction of at least 700 °C in less than 1 second is demanded. To prevent a new formation of dioxins the waste gas loaded with dust or ash particles has to remain below a temperature of approximately 300 °C. The size of the necessary filter system rises thereby by the additional vapour volume. Regenerators which can exhaust off 100 % waste gas are suitable as a replacement instead of water cooling. The residence time of the waste gas in the EcoReg® regenerator is in fact below 0.5 seconds. The waste gas is cooled down to temperatures between 150 and 220 °C. A smaller filter system can be installed. Due to its smaller dimensions the investment costs can be reduced and the savings will additionally cover more than the costs of the EcoReg® regenerator.

Therefore the "Return on Investment" is not only obtained by the energy saving.

Controlling and visualization

The whole swarf drying plant is controlled by a Siemens S7 unit. Theoretically only one person is necessary for supervision and controlling of the whole system. Only due to safety regulations a second person is required for the plant.

The plant can be operated in automatic and in hand mode. All measuring data and adjustments as well as operating and fault signals are indicated by the visualization on a monitor. Interacting with the visualization it is possible to engage immediately in the operation of the plant and/or make changes in the adjustments.

Fig. 4 shows exemplarily a screenshot of the flow chart. All data, which are necessary for well operation, can be integrated into the visualization. The data collection and the reproducibility of flow charts are only limited by the memory accoutrement.

Results

Table 1 shows results of first operational experiences and results with the modernized swarf drying plant. With the swarfs of kind A – central rough to rough swarfs – a operational capacity with an average of 2.67 tons per h was achieved. The original design of this plant amounted to 1 to/h. The energy consumption, accounting to 325 kWh per ton alumi-

Table 1: First results during operation

Kind of swarf	Oil and water Moisture in weight-%	Operation capacity t/h	Energy consumption kWh/t
Kind A	13,70	2,67	323,55
Kind B	11,59	2,70	515,80

Table 2: Results of the official emission measurement

Name	Solid particles [mg/m^3]	C [mg/m^3]	NO_x [mg/m^3]	SO_2 [mg/m^3]	TOC [mg/m^3]
Measurement I	1,33	13	56	19	1,8
Measurement II	0,17	11	51	25	3,1
Measurement III	0,5	10	49	34	3,6
Max.	1,4	14	56	38	4,1

nium swarfs, is due to the high oil content of the swarfs. For kind B of swarfs - also central rough to rough swarfs - the operational capacity was about 2.7 tons per h. The higher energy consumption of approx. 515 kWh per ton of aluminium swarfs arises due to higher water content. In order to achieve a continuously plant condition it is advisable to operate the system with homogeneous sorts of swarfs. Unfortunately this is not always possible and requires certain flexibility of the control unit. In consequence of this flexibility the operational capacity of A was reached at times of up to 4 to/h. The residual moisture content of the swarfs is responsible for the efficiency of the plant. This plant reaches residual moisture content clearly below 0.5% in weight.

Swarfs at this drying level can be fed into a melting or an alloying furnace without any problems.

The emission measurements according to the legal regulations of the German TA-Luft are shown in **Table 2**. All values are far below the allowed limits. Especially the indicated values for the nitrogen oxide emissions are on an absolutely low level of max. 56 mg/m^3.

Conclusion

One of the most important raw materials recovered by recycling are aluminium swarfs but their preparation requires a lot of work and energy expenditure. In order to realize such thermal processes in economic and environment-friendly way, well known processes have to be combined which corresponds to the today's “state of art” techniques. In cooperation of Aluhut a.s. in Dobris (Tschechien) and Jasper GmbH in Geseke (Germany) a conventional swarf drying plant with rotary drum and thermal post combustion was rebuilt with current technology and additionally equipped with a rotating regenerator (EcoReg®). First operational experiences show in average 2.5 to 4 times higher operational capacity value with a low energy consumption of 300-500 kWh per ton.

This successfully finished project impressively clarifies the enormous saving potentials and productivity gains which can be obtained by well directed investments into modern technology of aluminium recycling - with improved environmental compatibility at the same time.

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