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New tools for melting of secondary aluminum in rotary furnaces

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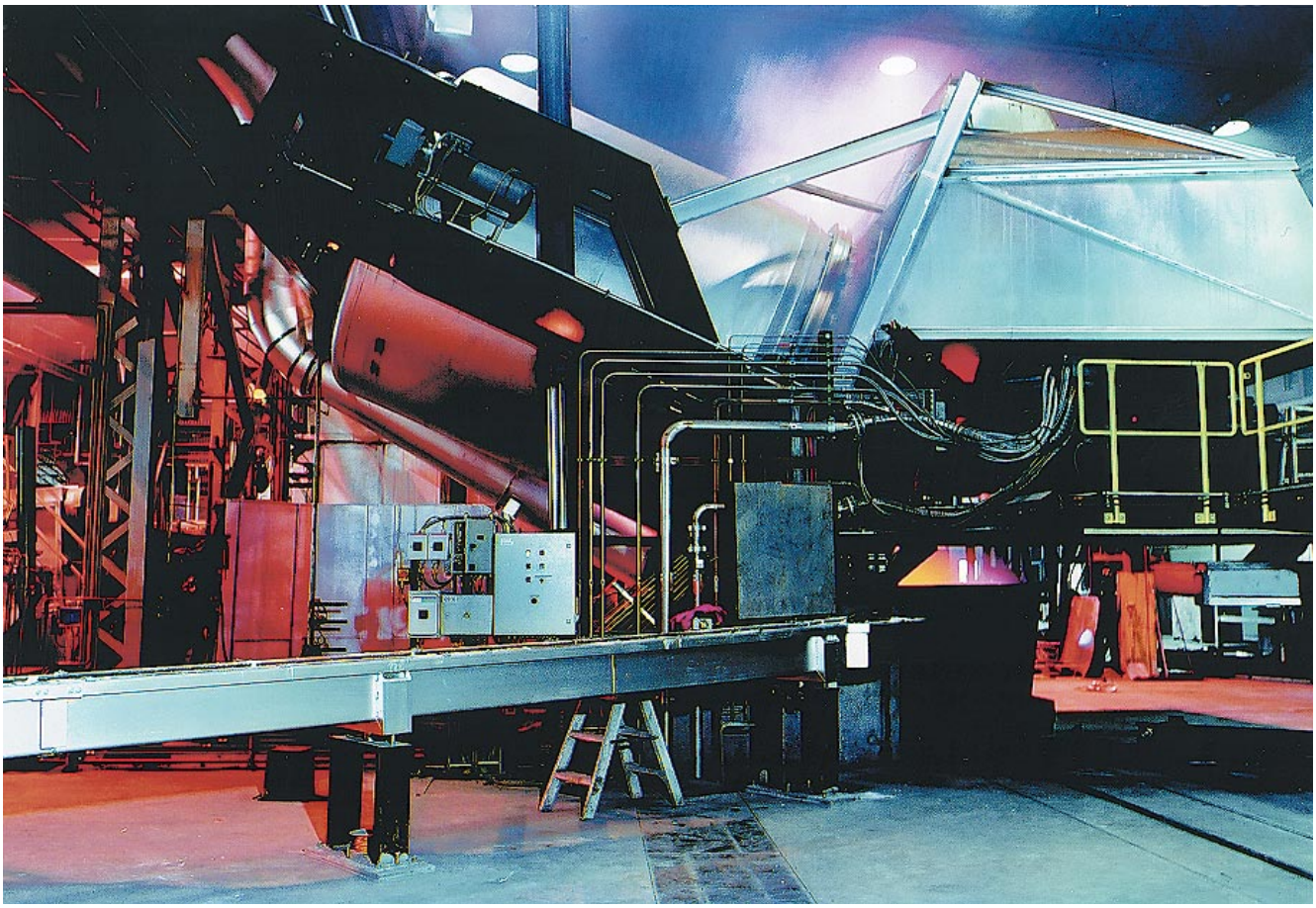


The URTF12 at Stena Aluminium

The melting of aluminum scrap and dross provides many challenges to the secondary aluminum industry. Control of organic emissions and optimizing salt-flux use are two examples. Scrap raw materials contain organic components such as lacquer and oils. These generate emissions that may negatively affect productivity and the environment. This has limited the amount of organic components that can be allowed in the charge. The new Wastox, process uses controlled oxygen lancing and oxy-fuel burner management for combustion of emissions in the rotary furnace. Flue-gas composition is used for on-line process control. Use of the Wastox process has shown that the process allows the use of scrap with higher levels of organic contamination and that process economy and productivity is improved. By reducing or eliminating the amount of salt fluxes in the rotary furnace melting process, productivity, efficiency and environmental performance is improved. The new Universal Rotary Tiltable Furnace (URTF) is designed using the latest know-how from low-salt and salt-free melting of secondary aluminum.

The Rotary Salt Furnace (RSF) has been the furnace type used in the recovery of aluminum from secondary scrap and from dross. The furnace consists of a fixed axis refractory-lined cylinder, which is rotated during the process. Energy is supplied by a burner flame. In the last ten years, adapting oxygen-fuel burners to the RSF has been 'state of the art technology'. However, large amounts of salt-flux are used in this process. The addition of salt flux is balanced so that a liquid salt slag forms with the oxides in the aluminum scrap or dross charge. The amount of salt added is approximately proportional to the amount of oxides in the batch. The use of a liquid salt slag is referred to as the 'wet-process'.

One major disadvantage with the wet-process and the RSF is the high levels of salt-flux required. This generates large amounts of salt slag waste products, which add significant costs to production both from salt purchase and from the recycling or disposal of salt slag. Increased environmental concern has also meant that these costs are increasing. Salt slag dumping is also being prohibited in some areas. Costs and productivity are also negatively affected by the additional extra energy required to melt the salt. The disadvantages are greatest in the processing of dross. This is due to the high oxide content in the charge. As a result of this, the industry began to look for alternative processing techniques to reduce the amount of salt used in dross melting. In the early 1990's AGA and Hoogovens Aluminium in Voerde, Germany developed, patented and put into commercial operation Alurec, a rotary furnace process for melting dross without the addition of salt [1]. The current trend in the industry is to use the dry-process in dross melting. The amount of salt required is reduced by more than 50 % and gives a solid (dry) salt slag. The rotary furnace is tilted to allow the dry salt slag to be discharged.

URTF and Wastox development

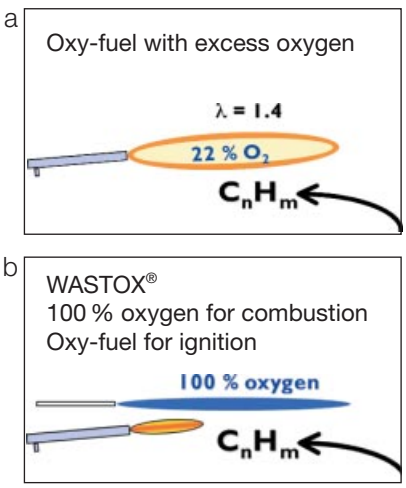
The Universal Rotary Tiltable Furnace (URTF) was developed to allow the dry process and the use of tiltable rotary furnaces in the melting of secondary aluminum scrap to be taken further. Linde Gas, Hertwich Engineering GmbH and Corus Aluminium Voerde GmbH (formerly Hoogovens Aluminium) joined forces to develop the URTF. The URTF has been designed for both dross and secondary scrap melting. It is based on the use of the dry salt method and advanced oxy-fuel combustion systems. The URTF therefore uses low levels of energy and low levels of salt and generates only small amounts of waste products (table 1).

Table 1: Process data for melting aluminum scrap in rotary furnaces. The data is dependent on the type of scrap processed.

Furnace	Process	Salt addition [kg/t]	Slag [kg/t]	Fuel consumption [kWh/t]
Fix axis furnace with oxy-fuel burner	Wet	200	400	500 (1000*)
URTF	Dry	0–70	180–250	350

Secondary scrap contains organic contamination, such as lacquers and oils. These evaporate during melting giving emissions that can have a negative effect on the environment and productivity. The industry uses a number of methods to deal with this problem. For example, by limiting both the amount of organic material in the batch and the melting rate. The Wastox combustion system is used in the URTF to optimize and control the combustion of organic contamination inside the furnace. This gives better energy utilization and lower emission levels. The Wastox system is developed and patented by Linde. It uses separate oxygen lances to combust emissions in the URTF. The oxy-fuel burner is used in tandem with the oxygen lance to ensure ignition and to balance the energy input to the furnace. The oxygen lances are controlled by continuous flue-gas analysis.

The use of separate oxygen lances has several advantages over firing the oxy-fuel burner with overstoichiometric amount of oxygen. The separate oxygen lances gives greater flexibility. Separating the extra oxygen from the burner allows the direction of the burner flame and oxygen lance to be controlled individually and the use of a higher level of oxygen flow. Combustibles meeting and reacting with a pure oxygen stream is believed to provide higher levels of efficiency than reaction with an oxygen enriched oxy-fuel flame. This is illustrated in fig. 1. A pilot plant study reported by VAW [2] showed lower levels of organic emissions when a separate oxygen lance was used when compared with an oxy-fuel burner with overstoichiometric flame. Good process control and rapid process information feedback are important in achieving optimum operation levels for the low salt and salt free melting methods. The control of the URTF has been developed during several years of experience with salt free melting in the Alurec process and uses the latest in computer control.



Figs. 1a to 1b: Schematic comparison between oxygen enriched oxy-fuel flame and separate oxygen lance; Oxy-fuel with excess oxygen (a); Wastox 100 % oxygen for combustion Oxy-fuel for ignition (b)

Implementation of URTF and Stena Aluminium

Stena Aluminium is a major European supplier of foundry ingots. It operates plants in Kolding, Denmark and Älmhult, Sweden. Aluminum scrap is recycled at both plants by re-melting, refining, alloying and casting. AGA Gas AB (a member of the Linde group) and Stena Aluminium have a long history of co-operation. They also have many years of experience in the development of oxygen enhanced melting in the RSF process, including several field tests with secondary scrap at the Alurec plant in Voerde. In 2001 Stena Aluminium decided to replace one of the RSF furnaces at the Älmhult plant with a URTF from Linde and Hertwich Engineering. Stena Aluminiums high competence in aluminum recycling was important for the realization of the project. The new furnace was commissioned in August 2001.

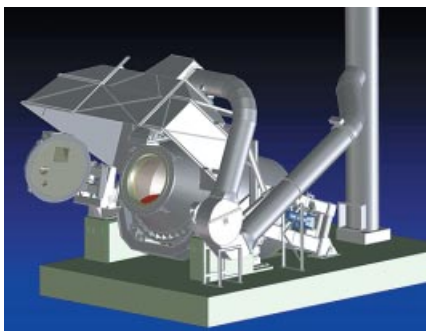


Fig. 2: CAD drawing of the URTF 12

The URTF 12 operated by Stena Aluminium is shown in fig. 2. It has a useful furnace volume of 12 m^3 and can accommodate up to 23 tons of aluminum scrap per furnace cycle. The melt rate is 6 tons scrap per hour. The furnace tilting range is –20 deg to +40 deg. A unique feature is that the furnace can be operated at various angles in the –20 deg to –10 deg range. This enhances quick charging at –20 deg and a range of operating angles during melting. Two drive units rotate the furnace drum, one is built in redundancy.
A 4 mw oxy-fuel burner provides the energy for melting and heating the charge. Additional energy is provided by the system. The system consists of three oxygen lances and a laser technology based flue-gas analyzer. The positions of the oxy-fuel burner, the lances and the flue-gas analyzer are illustrated in fig. 3. The flue-gases are led into the furnace hood and are cooled by ambient air.

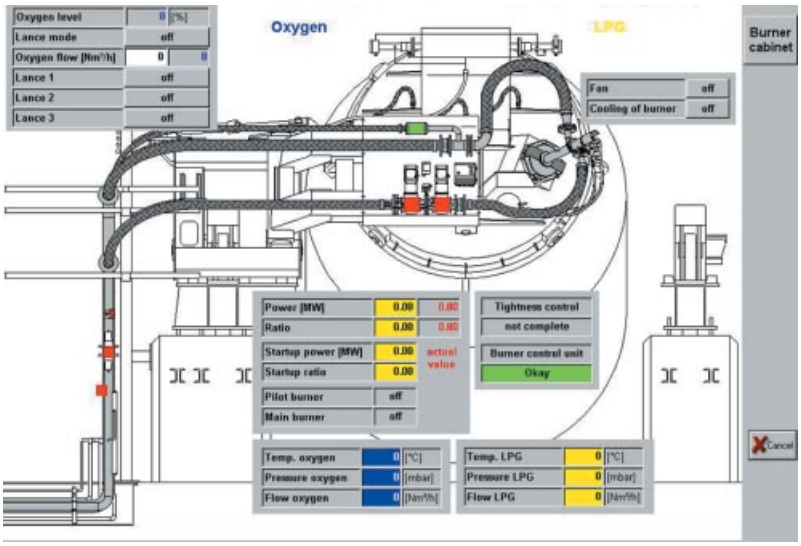


Fig. 3: Furnace door. Indicating positions of the oxy-fuel burner, the lances and the flue-gas analyzer

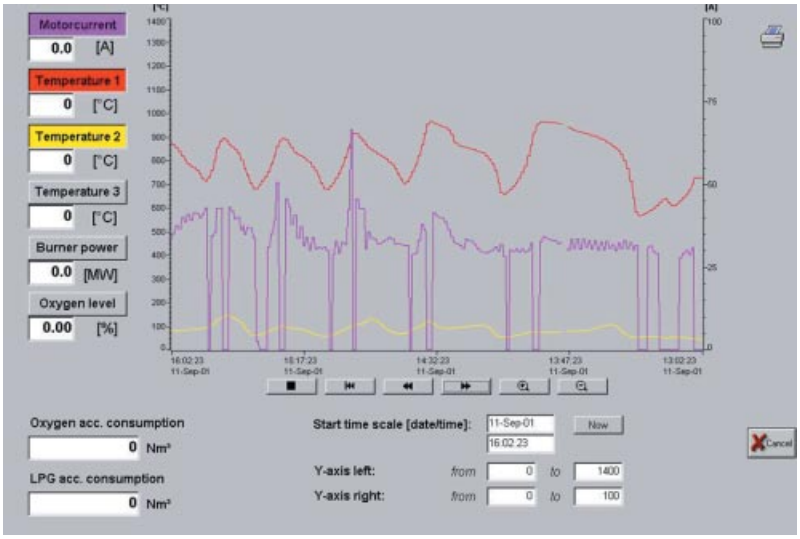


Fig. 4: On-line display of process data from URTF 12

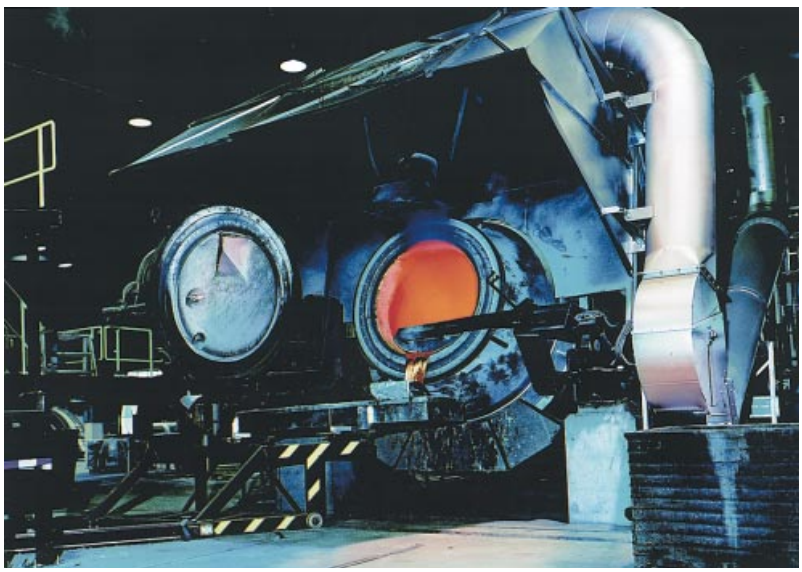


Fig. 5: Metal tapping from the URTF 12 at Stena Aluminium

The URTF 12 is equipped with an advanced PLC control system. It controls all mechanical movements and the oxy-fuel burner and oxygen lance settings. It also has recipe management and operator menu systems. Two 15-inch color screens display information. The recording and display of process data is of vital importance to URTF operation. It provides on-line information on the melting process in the furnace. The following data are displayed as trends (fig. 4).

- ❒ Flue-gas temperatures,
- ❒ flue-gas monitoring,
- ❒ torque for rotation of the furnace drum,
- ❒ rotation speed,
- ❒ burner power.

The furnace is charged 4 times per cycle with in total up to 23 tons of scrap. All functions are automatically controlled. To tap the metal, a launder is moved in front of the furnace (fig. 5). The metal is transferred to a holding furnace for refining and alloying before being cast to pigs on a conveyor belt. All process steps, including metal and salt cake tapping, are operated remotely from the control room. The URTF operation therefore uses a minimum level of manpower.
The effect of the use of oxygen lances is shown in fig. 6. The flue-gas was analyzed at the small chimney on the furnace door before it is quenched by ambient air. Contaminated scrap was heated by a 2 mw oxy-fuel flame, using 50% excess oxygen. At this point gas analysis measurements showed 45% of CO_2, 25% of CO and less than 2% oxygen. When the oxygen lances were turned on the CO content dropped, the CO_2 content immediately increased and the oxygen content remained unchanged. The graph clearly shows that the oxygen added reacts with CO to form CO_2 inside the furnace.
After 5 months of operation the performance of the URTF 12 was evaluated. Compared to the RSF it was concluded that the URTF 12 gave improved metal recovery, 40% reduction in fuel consumption and a 70% reduction in salt addition. The results with the URTF 12 at Stena Aluminium have been very successful and fulfilled all expectations.

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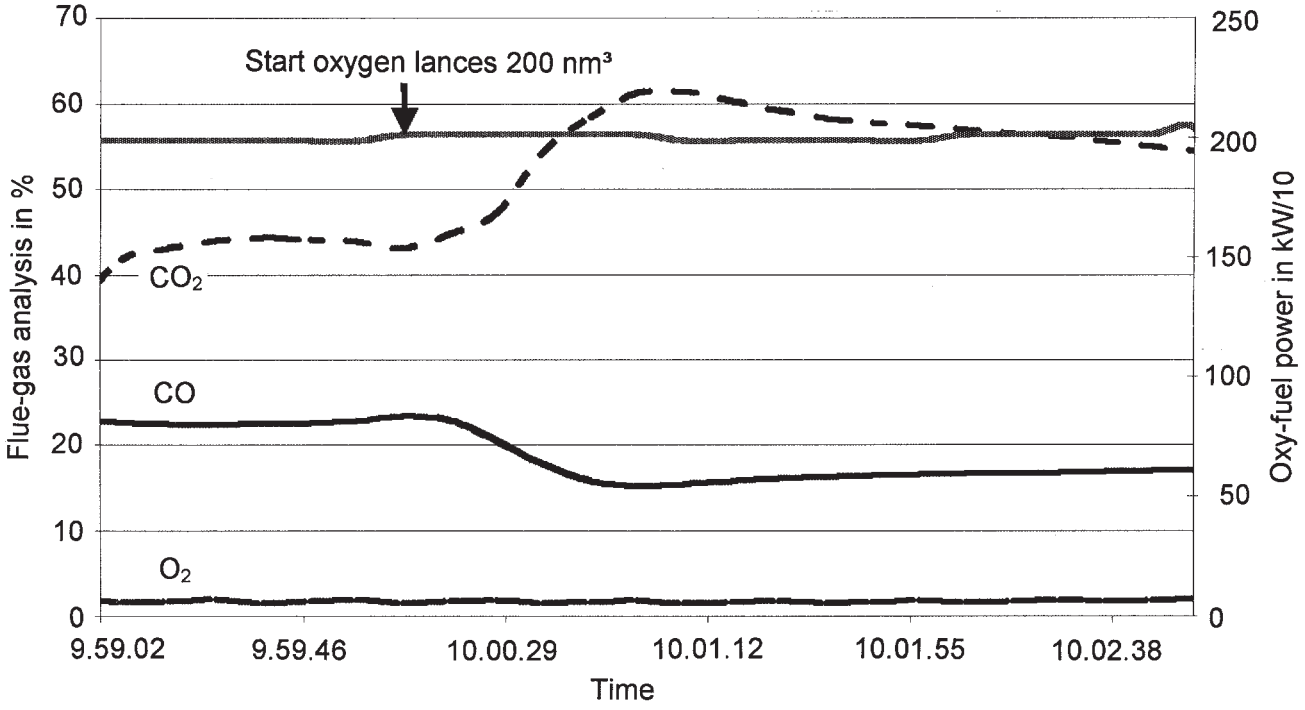

Fig. 6: The influence of Wastox lances in the URTF 12 while heating with a 2 mw oxy-fuel flame fired at λ=1.5.

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Authors

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