

Storvik's Casting and Holding Furnace Tending Tools and Best Practices

Helgi Magnússon

Managing Director

Storvik Iceland

220 Hafnarfjordur

Corresponding author: helgi.magnusson@storvik.is

Abstract

Storvik has been servicing the aluminium industry globally for many years and has been focusing on identifying and developing improvements and cost saving projects that can benefit all our customers.

One of those very successful projects is our “standardized” cast iron furnace tending tool line-up and standardizing best practices in furnace tending.

Storvik's development of the tool line-up was done in close cooperation with the end users to ensure the absolute best result and customer satisfaction. Storvik has proven in cooperation with our customers that implementing our tools and best practices generates savings in the following areas: Tooling cost, energy savings, dross handling, furnace maintenance cost, etc. In addition, our tools and best practices greatly reduces HSE issues around the conventional furnace tending, the furnace area is rated to be one of the highest HSE risk area in the Aluminium industry.

Keywords: Cast iron casting and holding furnace tending tools, best practices, process improvements, reduced traffic in furnace area, improved HSE.

1. Introduction

Cast house furnaces can be found in many shapes and sizes within the aluminium industry, they might be using gas as fuel or be electrically heated, but in the end, they all serve the same purpose of re-melting, holding and casting, they also all need basically the same furnace tending.

Metal handling to and within the furnaces basically consists of metal transfer, alloying, stirring and finally skimming of dross from the top of the metal in the furnace, the dross formation is sadly an unavoidable and costly by-product that all cast houses need to deal with. As stated in [1]:

“Aluminum dross is generally valued on a recovery basis, which necessarily involves accurate sampling and evaluation. Since most drosses are a heterogeneous mixture of large lumps, fine oxides, and small pieces of metal, sampling and assaying requires considerable work and experience.

Aluminum dross is a mixture of free metal and nonmetallic substances (e.g., aluminum oxide and salts). Aluminum nitrides and carbides may also be present, as well as metals oxides derived from the molten alloy. The free-metal content of the dross depends on how carefully skimming from the melt was executed, the composition of the molten alloy, the fluxing, and the dross-cooling process.”

Tables 1 and 2, show an example of chemical composition of dross.

Table 1. The range of physical and chemical properties measured [1].

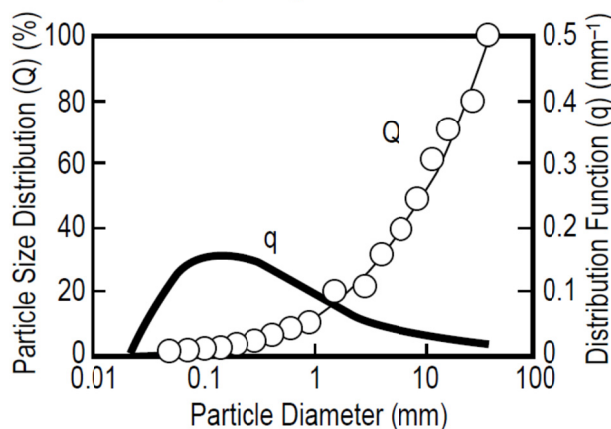
Properties	Granular Dross	Compact Dross
Alloy Content (%)		
Melt	2.44–11.77	1.34–10.03
Recovered Metal	1.03–5.51	0.33–6.80
Distribution(q) (mm ⁻¹)	0.08 (coarse)–0.452 (fine)	—
Density (t/m ³)	0.828–1.118 (bulk)	2.396–2.528 (apparent)
Metal Content (%)	46.9–69.1	71–93
Lixivate (pH)	9.52–10.14	9.03–9.48
Salt Content (%)	0.18–6.21	0.01–0.03
Gas Evolution (l/kg dross)	0.25–1.17	No evolution

Table 2. An example of a dross identity card [1].

Bulk density: 0.975 t/m³, Metal content: 61.8 %, Leaching test: pH: 9.80, Electrical conductivity σ = 0.912 S/m, Salt content: 2.8 %, Gas evolution: 1.7 L/kg dross.

Dross No. 1, Granular	Mg	Si	Cu	Mn	Cr	Fe	Zn	Ti
Melt Specification: AlMg3, 3.3535, DIN 17257								
Maximum	3.60	0.40	0.10	0.50	0.30	0.40	0.20	0.15
Minimum	2.60	0	0	Mn + Cr = 0.6	0	0	0	0
Melt Composition (Alloying Metals = 3.60%)	2.79	0.12	0.05	0.22	0.03	0.30	0.06	0.03
Composition of Recovered Metal (Alloying Metals = 1.05%)	1.01	0.37	0.09	0.15	0.02	0.29	0.11	0.03

Particle Size Analysis: q = 0.155, medium



Storvik’s investments in R&D and improvement projects has been generating many interesting new products for the aluminium industry, just to name a few from the same category as the main focus of this paper. Figure 1, shows samples of the products:

- Tapping tubes with improved design and lifetime
- Furnace spouts with improved design and lifetime
- Moulds with improved design and lifetime
- Tools with improved design and lifetime
- Crucible lining with improved design and lifetime
- Etc.

All the items mentioned above have in common to be categorized as consumables, which are fully or partly consumed in the processes, this again means that those items are a part of the fixed running cost of each operation. This fixed running cost is understandably one of the key elements that all managers and middle management is focusing on to somehow reduce. The low hanging fruits for cost savings on consumables like these is firstly best practices, then secondly by improving the products by redesigning, using alternative materials, etc., to increase lifetime of each consumable in question. The optimal results will be from combining best practices and improved product.



Figure 1. Samples of products: From left to right - metal tapping tube, furnace spout, sow mould, alloying cage and cast iron lining for bath crucible.

2. About Storvik

Storvik's headquarters are located in Sunndalsora in the mid-western part of Norway, situated beside the biggest primary smelter in Europe, Hydro Sunndal. Being a neighbor and a service provider to the local smelter for more than 60 of the 104 years in its history has dictated the company's main focus on the aluminium industry. Storvik has subsidiaries in several locations, two more locations in Norway, Mosjoen and Kristiansund, then also in Prague in the Czech Republic and in Reykjavik Iceland, our main production facilities are in the Czech Republic. Storvik's history dates back to 1913 and was founded by a local black smith named Nils Storvik. Figure 2 shows him working in his smithy at Viklandet, Sunndalsoera. Storvik provides multidisciplinary services, products and projects to Norwegian and international primary and secondary aluminium industry, which is the main market. Storvik, also delivers projects and products to oil and gas industry and hydro power stations.



Figure 2. Mr. Nils Storvik in his smithy.

3. Furnace Tending Tools

In 2012 we at Storvik started to investigate the possibility to develop “standardized” tool line-up for furnace tending, both for holding- and casting furnaces, as we had already developed our own materials from cast iron with high resistivity towards corrosion it seemed the obvious material choice for this R&D project. Our initial goals for the project were as follows:

- Standardize tool designs
- Design tools with extended lifetime
- Design simple fastening system
- Tools should be gentle on the refractory
- Finding optimal shape for each tool for maximum effectiveness

Our initial goals for this project seemed rather bold to start with, standardizing design, to develop an off the shelf product to fit all, to achieve extend lifetime we needed to make sure our materials would handle this harsh and demanding environment, the chemical erosion and at the same time have sufficient mechanical properties to handle the unavoidable mechanical stresses the tools are subjected to in normal use, we needed to come up with a simple and strong connection method to connect the non-weldable material tools to the regular mild steel booms in each location, we needed to make sure that our tools had no sharp corners that could damage the refractory lining inside the furnace and find the absolutely optimal shape for each tool to maximize its efficiency. We soon realized that we were also facing the following challenges:

- Various shapes and sizes of furnaces
- Various equipment used for tending, lift trucks, wheel loaders, specially designed furnace tending vehicles (FTV’s), etc.
- Various furnace tending tools, usually fabricated from mild steel (Figure 3)
- Operators are used to doing the tending in a certain way.



Figure 3. Skimming with mild steel tool.

4. Design

As we started our design work, we set out to reach a certain lifetime on our tools, the reference for our stir tool was to reach similar lifetime as refractory type stir tool, which had a lifetime of approx. 4 weeks at our test location, mild steel stir tool had approx. 5 days lifetime at the same test location, the reference for our skim tool was a mild steel skim tool which had a lifetime of approx. 4 weeks and our aim was to reach up to 15 weeks, and finally the reference for our alloying cage was a mild steel alloying cage at our test location that had a lifetime of approx. 4 days, our aim was to reach approx. 4 weeks lifetime.

5. FEM Analysis

We started out with designing our tools using sophisticated computer software to do in depth analyses and simulations, possible deformation, thermal stresses, safety factors, flow analyses etc. see samples of simulations below (Figures 4 and 5):

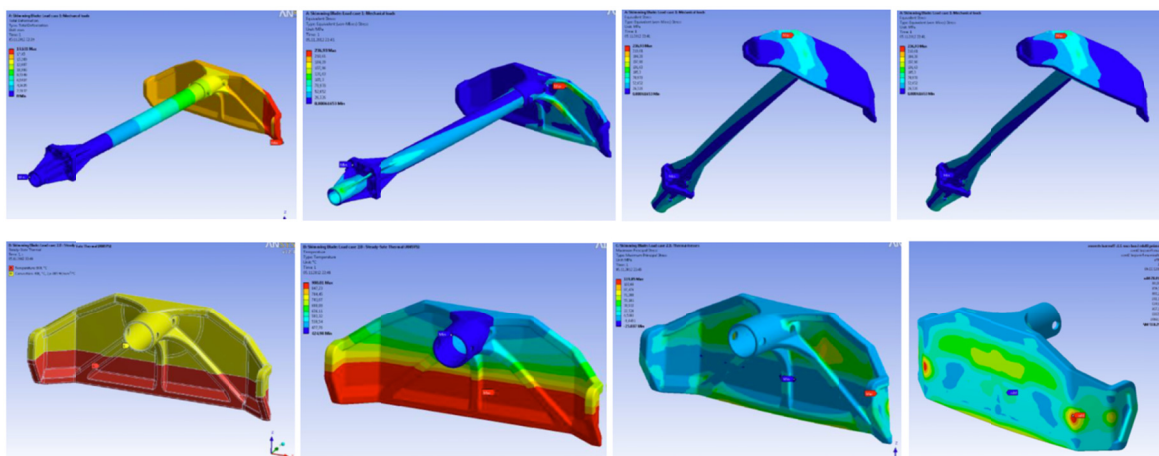


Figure 4. Thermal and stress analysis of Storvik's cast iron skim tool.

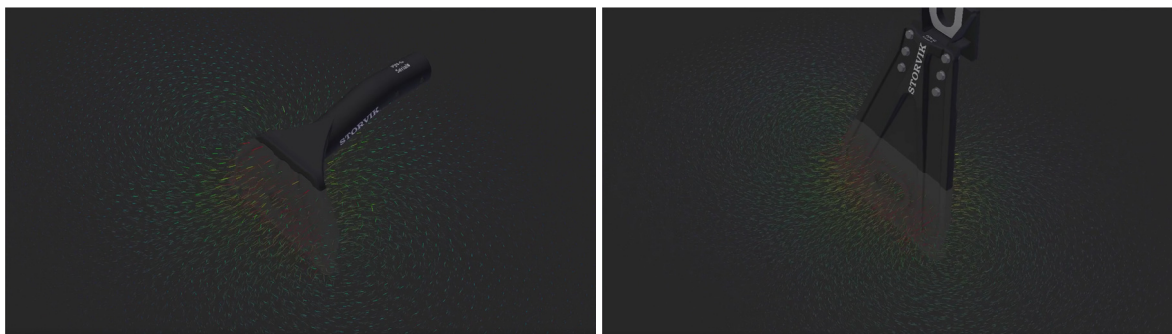


Figure 5. Flow simulations of Storvik's cast iron stir tools.

6. Trial and Error

Even though we did all possible computer simulations before starting real life tests on the final product, we still needed to go back to the drawing board with some major and minor adjustments several times before reaching our goals, this was a long and tedious process at times as the process of doing changes on big cast iron pieces like that is rather complicated, first changing the design, update the drawings, then changing the cast pattern accordingly, casting new specimen, shipping out to the test site and then monitoring the affects, which could possibly have the opposite affect to what you hoped for. Anyway, this is more or less the normal road in product development, luckily, we had skilled operators testing our initial tools and they contributed a lot on the final designs.

7. Results

We can say that it took us more than 4 years to fully develop our tools and reach our goals, actually we ended up exceeded all our goals, our initial test site is now getting up to 9 weeks lifetime from our stir tool, lifetime of skim tool at this same test location is up to 8 months lifetime, lifetime of alloying cage is up to 8 weeks in initial test site, results from all our customers are in line with those lifetime results. In addition to extended lifetime, our new skim tools are more effective than conventional straight mild steel tools, due to its special wing shape ends, which ensures that no dross trails are left behind at the side of the blade, see Figure 6. Another important feature of our skim tool design is that it is taking less metal out with the dross due to a small gap it leaves up to the furnace ramp, to allow flow back of the metal from the dross, see Figure 7. Our new stir tool is has proven more effective on stirring than a conventional straight stir blade due to its special shape and the hole in the middle, which adds considerably to the stirring effect of each stroke (this has been verified with flow simulations and actual stir time measurements in a controlled test environment), upper area of stir tool is specially shaped to minimize creating top waves or turbulence at the top of the metal to reduce dross formation while stirring. This results in quicker skimming and stirring time, saving energy due to shortened opening time of furnace, extended lifetime of furnace refractory due to reduced thermal cracking around furnace doors. Both the skim tools and the stir tools have a simple two bolt fastening system for easy exchange of tool on the tool holders/tool booms. We have now assembled detailed training material to ensure best practices with our tools to optimise the furnace tending

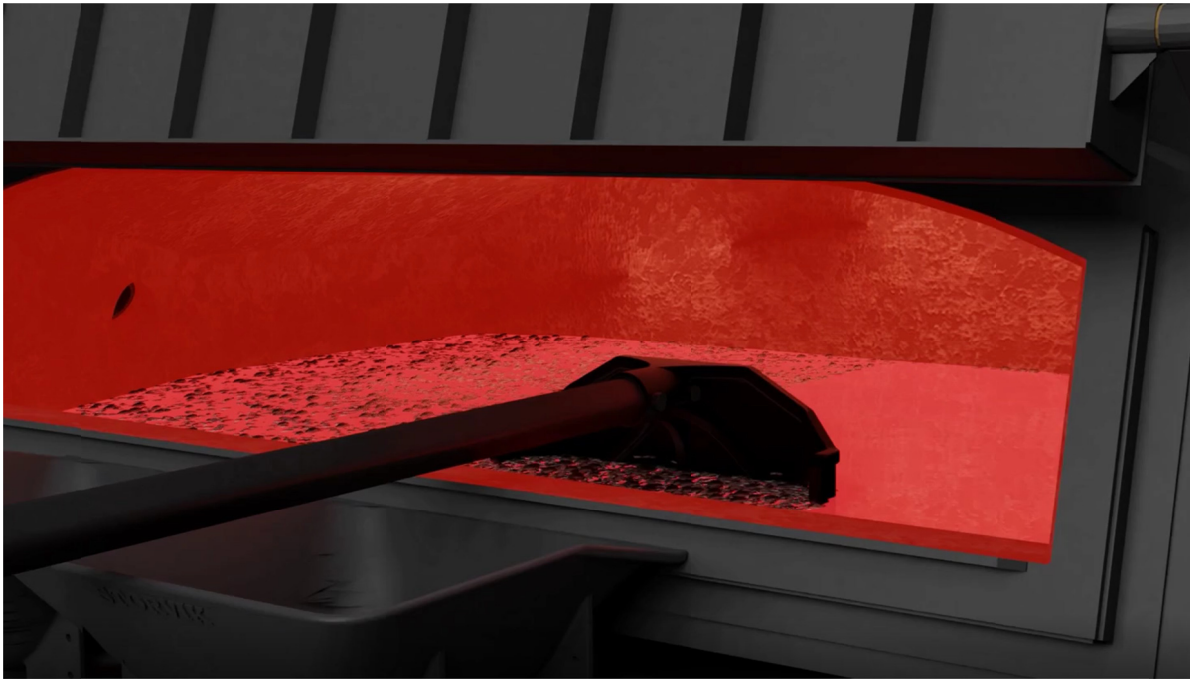


Figure 6. No side trails left at skimming.

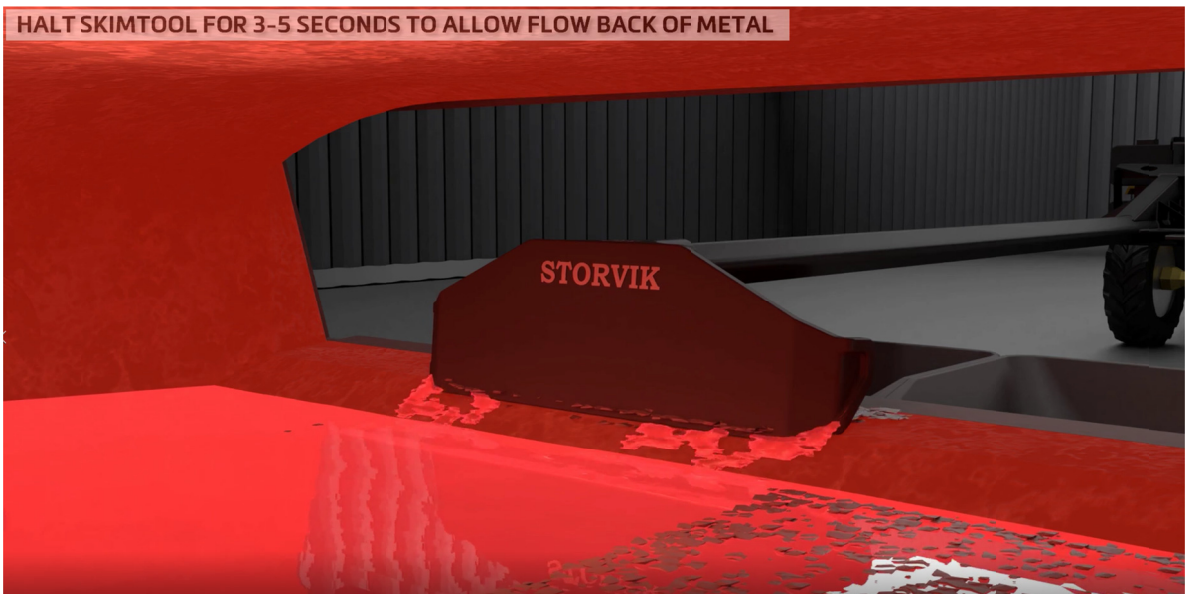


Figure 7. Flow back of metal from dross.

8. Product Line-Up Today

We soon found out, when we had designed the basic shapes and reached the optimal effects of each tool, that we would need to offer several variations to of each tool to accommodate the majority of our customers, due to the differences in equipment used and also due to various furnace sizes and shapes, our line-up now consists of 13 different tools which we believe can accommodate most casthouse furnaces, both for primary and secondary aluminium producers (Figures 8 – 13).



Figure 8. Skimming process with lift truck.

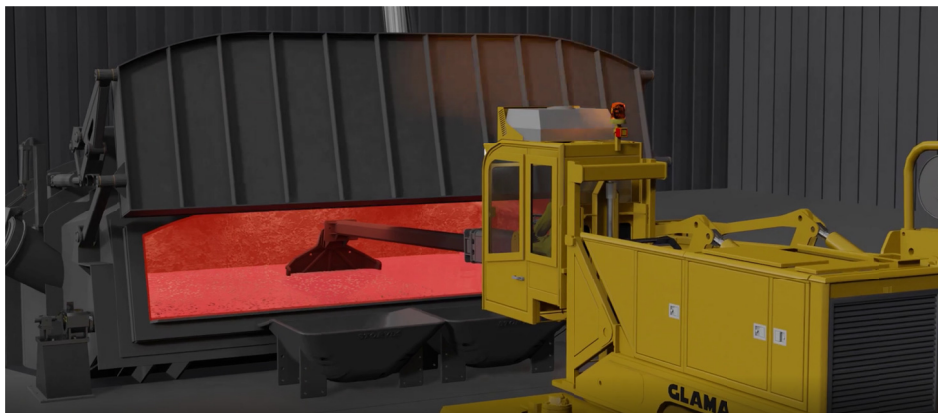


Figure 9. Skimming process GLAMA (FTV).



Figure 10. Skimming process with wheel loader.



Figure 11. Stirring process with wheel loader.



Figure 12. Stirring process with wheel loader.

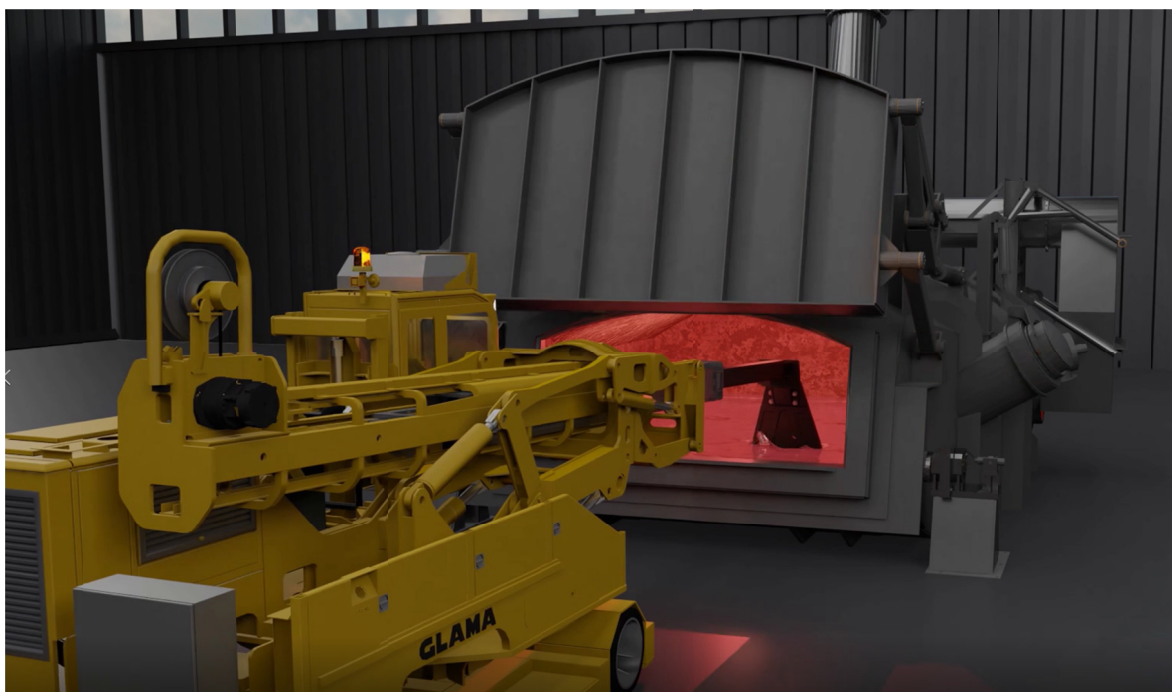


Figure 13. Stirring process with GLAMA (FTV).

9. Conclusions

Customers, which have fully implemented Storvik's furnace tending tools and best practices, have documented the following:

- Less tooling cost
- Shorter preparation time of furnaces
- Less dross formation
- Less metal in dross
- Energy savings
- No iron contamination from tools*

*Iron contamination from regular mild steel furnace tending tools can be a big problem for some producers as some alloys need to have extremely low iron content, which can be hard to achieve, especially for the aluminium recycling industry which in many cases is already fighting with iron contaminated scrap, too high iron content can also occur in the primary sector in case of unsteady pots in the pot rooms (often happens after power outage or other electrical interference).

10. Reference

1. O. Manfredi, W. Wuth and I Bohlinger, Characterizing the physical and chemical properties of aluminum dross, *JOM*, November 1997, 48-51.