GRANULATION OF FERROALLOYS – RESULTS FROM INDUSTRIAL OPERATIONS AND COMPARATIVE STUDY ON FINES GENERATION

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ABSTRACT

To meet the needs from ferroalloy producers and the consuming steel makers, the GRANSHOT metal granulation process and the granulated ferroalloy have been found to have several important properties. The GRANSHOT process is an industrial and high capacity solidification process replacing the traditional and extensive casting, crushing and sieving operations in ferroalloy production. The process also has a minimum of fines and losses of the high cost ferroalloy product. Granulated ferroalloy is a homogenous and clean product which meets the increasingly stricter demand for cleaner steels. Steel makers requests alloys to have a shape and size which is suitable for automatic handling and use into any metallurgical processes. Today granulated ferronickel is the standard format for the market. This paper will present results from ferroalloy granulation, proven in over 20 installations, as well as a comparative study on the lower fines generation of a granulated vs. a crushed ferrochrome material.

Key words: solidification, granulation, ferroalloy, ferrochrome, ferronickel, GRANSHOT, fines

1 BACKGROUND – LOW PERFORMANCE SOLIDIFICATION

Ferroalloy producers have often used pan and sand bed casting (fig 1, left), followed by cooling, crushing and sieving for the solidification and production of ferroalloy products for the market. This is both a time consuming and labour intensive process with poor yield performance.

Figure 1. Dry-pit or pan casting (left) & crushing of ferroalloys results in high levels of fines. Dust-like FeCr 0-10 mm fines (right) has limited value in steel making.

The ferroalloy would also pick up impurities when casted. This procedure also causes in-homogenous material analysis since casting is often done in several layers and material is mixed during the crushing and packaging process.

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Fines of 0-10 mm crushed product, often as a dust-like material, is recycled back into the casting or melting process or available as a discounted product to the steel plants, fig 1, right. Such fines are also produced during transport to and during handling in the steel plant. Such fines results in logistical problems and to the actual end-users, i.e. steel making process operators, the dust-like fines are considered difficult since they are not suitable for automated handling as well being a health hazard to the staff. Authorities are also on the move to monitor and control dust type FeCr residues that are lost during handling and transport.

2 GRANSHOT METAL GRANULATION PROCESS

As a reply to the need for alternative solidification process with higher efficiency and higher capacity, the GRANSHOT process was developed in the 1970s. Here, liquid hot metal first arrives into the tundish, from which it exits at a controlled flow rate to hit a refractory sprayhead, where the hot metal stream disintegrates into droplets, distributed evenly over the entire granulation tank surface, figure 2, left.

Figure 2. Hot metal hits the refractory sprayhead, producing droplets (left), cooled in water tank below as to make solid granules, here FeCr (right).

The droplets are immediately cooled when entering the water volume. The ejector transfers the granules from the tank to the dewatering unit where water is mechanically removed down to approximately 1%. The total process, from entering into the granulation unit and exiting the dewatering section, has so far only taken 30 seconds. The compact and stand–alone granulation unit is completely automated, allowing one person to control the process while another person handles and supervise the hot metal handling.

2.1 FERROALLOY GRANULE PROPERTIES

The granulated ferroalloy has a spherical and deformed shape, fig. 2, right, typically within 4 to 25 mm without any dust-like content. This can however vary some depending on the composition of the metal. SLN states a size range of 4-60 mm for their granulated FeNi material [ref 1] while Samancor reports typical 4-25 mm for their MC FeCr material [ref 2]. Granules can be handled by front-loaders, magnets or conveyor as to enter the granules into the metallurgical process, preferably continuously or batch wise. The granulated product has a high bulk density, typically 3500-4500 kg/m^3, to penetrate the slag layer during addition, while the shape and size allows for rapid melting and dissolution in the hot metal bath.

The analysis of the granule is homogeneous and identical to the metal fed into the granulator and without the variations in composition that is obtained when casting in sandpits or pans.

2.2 GRANSHOT in Ferroalloy Installations

The huge number of GRANSHOT installations, today well over 40, whereof 20 in ferroalloys, fig 3, has resulted in a wealth of accumulated experience within UHT as to deliver economically viable metal granulation processes:

- High capacity granulation 2-3 tonnes/min, fits the needs in ferroalloy production,
- A minimum of metal loss, typically less than 0.5 % and no formation of dust
- Repeatable and industrial process due to rugged design and full automation
- Ease-of-use with an equipment availability of up to 98% and a minimum of staff

Figure 3. FeNi granulation at VALE Onca Puma, Brazil (left) and granulation of FeCr at SAMANCOR Ferrometals, South Africa (right).

3 COMPARATIVE STUDY ON FECR FINES GENERATION

3.1 Objective of Study

The study aim to simulate the generation of fines, here defined as material less than 4 mm, which are generated during the FeCr producers handling, packaging and loading as well during transport. Such a studu should also take into account fines generation during repacking in intermediate storehouse and finally fines generated at the end-user by internal transport, handling, storing and entering into metallurgical process.

To do so it is necessary to define a test and to produce comparative data as to describe the difference of fines generation, from handling and transport of the purchased 10-50 mm HC FeCr product with that from granulated HC FeCr.

3.2 Test Procedure

A survey found no existing test procedure for the comparison of fines generation during production, handling and transport of HC FeCr. It was decided to compare the differences between the two materials using an in-house tumbling test.

The tests use a construction-site type concrete mixer for the tumbling tests, fig 4. The time for tumbling is set long enough, 30 minutes, as to ensure that loading and operation of the mixer would not have any impact on measured values. After the tumbling, sieving is performed. Commercial grade 10-50 mm HC FeCr (C 7.0%, Si 2.05%, Cr 61.6%) was acquired for the

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tests. Such standard material is casted, crushed and sieved as to achieve the required fraction size of 10-50 mm.

Figure 4. Tumbling of granulated HC FeCr

This material is to be defined as “crushed” in text, tables and figures. Three 20 kg batches of this material were sieved as to define the actual fraction before and after tumbling. In this commercially purchased 10-50 mm HC FeCr, it was found after the initial sieving (before tumbling) that there was some material with sizes below 10 mm, fig 6. An average value of the 3 different batches is represented in each diagram.

Some HC FeCr was melted and granulated by the GRANSHOT process as to establish three batches of 20 kg granulated HC FeCr, fig 5, right. The granulated HC FeCr has a bulk density of 4.14 tonnes/m^3. It was produced in the UHT pilot granulation plant, figure 5, left.

Figure 5. HC FeCr melted in Pilot granulation unit (left) to produce FeCr granules (right).

Sieving was also done as to establish the typical fraction of the granulated and ready-to-use HC FeCr material that directly comes out of the GRANSHOT process, fig 5, right. The initial sieving, before tumbling, showed that 91% of this material is larger than 8 mm size and 99% are larger than 4 mm, fig 8 (Start). It was decided to keep all fractions, including the smaller sizes, of the granulated HC FeCr in the following tumbling test, which is one difference compared to the crushed HC FeCr which is a sieved and delivered as a 10-50 mm sized product.

3.3 Results after 30 minutes Tumbling

3.3.1 Material Size

After 30 minutes of tumbling crushed, it shows that crushed HC FeCr generates fines (<4 mm) at a level of 6 % and with losses of 1.4%, fig. 6, 8, 10 (left).

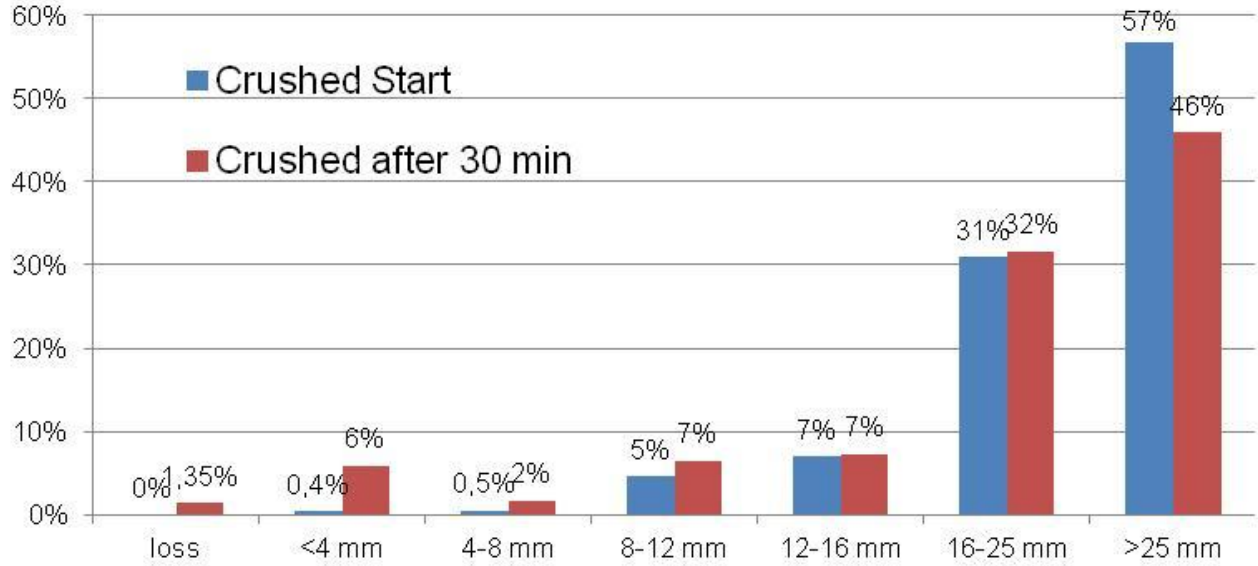

Figure 6. Percentage (%) of size fractions of Crushed HC FeCr, before (Start) and after 30 minutes after tumbling.

Some losses were expected since the mixer is not a closed system and this indicates that crushed HC FeCr has been grinded down to dust like appearance and are lost during test phase. It is clearly seen that the large crushed material pieces are rounded off, producing fines and dust type residues, fig 9 (right) and fig 10 (left).

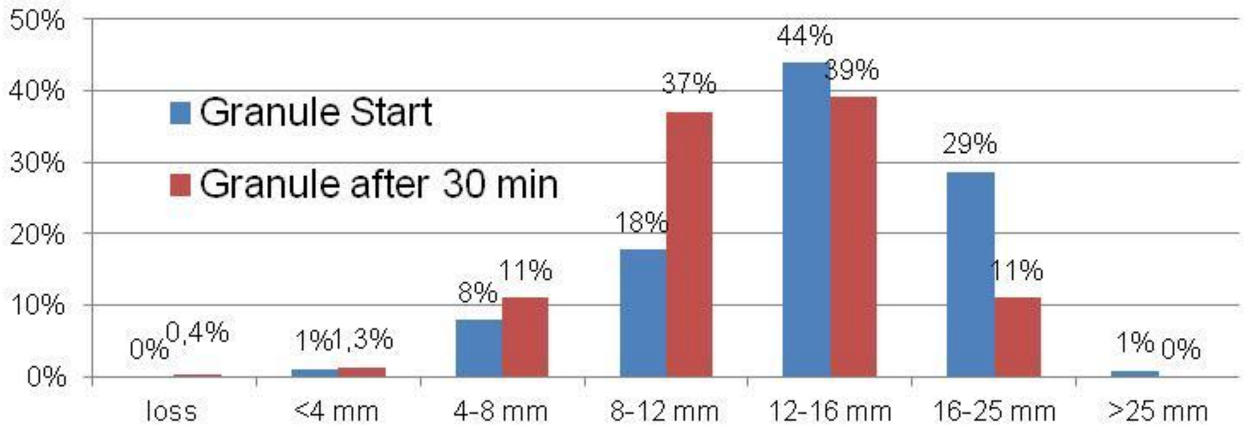

Figure 7. Percentage (%) of size fractions of Granulated HC FeCr, before (Start) and after 30 min of tumbling.

After 30 minutes of tumbling of granulated material it showed limited fines generation, (fig.10, right) it increased from already existing 1% to 1.3%, thus an increase of 0.3%, larger granules are seen to break into two large solid parts, fig. 7, fig. 11.

When comparing the data for fines and losses generated during the tumbling for Crushed and Granulated HC FeCr, fig. 8, it is seen that crushed material are at a 10 times higher level.

	Crushed	**Granules**	**Factor (Crush/Gran)**
Fines before Tumbling	0,4%	1%	x
Fines after Tumbling	6%	1,3%	x
Fines from Tumbling	**5,6%**	**0.3%**	**18**
Loss	**1.4%**	**0.4%**	**3,5**
Total	**7%**	**0.7%**	**10**

Figure 8. Percentage and Comparison Factor of tumbled HC FeCr

It can be noted that the fines and dust generation during production of crushed and sieved 10-50 mm HC FeCr is not included in this investigation but it is reported to be at high levels, well in the range of 10-15%. Some of is returned back into the process or sold but as much as 3-5% is considered a process yield loss. For granulated FeCr this figure is around 0.5%.

Figure 9. Crushed HC FeCr before (left) and after 30 min tumbling (right).
All sharp edges of the crushed material are removed.

Figure 10. After 30 min of tumbling, fines of crushed (left) and for granulated HC FeCr (right)

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Figure 11. Granulated 16-25 mm HC FeCr after 30 min tumbling. Still the same shape of granule with some broken into two pieces.

3.3.2 Material Analysis of Crushed and Granulated HC FeCr

Samples of crushed and granulated HC FeCr were taken and it showed that no changes of analysis took place during the remelting and granulation of the HC FeCr. This is in line with our experience that the rapid quenching and cooling processes during granulation conserves the original product analysis.

4 CONCLUSIONS

The result of the study showed the following;

- The size of the granulated HC FeCr is the direct output of the GRANSHOT process. These granules are to almost 99% over 4 mm size and there is no dust generation. The shape, weight and size as well as the homogenous and clean analysis of the granulated material are ideal from logistical and metallurgical point of view. Some large HC FeCr granules were during tumbling broken into two pieces but with no major fines generation.
- Tumbling of crushed HC FeCr generates fines and losses at some 10 times higher levels compared to granulated HC FeCr. The combined figure of material losses and fines (<4mm) was reported a total of 7 % for crushed material as compared to 0.7% for granulated material.
- The tumbling tests in this study do not represent actual generation of fines in the industry during production, transport or at end-users, it however serves as a good indicator that there a significant difference between the crushed and granulated HC FeCr when it comes to dust and fines generation.

5 DISCUSSION

The results from this conducted study comply well with UHT experience of the increased production and use of granulated ferroalloy. The granulation process and resulting metal granule support three strong trends in current modern steel making.

Request for Automated and Simple Raw Material Handling

Granulated and dust free alloying material used into a metallurgical process is highly suited for automated handling and feeding. This also has benefits at the ferroalloy production site where material can be handled by conveyors, silos and front-wheel loaders, fig 12, left.

Figure 12. Granulated ferroalloy can be handled by conveyors and silos (left). Tapping directly from the furnace to the GRANSHOT unit saves on operational cost (right).

Increasingly Cleaner Steels

The need for increasingly better steel grade products and higher quality levels requests raw material, such as granulated ferroalloys which has homogenous composition, a minimum of pollutants or oxides and rapid melting properties. As many ferroalloy grades, especially low carbon grades; LC FeNi, LC FeCr, are added at the very final stages of the steelmaking process, then requirements on cleanliness becomes even more important, since little time for removal of impurities are available. The granule size and shape also favour rapid and complete dissolution in the melt.

Strict Cost Control

With rising material cost and fierce competition, cost control is as vital as ever. It becomes important to further reduce any possible yield losses during production of ferroalloys but also ensuring that all of the ferroalloys really enter the metallurgical process. Granulation of FeCr is a cost effective solidification process that results in a high yield ready-to-ship product, also saving costs by efficient possibilities of handling and transport. As to further cut costs and processing time during ferroalloy production, direct tapping of hot liquid metal from the furnace, fig. 12, (right) thus avoiding the use of intermediate ladles, is also possible.

6 REFERENCES

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