Software for the Optimization of Raw Materials in Casting: A Key to Quality and Competitiveness

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INTRODUCTION

Fusion raw materials represent the major manufacturing expense of any foundry, and can reach values of over 70% in the case of ingot or raw parts. This is why the selection of charge materials is such a delicate process: not only do we have to find a chemical composition specified by a standard and casting which will produce flawless parts, but we must also do it at the least possible cost.

It is commonly thought that to ensure the quality of the final alloy, cost reduction becomes a secondary factor that should not be taken into consideration. Quite on the contrary: quality and optimization are two elements that must go hand in hand, together constituting the key to competitiveness.
Below we shall see how both factors can be treated simultaneously through today's scientific knowledge and technology, through charge optimization software: the foundry worker fixes the quality pattern and the software responds with the minimum cost solution which guarantees that pattern.

ROUGH ESTIMATE CHARGE VERSUS OPTIMAL CHARGE

At present, to calculate charges, most foundries employ systems based on a rough estimate, either using paper and calculator or a spreadsheet. In some cases, these sheets can handle a significant amount of information showing, among other things, the final cost of the charge. The person responsible for its preparation, as well as having enough experience before assuming such responsibility, usually has calculation skills that enable him to reach results in a reasonable time that the company considers acceptable.

This often leads the foundry worker to an erroneous conclusion: my foundry already optimizes costs.

Reflecting a little, we could ask ourselves two questions:

1. What do we mean by acceptable results? The only way to assess whether a result is acceptable would be by knowing the most economical unit cost of the charge, and the only thing we can know about this value, without a specific tool, is that it cannot be lower than the cheapest raw material.
2. What if after a period of trial and error we do not get a solution within the desired standard? We will not know if the solution does not exist or if we have simply failed to find it.

These questions are meaningless for a charge optimizer:

1. It returns a more than acceptable solution instantly and without errors: the one with the lowest possible cost.
2. If there is a solution, however complex it may be, it will find it. If it does not exist, apart from notifying us, it will tell us what chemical elements are impossible to cover and what additional amounts are required to complete the charge.

We will try to illustrate the comparison between the two procedures with an example. We wish to calculate a load of 1000 kg for GX -40 CrNi 25-12 type steel. We start from 30 different materials in stock, out of which 15 belong to returns.

Two different procedures were used to calculate the charge:

1. Using as a base the available 450 kg of GX- 40 return, a spreadsheet was used to complete the charge, trying to prioritize the cheapest raw materials. After about twenty minutes of trial and error, the following solution was approved:

Table 1. Rough Estimate Calculation

MATERIALS USED	QUANTITY (kg)
Steel Scrap	**250**
FeCr	**210**
FeMn	**13**
FeSi	**14**
Graphite	**1**
Nikel	**62**
Return GX-40 (Stock = 450 kg)	**450**

2. On the other hand, the charge was calculated directly using an optimization system, limiting the returns to a maximum of 70 %. The following solution was instantly obtained:

Table 2. Optimized Charge

MATERIALS USED	QUANTITY (kg)
FeCr	**163**
FeSi	**13.6**
Ingot 3.8C-0.7Mn-3.15Si	**85**
Nikel	**38.4**
Return GS-52 (Stock = 250 kg)	**16**
Return GX-40 (Stock = 450 kg)	**450**
Return CF8M (Stock = 450 kg)	**234**

The analysis of both results suggests the following conclusions (charge price shown in U.S. dollars) :

Table 3. Comparison of Results

	SPREDSHEET	OPTIMIZER
Time of Calculation (min)	20	0
Use of Purchased Raw Materials (kg)	550	300
Use of Returns (kg)	450	700
Charge Cost (US$)	3,770,00	3,120.00

With the optimization software the use of returns increased by 56 % , confirming its capacity when handling the endless possibilities that an average stock may offer . In addition, the final price of the charge was reduced by 17.2%

USE OF RETURNS: TWO FALSE BELIEFS

One of the keys to the competitiveness of a foundry is the use it makes of its returns. The way in which they are combined with virgin material and scrap is critical in the final manufacturing costs. In this regard there are two beliefs:

1. I cannot reuse all my returns. Some are contaminated after cutting and I have no choice but to sell them.
   FALSE: A well-designed optimizer will enable you to define charge templates which limit each family of returns separately for each type of alloy. Even assuming the highest possible pollution values, the system will distribute the stock returns among the different alloys to be manufactured without the risk of damaging the most sensitive ones.

2. I already use all my returns. It is impossible to reduce costs any further.
   FALSE: If it is possible to reuse all the returns, there are endless ways to do this and not only one, or a very limited number of them have minimum cost. The estimate can lead to solutions that use up the returns, but still do not guarantee that the balance of the charges is optimal.

IN BOTH SITUATIONS, WHEN WE USE A CHARGE OPTIMIZATION SYSTEM, THE PERSON RESPONSIBLE FOR ITS PREPARATION IS OFTEN SURPRISED WITH THE PROPOSED SOLUTION, HE MAY EVEN RESIST
using it: his doubts are dispelled when he realizes that the actual results not only meet his expectations, but in many cases improve the composition values which are obtained using traditional systems.

OBJECTIVE: NO MORE CASTING ADJUSTMENTS

Many foundries assume the casting composition adjustment as something necessary in most charges. These adjustments have three very distinct disadvantages:

1. Increased energy consumption of furnaces.
2. Increase of losses during fusion.
3. The quality of the adjusted casting will be inferior to that of the initial one, it will have less uniformity and there will be a bigger risk of porosities.

Is it possible to drastically reduce the need for adjustments? Fortunately, the answer is yes. There are systems that allow you to set all the parameters related to raw materials and furnaces that determine the variability in the final composition, such as:

- Overall performances of each material.
- Profits and losses per raw material, chemical element and type of furnace.
- Automatic limitation in each charge of the raw materials with greater uncertainties in their composition depending on the desired alloy.

The work of setting these parameters results in two clear advantages:

1. All the fusion know -how is recorded in a system that evolves with the foundry and that can be applied systematically, regardless of whether there are replacements in the personnel responsible for the preparation of charges.
2. Each charge that is optimized will take into account all the parameters, instantly getting a casting whose actual composition will become increasingly similar to the one anticipated by the optimizer.

How can we know the value of these parameters? In many cases, it is the experience gained by the foundry which allows determining them. However, by applying today's mathematical knowledge we can go further: by accumulating a history of castings with all the information relating to the raw materials used, the expected composition and the one obtained in each case, it is possible to calculate these parameters using Regression and Multivariate Analysis techniques.

Experience tells us that the foundries that use charge optimization software which is properly configured, manage to reduce the number of charges that need adjustment to below 3%.

INTEGRATION WITH SPECTROMETERS

One of the priorities of any production system should be to reduce manual data entry to a Reminimum, in order to save time, minimize errors and prevent the user from performing tedious and unnecessary tasks. In the case of a foundry, this need is evident when using the results of spectrometer readings. The optimizer should allow:

- To automatically incorporate the chemical composition of the raw materials that have been analized. This is especially interesting in foundries whose variability of raw material composition is high.
- Recover in real time the chemical composition of the casting and automatically calculate:
    - The materials you should add to the casting so as to correct the composition, minimizing quantity and cost.
    - The minimum amount you should empty before adjustment, if necessary.
    - If there is a casting surplus, the raw materials which should be added to prepare the next alloy, which is something very useful when there are quality changes.

SIMPLIFYING TASKS: CONNECTION WITH EXTERNAL SYSTEMS

A specific production tool that aims to be used systematically should offer the possibility of integrating with general management systems type ERP / MRP. In the case of a casting optimizer, this integration is especially important in two sections:

1. In the automatic charging of raw materials from the external system , including stock , average cost and that of the latest purchase, family, performance and chemical composition.
2. In the record of the castings performed in the aforesaid system: quantities of raw materials used, resulting composition , furnace, operator...

On the market there are optimization systems that allow this integration to almost any database system, via ODBC or from files of various formats (plain text, spreadsheet, csv...).

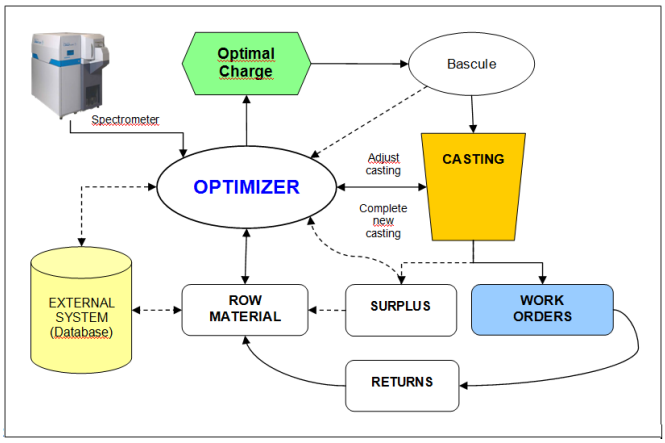

Fig. 1. Diagram of System Integration

CHEMICAL COMPOSITION AT THE SERVICE OF METAL PROPERTIES

Foundries that manufacture ingots find in a casting optimizer the perfect ally to ensure their chemical compositions, eliminating errors and minimizing costs. However, the part manufacturer needs to go further: what variants within each alloy standard guarantee particularly good mechanical properties?

Once more, the history of castings is the key element. Some optimizers have a specific interface to analyze what compositions within the standard give metal some mechanical results which are above certain values, as well as the suitability of using some raw materials or others depending on the desired quality. It is also possible to study which values of certain formulas (Carbon Equivalent, Chrome Equivalent, PREN, ...) have a positive impact on the test results.

From the conclusions drawn from this analysis, for each alloy you can record in the optimizer different qualities depending on the desired quality pattern.

FULL OPTIMIZATION: SHOPPING, QUALITY, PRODUCTION AND SALES

A raw material optimization system reaches its maximum effectiveness when used in a coordinated way among the different areas. We have already mentioned in this article how the production department, together with the quality one, can use these systems to minimize costs while respecting the requirements of each alloy, eliminating errors and accumulating the know-how for the company.

The metal market variability and the changes in demand for alloys, require continuous updating of the definition of charges if you wish to adjust costs to the maximum. Static recipes now have no place at the level of competitiveness in the market today : both the purchasing and production area should have a tool which calculates its raw material needs based on their current cost , access to scrap and availability of returns at all times.

Therefore, there are systems that offer a specific module so that those in charge of purchases analyze which are the most suitable raw materials so as to meet manufacturing orders in each period. The idea is both simple and useful: in the same window the user can charge the production of the study period for each type of alloy. The optimizer will automatically calculate the optimal purchase to meet this production, taking into account all technical data configured by the areas of quality and production. Thus, the optimization of raw materials starts from the time of their purchase.

One in optimization is the evaluation of new materials. Introducing the basic information (composition, performance, available quantity and cost offered by the provider) , you can know immediately how this raw material fits in each of the alloys, what its operational value is and the cost reduction its use will signify.

Another very interesting option that some optimizers offer, which is intended for the sales department, is the possibility of knowing at every moment what the minimum cost of manufacturing each alloy is. Result: you can issue much more competitive estimates in a much faster way.

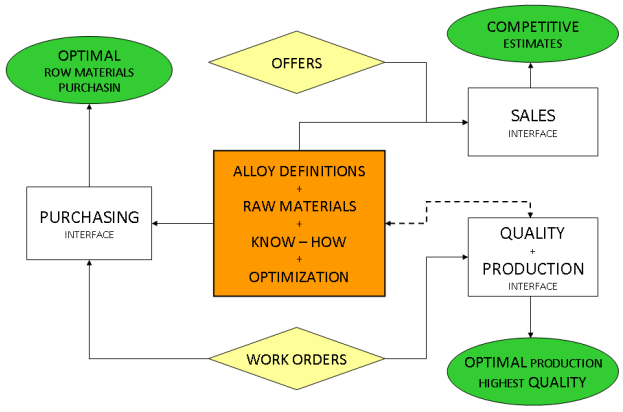

Fig. 2. Interfaces for purchases, production, quality and sales

OPTIMIZATION IN FIGURES

Charge optimization is profitable from the simplest case: foundries which produce a single alloy and base their charges on less than ten different raw material groups, already use optimizers in the preparation of their charges and the adjustment of their castings.

The losses of a foundry which arise from not optimizing raw materials, which are already very substantial even in the simplest cases, are directly dependent on a series of factors that can make for even greater losses. The main ones are:

- The number of alloys produced and, therefore, the number of different returns generated.

- The range of raw materials used.
- The economic cost of the constituent elements of the alloys.
- The complexity of the chemical composition of the alloys, including individual and global limits for trace elements and the objective for other values type Carbon Equivalent, Chrome Equivalent , PREN...).
- The production volume.

Depending on the importance of each of these factors, the average cost reduction in raw materials using an optimization system can range between 5% and 25 % of expense in this section. No optimization means, in any case, losing money. But if a foundry meets two or more of the aforementioned factors and does not optimize charges, the losses may eventually become unsustainable.

We show below, in U.S. dollars, the estimated cost reduction in raw materials for a production of 1000 tons and four sectors: grey and nodular iron, aluminium, copper based alloys and alloyed steels. These values were calculated from the average reduction percentage observed in each sector, 10% in the case of iron, 12% for copper base alloys, 15 % for aluminium and 20 % in foundries of high alloyed steel.

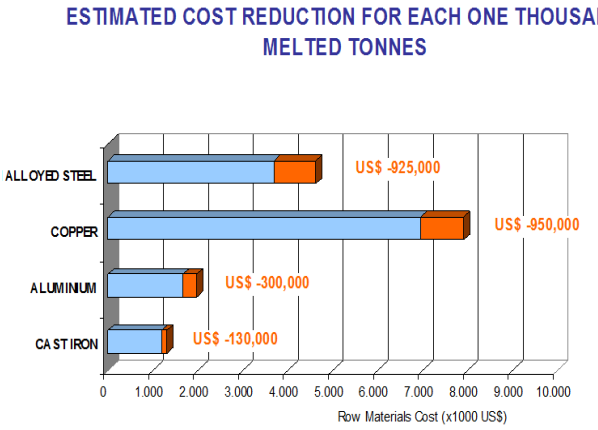

Fig. 3. Cost reduction with an optimization system

CONCLUSION

Charge and casting optimization software is not a statement of good intentions: it is the realization of the scientific and technological knowledge of the twenty-first century in a tool thought and designed specifically for foundries.

For each casting calculation time is dramatically reduced, errors are eliminated and the cost of raw materials is minimized. The Know-How is logged into a system capable of evolving, transcending the knowledge of a single user and allowing engineers to design models so as to obtain increasingly more accurate and economical castings. The return on investment is almost immediate. Progress in quality, unquestionable.

As few foundries today employ optimization systems (they do not reach 5% of potential users), their use is marking a factor of differentiation and positioning relative to the competition, not only due to cost reduction in raw materials (between 5% and 25% depending on the type of foundry), but also due to the gap from the quality point of view.

However, what today is a market position factor, in a few years, maybe months, will be a necessity.