Value Creation in Simulated Steel
Carl-Johan Rick*, Mikael Engholm*, Dr Kristina Beskow*

*Uvån Hagfors Teknologi AB, Djurholmsvägen 30, 183 52 Täby, Sweden
Contact: Carl-Johan Rick, Uvån Hagfors Teknologi AB, Djurholmsvägen 30, Phone +4630358950, Fax +4630358951, e-mail carljohan.rick@uht.se

ABSTRACT
By its ability to repeatedly and accurately generate information in line and on time in the steel meltshop the UTCAS process control software has also become valuable off line. Its different tasks are process development, operator training and investment evaluation. In this paper it is highlighted how the simulated process generates value and it is discussed how this value can be measured. Special applications in process development, training and investment evaluation are presented and practical examples are used to illustrate how value is created.

Background
Stainless steel converter process control is primarily a matter of making the correct amount of metal, to the right analysis, at the right time and temperature. Secondarily this has to be done as cheap as possible within restrictions given by available raw materials and available process equipment.

Cost efficient production requires accurate control and intelligence about the present situation. Within the steel plant the metal losses can amount to several tons. The heat losses amount to in the region of 10 GJ for one heat during its treatment in the steel plant. Yet it is necessary to at any point in time track the heats composition in mass percent down to the second or third decimal depending on element and down to a within a few degrees centigrade in terms of temperature.

UTCAS is a level 2 process control system [1, 2]. It plays a key role in the dynamics of meltshop management at Acerinox Groups Columbus Works and at Outokumpu’s Avesta Works. At both locations it enables the converters to accept a wide range of metal conditions supplied by the EAF’s and to still make the necessary analysis and expected amount. Over the years it has enabled these producers to keep developing and changing their processes with minimal disturbances and to withstand turbulent situations on steel and labor markets.

Figure 1) Optimizing the AOD-process with UTCAS in Avesta

When studying the matter in detail it is evident that a number of people depend on the process control system to do their job efficiently. This also means that these personnel categories have over the years often been involved in the systems evolution one way or the other, see figure 2.

Figure 2) Organogram of people directly involved with UTCAS converter process control system.

The need for involvement of many people on different levels and with versatile skills is caused by a combination of a complex process, high client quality demands and the high raw material costs associated with stainless steelmaking, see figure 3.

Process development
In an operating plant changes are imposed by keen developers, the market, society and owners. It is in the nature of change that an area that can easily be reconfigured is more attractive to develop than one which is less dynamic. Due to the relatively low capital involved and the high configurability of the
converter station it is often a target for change in a stainless steel plant. A powerful level 2 system improves the rate of change and remove much of the risk involved in it.

Additionally general improvements in production speed that increase plant output and yield is always expected and is also experienced [6].

Training of Personnel

The classical way of making an operator productive in a stainless steel meltshop is to do on the job training together with senior operators for several years until experience has ensured that the new operator acts and reacts like his tutor.

This method is time consuming and it puts a great responsibility on the senior operator neither to change the way the job is done and nor to change job- if he does then his inherited know how risk to disappear. An important consequence of this is that process development is not practical while operator training is in process.

For many years’ plants has been downsizing production staff and during that time recruitment and operator training was not an everyday problem. Today, when operators work in lean operational teams and more actively develop their own career and change jobs operator training is a continuous process in most plants. As any other process this one has to be efficient and to make new operators available within a few months of training.

Training of Personnel

The classical way of making an operator productive in a stainless steel meltshop is to do on the job training together with senior operators for several years until experience has ensured that the new operator acts and reacts like his tutor.

This method is time consuming and it puts a great responsibility on the senior operator neither to change the way the job is done and nor to change job- if he does then his inherited know how risk to disappear. An important consequence of this is that process development is not practical while operator training is in process.

For many years’ plants has been downsizing production staff and during that time recruitment and operator training was not an everyday problem. Today, when operators work in lean operational teams and more actively develop their own career and change jobs operator training is a continuous process in most plants. As any other process this one has to be efficient and to make new operators available within a few months of training.

Figure 4) By comparing a number of simulations with an initial reference case it is possible to work through each grade and thus to find what changes in the EAF/converter equipment is most appropriate.

UTCAS assists the operator in operation of the process, but also feed the operator on-line information about the process that makes the operator understand what is happening in the process at a specific time much faster than without a process visualization tool.

The simulation environment makes it possible to train operators in the handling of special situations off line
from production and even to give him “hands on” experience from plant operation without making him handle the full financial responsibility of a heat of stainless steel.

Engineer training is a slightly different matter where UTCAS also makes a significant difference. Engineers and metallurgists are recruited for a number of tasks to steelmaking companies. A key role for them is of course that they fill specialist positions but they are also an important resource in terms of future management. This means that at any point in time there is a significant risk that a specialist is removed to another position in the organization and then it is necessary to rapidly retrain a new specialist.

The AOD specialist will not only learn the process from the system but will also use UTCAS for process examinations and development which is generally a key task for steel plant metallurgical engineers. Also in this aspect UTCAS enables the engineer to partake in process development much faster than without the powerful model package available.

**Investment evaluation**

Evaluation of investment is illustrated with an example. It is assumed that a 100 t converter conventional AOD with a blow rate of 100 Nm3/min is used, and the plant is supplied with liquid metal from an EAF with a 90 MVA transformer. In the plant 500 kt/y stainless steel is made with equal portions of AISI 409, 304 L, 304, 316 and 316 Ti. The plant is restricted by the access to melting and refining capacity.

It is desired that the production is increased with another 100 kt/y 409, it is not expected that the caster will have any problem keeping up with this production.

The question is what investments are necessary to accommodate this production increase? To what extent can the desired situation be managed by changes in the converter or in the converter feed stock?

When handling a mixed production such as described above it is necessary to work on a campaign basis so that the 409 is not contaminated by alloys such as Ni and Mn from the 304 and the 304 is not contaminated by Mo from the 316.

What is therefore clear is that the production pattern will not change in an important way by the expanded production, it is just more heats to handle in the same time. Furthermore it is clear that only changes made to the process for the 304 L and 409 will make significant difference to the final production time as those are the heats that consumes most time in melting and refining.

![Figure 5: Work flow to optimize process and to implement changes in production using UTCAS.](image)

Given this information it is evident that to accommodate the production increase sequence length must increase for the slower grades and this requires the converter tap mass to increase to the maximum volume possible in the converter, ie 110 tons. The converter must be used for melting with at least 15 tons on the 304 L steel and with at least 10 t on the 409 as higher scrap melting will require extra time consuming scrap baskets to be added. Yet the steel has to be refined using the same time as before.

Using UTCAS some different alternatives are investigated:

a) Change of input steel composition and amount
b) Introduction of a top lance
c) Increase of side blowing flow rate

From the analysis conducted in figure 4 it is clear that while different methods to reach the desired target is available it is necessary to make an optimization to find the cheapest solution. It turns out that a
moderate increase of the gas flow rate that does not stretch the limits of the dust plant gives the best process values in combination with a moderate weight increase tapped from the EAF. The work flow for the optimization is described in figure 5. In this figure it is also illustrated how a process change that requires an investment is implemented using UTCAS.

In fact the only change that is necessary to solve the requested case is a tuyere size increase

**Evaluation of benefits**

Excellent process control compared to acceptable process control often means that carbon prediction accuracy is better; this leads to shorter process time and saved consumables. A big improvement in this respect is an average shorter process time of two minutes per heat, this leads to immediately lower costs for media, slag formers, reduction agents and refractory. In addition to this the two minutes increase overall plant yield and plant output when the converter is the bottleneck that prevents longer sequences.

The value created by operator training means that there is less need for surplus operators in the staff to be present and while at the same time mistakes made by inexperienced operators becomes less. The economical value for this benefit is in the range of 12 operators on staff instead of 14 for a five shift operation. Avoiding mistakes caused by inexperience increase production by up to two heats per month.

The value created by engineer training means it is possible to build in redundancy in the organization by having several engineers trained in managing the process and technology of the converter because UTCAS allows engineers to be trained to an acceptable process engineer level within a few weeks with access to the tool. This will also increase overall skill in the engineering and management teams over time.

To improve preparations, implementation and evaluation of a process change by redesigning all aspects of the process off-line rather than to redesign it bit by bit in a production environment greatly increases the speed at which development and development implementation is made. It also decreases the risk for unexpected production problems. Finally it immediately implements all quality information as the process is automatically documented in the control system. The increased implementation speed improves plant availability and the ability to conduct trials. The decreased risk for production and quality problems also increase the ability to conduct trials- this in turn improves the rate of development which leads to general improvements in the plant profitability.

<table>
<thead>
<tr>
<th>Improvement reason</th>
<th>Estimated improvement</th>
<th>Concerned production</th>
<th>Yield</th>
<th>Refining decrease</th>
<th>Financial impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved process control shortens time due to improved control and lack of over-blowing.</td>
<td>2 min/heat</td>
<td>50000</td>
<td>1000</td>
<td>1000</td>
<td>0.35</td>
</tr>
<tr>
<td>Improved operator training decrease need for surplus staff and mistakes.</td>
<td>2 fewer operators</td>
<td>10000</td>
<td>2250</td>
<td>18000</td>
<td>2.36</td>
</tr>
<tr>
<td>Improved engineer training decrease need for surplus staff and improves know-how base.</td>
<td>1 fewer engineer</td>
<td>50000</td>
<td>2600</td>
<td>2600</td>
<td>0.07</td>
</tr>
<tr>
<td>Improved process development shorter time by 5 min/heat on special grades and by 1 min/heat on standard grades.</td>
<td>5 min/heat</td>
<td>26000</td>
<td>2600</td>
<td>2600</td>
<td>0.65</td>
</tr>
<tr>
<td>Investment management</td>
<td>1 fewer engineer</td>
<td>50000</td>
<td>5000</td>
<td>5000</td>
<td>1.12</td>
</tr>
<tr>
<td>Quality improvement</td>
<td>1 fewer engineer</td>
<td>50000</td>
<td>1125</td>
<td>9000</td>
<td>1.18</td>
</tr>
<tr>
<td>Total saving on control</td>
<td></td>
<td>50000</td>
<td>5000</td>
<td>5000</td>
<td>1.12</td>
</tr>
<tr>
<td>Total saving on simulation and quality</td>
<td></td>
<td>50000</td>
<td>1125</td>
<td>9000</td>
<td>1.18</td>
</tr>
<tr>
<td>Total saving on entire system</td>
<td></td>
<td>100</td>
<td>5000</td>
<td>5000</td>
<td>1.12</td>
</tr>
</tbody>
</table>

*Table 1) Estimated value contribution of converter process control system in a 500 kt/y plant.*

Value created in investment situation is similar to that of process redesigns. In this case there is however an element of optimization involved as well as a matter of avoided capital spending.

In table 1 the value of different aspects of a converter process control system is estimated. In the table it is assumed that 500 kt/year is produced at a production cost of 250 Euro/ton. The refining cost is 200 Euro/min, based on 100 t/heat size. The operator and clerk cost is 35,000 Euro/year and the engineer cost is 50,000 Euro/year. It is further assumed that each minute of treatment equals 2% of the treatment cost for all grades. Finally it is assumed that decrease in treatment time will improve casting yield by 0.25% per minute for standard grades and by 1% per minute for special grades.

From table 1 it is clear that as much or more benefits may be found in aspects of the control systems that...
are only indirectly involving the process control. Instead benefits are found based on the reliability in the system that allows it to be trustworthy in simulation.

**Discussion and conclusions**

The main role of a process control system is to control and optimize the process. This is the main motivation for the systems presence and its functionality and performance in this respect is the key factor for selecting a certain system solution.

It is however the authors experience that a great deal of the value of having a powerful process control system lies in its capability to help managing change and data, not only in its capability to manage everyday production. In the estimations made in the paper an equally or more important saving is found based on the simulation role than on the process control application itself.

As demonstrated in this paper it is possible to find a very cheap solution to a dramatic increase in plant demand by using the process control systems analytical capabilities. Sometimes it is not possible to demonstrate this ability with its full force in terms of financial figures but it is yet possible to reach dramatic results and to avoid unnecessary capital spending.

It is worth considering that it is often easier to point out and measure the benefits of change and data management and to estimate the economical value of them than to estimate the value of the systems contribution on a good productivity.

**References**

[1] Engholm, M: UTCAS the complete system for converter process management; Nordic Steel and Mining Review. (2008/03), P. 125


