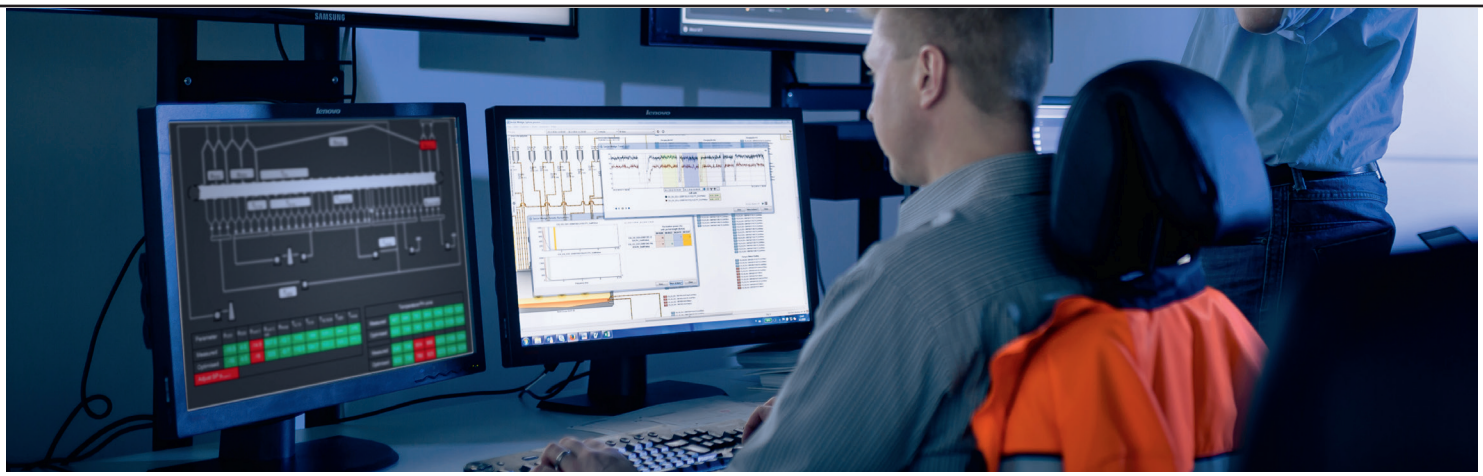
Optimizing iron ore agglomeration plant performance –

Outotec's solutions for plant monitoring and sustainable operation



Dr. Steffen Haus, Stefan Mehl, Outotec GmbH & Co. KG, Germany
Alex Lagerstedt, Outotec Oyj, Finland
Contact details: Stefan Mehl, stefan.mehl@outotec.com

Summary

The decline in iron ore grades and the need to diversify the raw material basis for economical plant operation are increasing the need to operate plants at maximum efficiency. Outotec provides reliable solutions to monitor plant performance and increase the transparency of operations. This is particularly important when adjusting plant operation in order to address the impact of changing feed materials.

Outotec identified strong fluctuations in the consumption of oil, gas, and electricity during the operation of some iron ore pellet plants. The reason for these fluctuations, which can lead to increased overall operating costs, can at least partly be explained by the plant operator's performance. Outotec has combined its process know-how and experience in plant design with experimental test work in its own R&D centers to develop advisory tools that help customers to run their plants more efficiently. Outotec's latest development, Outotec Optimus, provides guidance for pellet plant operators that reduces the time needed to make the required adjustments in case of changing process parameters.

The initial results indicate a high potential for significant fuel and electrical energy savings in the operation of such plants. Considering the production rates of modern pelletizing plants, this is a huge step toward more sustainable production of iron ore pellets. With the Outotec Optimus tool it is much easier for operators to run the plant at the optimal operating point. Clear and understandable graphical displays indicate the optimal plant operation mode based on real-time measurements.

Furthermore, the modeling, simulation, and monitoring capabilities can be used to improve the operation and maintenance support that Outotec provides to its customers. Outotec has recently been awarded contracts for the operation and maintenance of ferrous agglomeration plants and is the preferred partner for numerous operators worldwide. Outotec's solutions range from advisory services and optimal spare part management to full operation and maintenance support.

Key words: Iron Ore, Pellet Plant, Pelletizing, Optimization, Fuel Saving, Energy Saving, Cost Saving, Plant Performance, Advisory Tool, Outotec Optimus.

Introduction

The conditions in iron ore and pellet markets are currently characterized by the general market sentiment, which continues to be dull. This can be traced back to when the market moved into structural oversupply coupled with a stronger USD and weaker oil price. The major global diversified mining companies have reported weaker financial performance, further cost cuts, and operational streamlining that have also influenced their CAPEX spending projections.

In order to maintain productivity, pelletizing plant operators, whether affiliated to mining companies or steel producers, have to deal with cost optimization due to a significant drop in the price of seaborne pellets and the fall in global steel prices.

At the same time, increasingly strict global and local environmental regulations are forcing pellet producers to evaluate their environmental impact. This leads to CAPEX investments on projects to improve environmental aspects of the plants rather than focusing on improving plant output and product quality.

Savings in the energy consumption of pellet plants can make a significant contribution to reducing production costs. While raw materials account for the biggest proportion of a pelletizing plant's operating costs, energy costs are also a significant factor.

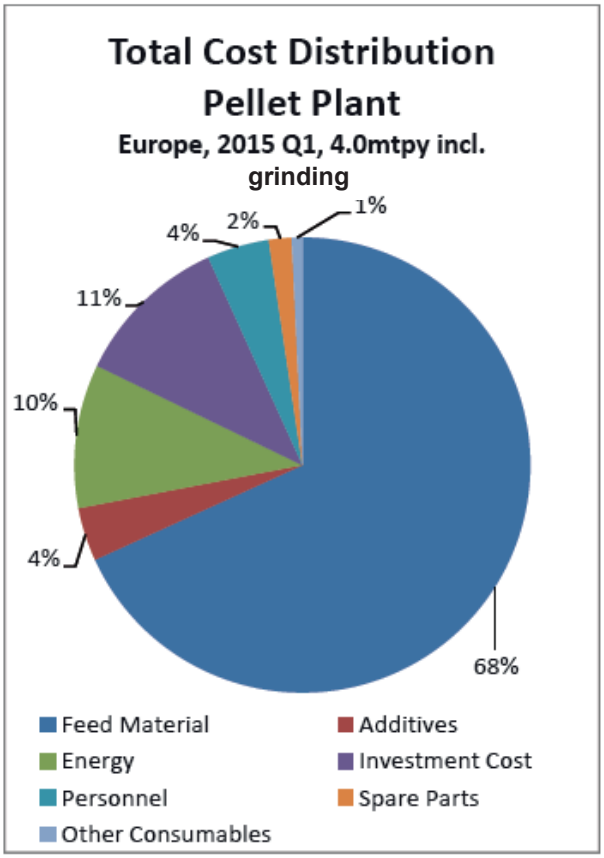


FIGURE 1: Breakdown of operational costs for a pelletizing plant

In Figure 1, the operational costs for a hypothetical pelletizing plant located in Europe processing Brazilian fine ore. The data is based on 2015 Q1 raw material and consumable prices including upstream raw material grinding. The chart indicates that approximately 10% of the annual running costs can be attributed to energy consumption (thermal and electrical). For this calculation the investment costs per year were estimated to be 16% of the total investment costs. Any costs outside the plant boundaries, such as land acquisition and infrastructure costs were not included.

Outotec Optimus enables efficient plant operation by significantly reducing the plant's energy consumption. Furthermore, improving the plant's operation stabilizes variations in quality, fines, and dust, as well as extending the lifetime of the equipment.

Tackling Operational Challenges

In recent studies Outotec has identified substantial fluctuations in energy consumption in pellet plants due to the nature of operations and the decisions taken by operators. Operators are often forced to make decisions based on either too much data or insufficient understanding of the data. As plants become more complex, the amount of available data increases. It is therefore crucial to supply the operator with a selected amount of data that is easy to understand and analyze.

Preferably, the data should be automatically analyzed in order to generate real-time recommendations that improve both efficiency and product quality.

Figure 2 shows a hypothetical but representative example of variations in terms of energy consumption in a pellet plant over a period of one month.

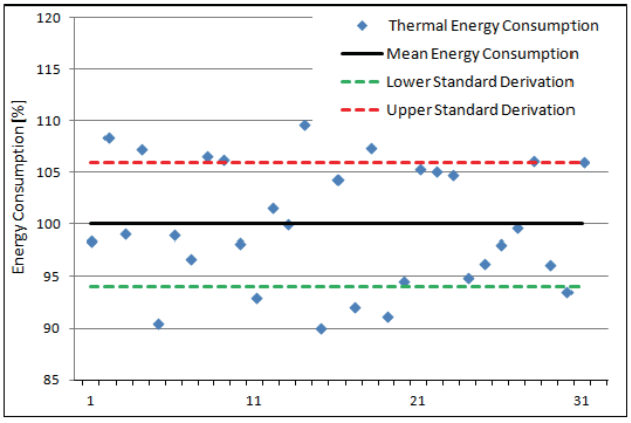


FIGURE 2: Example of plant energy consumption levels

The data is based on the energy consumption when operating the plant at full capacity. The energy consumption includes both thermal and electrical energy. It is obvious that a plant owner wants to reduce energy costs and thus prefers to operate the plant at optimum levels.

Besides the risk of increased energy costs per ton of pellets, fluctuations in plant operation can also negatively impact product quality due to poorly optimized operation. Parameters such as pellet strength and diameter can be affected by sub-optimal plant operation, resulting in reduced profitability.

Outotec's aim is to overcome these challenges by developing advisory tools that help operating personnel to maintain high product quality and thus maximize the profitability of the plant while also ensuring energy-efficient operation.

The Outotec Optimus Tool

Outotec Optimus is a supplementary system to the plant's distributed control system (DCS). The advisory nature of the tool ensures that the operator still has the main executive role in running the plant. It monitors various plant parameters which are otherwise easily overlooked. Based on these parameters it proposes appropriate steps to control the plant and optimize its energy efficiency. The final decision to follow the system's advice is, however, down to the operator.

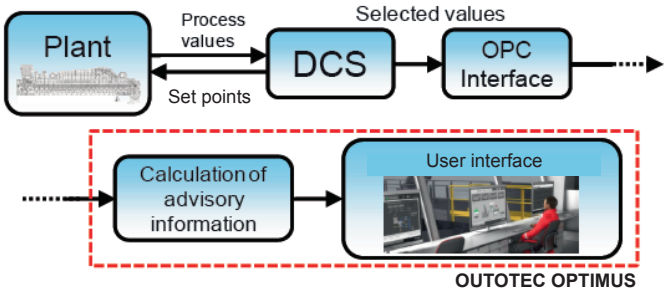


FIGURE 3: Structure of Outotec Optimus and integration into the plant control system

Figure 3 shows the structure of Outotec Optimus and its integration into the plant control system. As in all plants, the process is controlled via the DCS. Process values are measured and sent to the DCS, and the operator adjusts the plant set points and controls all equipment via the DCS. Only selected process values are transferred via the OPC interface to Outotec Optimus. The advisory tool itself consists of two main parts:

1. Calculation of advisory information;
2. Operator user interface/Human Machine Interface (HMI).

The first part is the heart of Outotec Optimus, where the DCS measurements and plant information are processed. Based on the information available, Outotec Optimus generates recommendations for the operator on how to adjust the process set points. If the operator enters the suggested set points into the DCS, it ensures that the plant is operated close to or at the optimum level in terms of energy consumption, product quality, throughput, and process stability.

The advisory information is displayed via the HMI. The interface design is designed to be easy to use and reliable. The goal was to develop an easy-to-understand array to ensure that the operator can accurately monitor the plant status at all times, thereby supporting improved decision making. The supplementary information is either omitted or visible via secondary display tabs to help the operator focus on the essential details.

The real-time operational recommendations provided by Outotec Optimus need to be distinguished from DCS alarms that are essential for plant safety.

Because Outotec Optimus targets operational profit and not plant safety, it is not necessary to send data back to the DCS system. The advisory nature of the system does not force the operator to make a decision, but rather recommends the best option based on available data and measurements. It is important to point out that disregarding the recommendations provided by Outotec Optimus does not compromise plant safety.

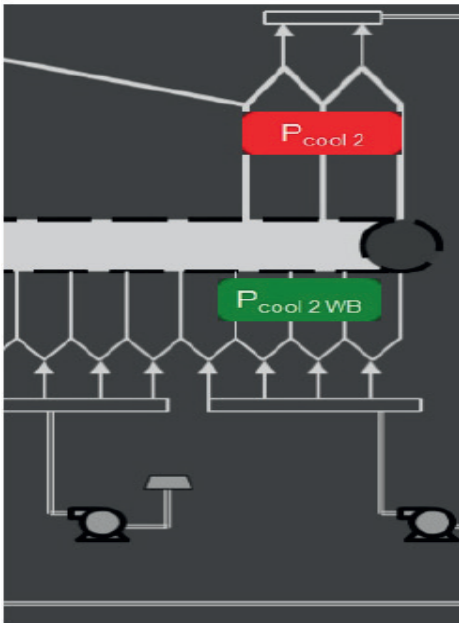


FIGURE 4: Outotec Optimus indicating that the operator should take steps to address an issue in the final cooling zone

Figure 4 above shows a situation where Outotec Optimus is recommending that the pressure above the pellet bed in the final cooling zone should be adjusted. The suggested numerical values for the respective quantity can be shown in a separate field. As a second option, the advisory information can also be displayed on a replica of the DCS screen to provide the operator with a familiar user interface. Further information, such as actual specific energy consumption and key performance indicators, can be displayed and evaluated.

Development of Outotec Optimus

The development of advisory tools like Optimus requires a combined and interdisciplinary effort. The advisory tool is implemented in Outotec's proprietary ACT software [1]. This software has already been used as the basis for other advisory and plant monitoring tools [2]. Using proprietary software as the basis for Outotec Optimus provides some valuable advantages over third-party solutions. Firstly, it provides Outotec with full control over the software and its development, which maximizes flexibility in terms of accommodating customer requests. Secondly, the tool and its associated methodologies, process know-how, and software components are all supplied by a single provider, which simplifies implementation for the customer.

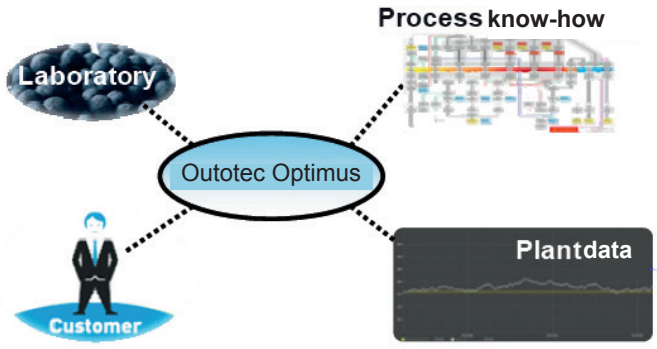


FIGURE 5: The stakeholders involved in the development of Outotec Optimus

At Outotec, several stakeholders are involved in the development of advisory tools. Figure 5 shows the development partners that are involved. Laboratory results form the basis of Outotec Optimus. Required process parameters such as temperature profiles or volume flows are determined through laboratory test work and are incorporated into the advisory tool. The process know-how comes from Outotec process development groups as well as from equipment specialists who provide information about all plant equipment, such as burners, blowers, and so on. Mathematical models of the process are implemented to enable Outotec Optimus to generate its operation recommendations. Fine-tuning of Outotec Optimus is performed based on plant data to ensure maximum accuracy of the calculations and minimum deviations between the Optimus model and real plant measurements. Fine-tuning requires adjustments to the model in terms of stable plant behavior as well as to delay and response times. Finally, close customer contact and commitment to addressing customer requests are vital, and this is why the customer is included as an important stakeholder in the development of advisory tools like Optimus.

Potential of Outotec Optimus

The following estimation of the potential cost savings that can be achieved with the Outotec Optimus solution is based on the variations of the energy consumption shown in Figure 2. Figure 6 shows the same energy consumption chart but with lines added to show the mean value plus and minus the standard deviation. With Outotec Optimus the mean energy consumption of the iron ore pellet plant can be reduced to the value of the lower standard deviation. Potential savings are indicated by the blue bars in the graph. For this example, energy savings of approximately 5% of the total energy were found. The thermal energy consumption in a pellet plant is generally split between burner fuel and coal (Cfix) contained in the pellets. Since the C-fix should remain constant for product quality reasons, the potential savings are purely attributed to fuel. It is assumed that 60% of the total energy comes from fuel and 40% from C-fix. Therefore, the potential burner fuel saving in the example is 8.33%.

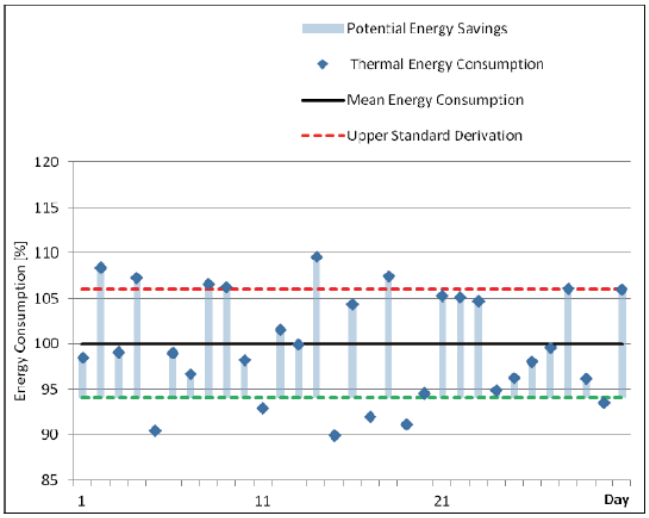


FIGURE 6: Potential energy savings enabled by Outotec Optimus

The total energy consumption consists of electrical energy for blowers, fuel for burners (oil or gas), and coal as an additive in the green pellets. Potential savings are calculated for the burner fuel and for electrical energy; the C-Fix content in the green pellet is assumed to be unchanged.

Table 1 shows the potential yearly cost savings for two assumed, realistic energy savings enabled by using Outotec Optimus. Given the assumption that the energy consumption can be reduced to a value close to the lower standard deviation (5% savings in thermal energy consumption), a potential saving in oil fuel costs of $3.93 million per year can be achieved for a 7 Mt/year pellet plant at an oil price of $93.50 per barrel (the average price for West Texas Intermediate (WTI) oil between March 2011 and the end of February 2015).

A more optimistic calculation with assumed 8% energy savings results in annual savings of $6.3 million. Real plant operational data on the specific energy consumption showed that there are days with 10% lower specific energy than average but also days with an energy consumption of 10% or more above average. It is on days such as this when Outotec Optimus can help to enable considerable

	POTENTIAL ENERGY SAVINGS 5% (8.33% OF BURNER FUEL)	POTENTIAL ENERGY SAVINGS 8% (13.33% OF BURNER FUEL)
Specific total energy consumption	700 MJthermal/tProd	
Fuel share	60%	
Specific fuel consumption	420 MJfuel/tProd	
Potential fuel savings	35 MJfuel/tProd	56 MJfuel/tProd
Oil savings	0.006 boe/tProd	0.0096 boe/tProd
Oil price	$93.50/barrel	
Potential fuel savings	$0.561 per tProd	$0.90 per tProd
Plant production	7 Mt/year	
Total potential fuel savings per year	$3.93 million	$6.30 million

TABLE 1: Potential fuel savings (1MJ=0.0001706boe, barrel of oil equivalent. The calculation is based on a four-year average oil price of $93.50/barrel which is the average between March 2011 and February 2015).

operational cost savings. Although the data shown in Figure 2 and Figure 6 have been generated artificially, they do reflect real plant operational data.

In addition to the potential fuel savings, electricity consumption – the primary source of which is blower operation – can also be reduced. Outotec's experience shows that the fluctuations in the specific electrical energy consumption are even higher than for fuel consumption. A realistic potential saving of 10% in electrical energy for a consumption of 15 kWh/tProd and a price of $0.098 per kWh results in savings of more than one million dollars on top of the potential saving in thermal energy consumption. The calculation is shown in table 2.

	POTENTIAL ELECTRICAL ENERGY SAVINGS 10%
Specific el. energy consumption	15 kWh/tProd
Potential el. energy savings	1.5 kWh/tProd
El. energy price	$0.098/kWh
Potential el. energy savings	$0.147 per tProd
Plant production	7 Mt/year
Total potential fuel savings per year	$1.029 million

TABLE 2: Potential electrical energy savings (price of $0.098/kWh: electrical energy price in EU 15, median Jan-Jun 2014 [3], is 7 pence stirling, converted from pence to dollar at a rate of 1 GBP = 1.4 USD.

In addition to potential energy and cost savings, maintaining a consistent and high product quality is a further benefit. Although it is difficult to quantify the cost benefit of reliable product quality, it is clear that the ability to lower production risk by enabling a more stable process is a significant benefit of Outotec Optimus.

However, lowering production risks by a more stable process is an extremely desirable side effect of Outotec Optimus.

Product Lifetime and Services Related to Advisory Tools

After the first implementation of the advisory tool at site Outotec focuses on software maintenance, providing updates and supporting the customer with performance analyses. Using Outotec Optimus requires cooperation and close relations with the customer, and the software has to be properly maintained. The first step is a model fine-tuning phase, which typically lasts a few weeks. The model will require further adjustment to allow for any changes in plant design, equipment, or raw material (beyond normal fluctuations and plant-specific recipes). Optimus can also be updated with further features in order to add software blocks for equipment monitoring and fault detection, or to extend the tool to cover other sections of the plant. Customer support in terms of performance analyses, advisory reports, and regular workshops are part of the services related to the implementation of advisory tools.

This allows an analysis of how precisely the recommendations given by Optimus have been followed by the operators and indicates where the full potential of the plant is not yet reached. In case of larger deviations between recommended and observed operation, Outotec can suggest ways to remedy the possible issues and provide proactive support to improve plant efficiency.

Outotec favors a remote service concept that allows updates and software maintenance to be implemented without requiring an on-site visit. This allows the fastest possible response time to customer requests and guarantees 100% availability of the advisory tool's functionalities.

Conclusion

Outotec has identified that providing operating personnel at iron ore pellet plants with comprehensive support is hugely beneficial when seeking to streamline production. Highly complex plant designs and increasing numbers of process parameters to be monitored by the operators are leading to undesired fluctuations in energy consumption and product quality. The related increase in a plant's energy consumption and operational costs can be avoided by implementing the Outotec Optimus advisory tool.

Optimus monitors plant performance using a selection of measured process data. Real-time interpretation of this data combined with an easy-to-understand graphical display ensure that operators have the most important information available at all times. Based on highly accurate process models, Outotec Optimus calculates an energy-efficient operational strategy for the plant and generates clear recommendations for the operators on what actions should be taken.

Calculations of the potential benefits of Outotec Optimus indicate annual savings of up to $6.3 million in fuel plus $1.029 million in electrical energy consumption. Furthermore, Outotec Optimus lowers the risk of production losses due to low product quality.

A combination of Outotec Optimus and complementary support services results in the best available support for pellet plant operating companies, ensuring that plant efficiency remains as high as possible over the whole lifecycle, resulting in maximum operational profit for the customer.

Abbreviations

DCS	Distributed Control System
GBP	Pound Sterling
HMI	Human Machine Interface
HH	High High alarm
LL	Low Low alarm
WTI	West Texas Intermediate

References

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[3] https://www.gov.uk/government/statistical-datasets/international-industrial-energy-prices

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