ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 4, Issue 12, December 2017

Development of Tool for Efficient Casting Process

[1]Lalit Kumar

[1]Department of Mechanical Engineering, Galgotias University, Yamuna Expressway Greater Noida, Uttar Pradesh

[1]lalitkumar_m@rediffmail.com

Abstract: In the last century the manufacturing industry has enabled the move to efficiency, consistency and competitiveness by the development of fairly cheap and abundant energy resources with a restricted emphasis on energy and waste minimization. But in the last few decades, more and more stringent regulations have been introduced worldwide and, in particular, in Europe, to reduce pollution and consumption of resources. A highly mature and competitive industry, like the foundry, therefore expects challenges which can become significant future opportunities in an effort towards sustainability. A method is being developed to routinely examine energy and material movements during the casting process. A description of the architecture of the computer program is provided with confirmation of its performance against real world data from the foundries.

Keywords: Casting, Energy efficiency, Foundry, Sustainable development.

INTRODUCTION

Metal casting is an energy intensive production process that is technically difficult and has a long history, which plays an important role in the production of a wide variety of products. Casting can be summarized in very simple terms by the description below. Melt metal is then poured into a shaped mold and removed after solidification. If parts with complex geometries or when treating materials become difficult to handle, casting is usually compatible with other manufacturing processes.

Over the last years the advanced development of the metal casting industry has been driven by two significant factors. On the one hand the need to minimize waste and pollution from anthropogenic activities is a broad consensus in society. This urgency is reflected in increasingly stringent national and European legislation as well as in global agreements such as the one reached during the UN Conference on Climate Change in December 2015 [1], [2].

However, the growing aggression caused by the modern global economy leads to a more energy-efficient use at a reasonable cost. Sustainability seems to be an attractive approach to addressing these challenges that bring additional benefits. "Sustainable development is the development that satisfies the needs of the present without jeopardizing future generations ' ability to meet their own needs," according to the most famous definition given by the Brundtland Commission of the United Nations in 1987. Given the comprehensive effects of manufacturing (and casting in turn) on modern society, it is crucial in this context to play an important role and develop quickly to face, if not predict, the changes. As a further key driver of modern manufacturing, Salonitis and Stavropoulos propose to improve the established approach based on the' fabrication decision Tetrahedron' consisting of costs, quality, flexibility, and time.

A durable approach requires a thorough and broad-based approach which covers the entire product life cycle during design and is intended to optimize environmental, economic and social key performance indicators (KPI) [3]. This method allows foundries to step in this direction with an initial focus on environmental issues, without covering the entire supply chain or' end of life.'

Rationale:

One of the key findings of the workshop was the requirement for an energy auditing framework as well as an instrument for rapid analysis of measurements, attended by foundries, suppliers and advisors. The developing software is intended to meet this industry requirement by systematically analyzing the whole energy and material chain of casting processes, from the materials to the waste. Flow visualization in various forms (e.g. process flow or Sankey charts) can support decision-making to explore the effects of possible improvements [4]–[6]. In addition to opportunities for scavenge and associated costs, for example, waste that can be considered as non-trivial or traditionally uncontrolled. In the training of foundries personnel whose conduct plays a key part in implementing sustainable improvements, the visual nature of the computer program output can be effectively applied. Finally, this thorough analysis can be used to evaluate the plant's performance against similar.

Although some of the above objectives can be achieved by using existing Discrete Event Simulation (DES) tools, many small and medium-sized companies cannot accept the time, effort or skills necessary for establishing the realistic plant model. The program presented in this work was designed to require minimum effort to map the necessary flows and to flexibly adapt the quantity of information according to the desired level of precision to the requirements of the user.

Energy flows:

Energy costs have a significant impact on the productivity of fuel-intensive businesses such as foundries. There are therefore an interest in taking measures to reduce fossil fuel and electricity consumption. Audits and "lean theory" are strategies for finding ways to reduce energy use.

Power audit recommendations generally focus on infrastructure upgrades to optimize the return on investment. However, the necessary capitals could prevent energy saving measures from adopting the most advantageous measures. SMEs, in fact, are looking for relatively short remittances (this represents a major proportion of foundries).

Alternatively, one or more lean philosophy tools could save energy avoiding the major investment in the above-mentioned equipment. Salonitis et al. review in more detail the options available and note that lean tools generally are less deployed in companies that have large inventories of raw materials, such as foundries [1], [7], [8].

Material flows:

Another important information source to improve casting processes is material flows. Figure 1 provides a graphical representation of a Sankey diagram of a foundry’s material and energy flows.

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 4, Issue 12, December 2017

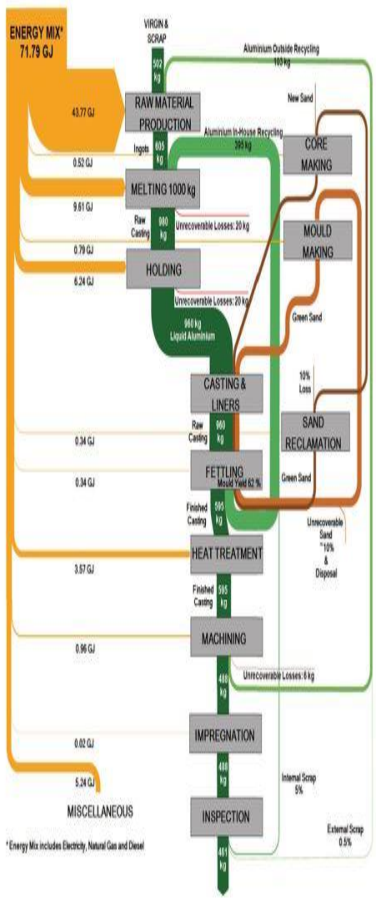

Figure 1: Example of Material and Energy Flows in a Foundry Represented by a Sankey Diagram

The main source of pollution for the environment are non-returnable material losses, such as (for example) hot fired gas from fossil fuels, decaying waste or sand that cannot be re-melted or reclaimed. In fact, waste often "contains," even without a more detailed and complex study of the life-cycle process that stretches over the whole supply chain, some of the resources historically used in the foundry for its production. More noble cases such as re-melting metal waste during fatting (i.e. a cast separation operation) where there is no movement of metal outside the plant's limits, also play a significant role in lowering the productivity of a foundry. Any activity aimed at reducing any form of waste is therefore worthwhile for improving the operation. The intrinsic decline in energy consumption of transported cast units is measured by a reduction in the internal recasting of scrap metal. Salonitis et al. analyze a number of ways in which an automatic means to regulate material flows increase energy

```
{
  "Components": [
    {
      "name": "Raw material",
      "flows": [
        {
          "name": "Virgin metal", "categ":
          "mat",
          "dir": "in",
          "qtity": 502,
          "um_q": "kg",
          }
        ],
      "next comp": [
          "Melting"
          ]
      },
  ...
    ],
    "plant name": "Sand casting plant",
    "start component": "Raw material",
  ...
}
```

efficiency in a foundry [9], [10].

The operational efficiency of material (OME), expressed as the ratio from the amount of shipped casting to the amount of metal melt measured in a certain amount of time, is an effective metric which can be used to describe the overall material efficiency of an installation as cast metal.

METHODS:

The computer program is in the new Fortran language used in this work. Its workflow begins with a text file with a plant description. This data is processed, categorized and saved to an internally appropriate data structure which constitutes the key tool to allow its content to be conversioned flexibly to the final representation desired. For the final graphical representation of the information, a modular architecture interfaces the tool with other packages (Figure 2).

The tool interfaces currently with the graph software to draw process flow diagrams (PFDs) with open-source graph display. The validation function presented in Section 7 will be used. Work is underway to create an interface with the open source statistical and programming software environment R. The main reason for developing an R-language interface is to create Sankey diagrams automatically, like those shown in Figure 1. Section 5.4 presents a more comprehensive description of the relevant process. Additional modules for the generation of other types of graphs would also be possible [11].

Input file:

The data file is supposed to be written in JSON format and based on text. "JSON is a lightweight, text-based data interchange format which is language-independent" according to its standard. The simple structure, the relative abundance of parsing libraries and the ability to interface easily with other software parts have chosen JSON. With relation to the latter argument, writing with future a GUI system that gathers plant information in a more user-friendly manner could be relatively easy, for example. In this case, the data exchange feature between the GUI and method introduced in this paper would be the JSON input file.

Data structure:

After parsing, the complete plant is internally stored and implemented in an object-oriented design in order to continue the post processing of an imaged data type derived from Fortran Language. There are several interconnected components of the overall data structure of the system, each of
which comprises a variable number of flows. The flow is defined by its direction (in and out relative to the feature in question) and type. There are actually two types of flow: substance and energy. However, for future capacity improvement, the plant-derived data type can easily be expanded.
The cross-routine is a polymorphic construct that loans you a valid interfacing with the data form of the plant to call the same transverse algorithm from all deployed post-processing modules.

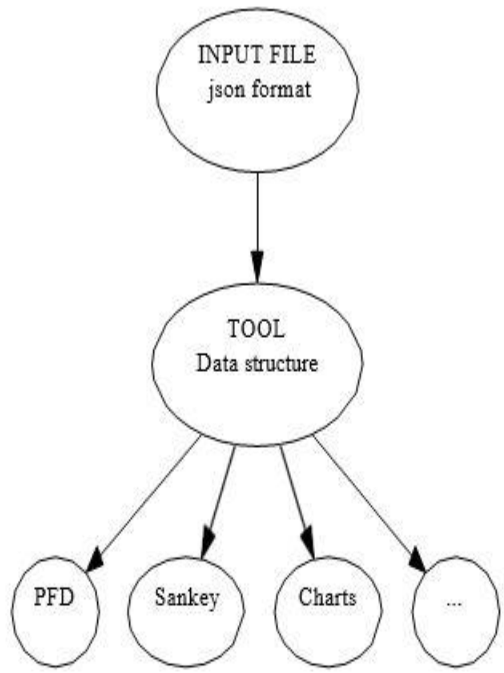

Figure 2: Work Flow of the Proposed Data Visualization Tool

PFD module:

PFD's graphic interfaces automatically generate graphs with a set of colors and forms that the user can choose to represent the components and flows as defined in the last section. Other types of flows can be narrowly represented or, if all flows are demanded, flows that represent the same physical process may be covered in two different categories. Of example, a furnace involves the same physical process for the input of the thermal energy as fossil fuels and air (materials) and should not be seen concurrently. Therefore, in addition to a default behavior, you should decide which flow type is defined in the PFD for each scenario. When such condition happens.
Sankey diagram module:
A Sankey diagram interfacing the tool in the d3.js library JavaScript is underway automatically. The integration is indirectly made using an R-script that uses the network analysis package igraph (created

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 4, Issue 12, December 2017

and automatically run). Finally, igraph executes the final rendering library routines of d3.js. The whole process is designed to be totally transparent for the end user who will see the data only converted into a Sankey diagram in the input file.

Additional charts:
A techno-economic analysis of the plant can be completed concurrently by extracting the corresponding information from the data structure by traditional charts (e.g. pies or histograms). This module is planned to be developed for future work.
Implementation

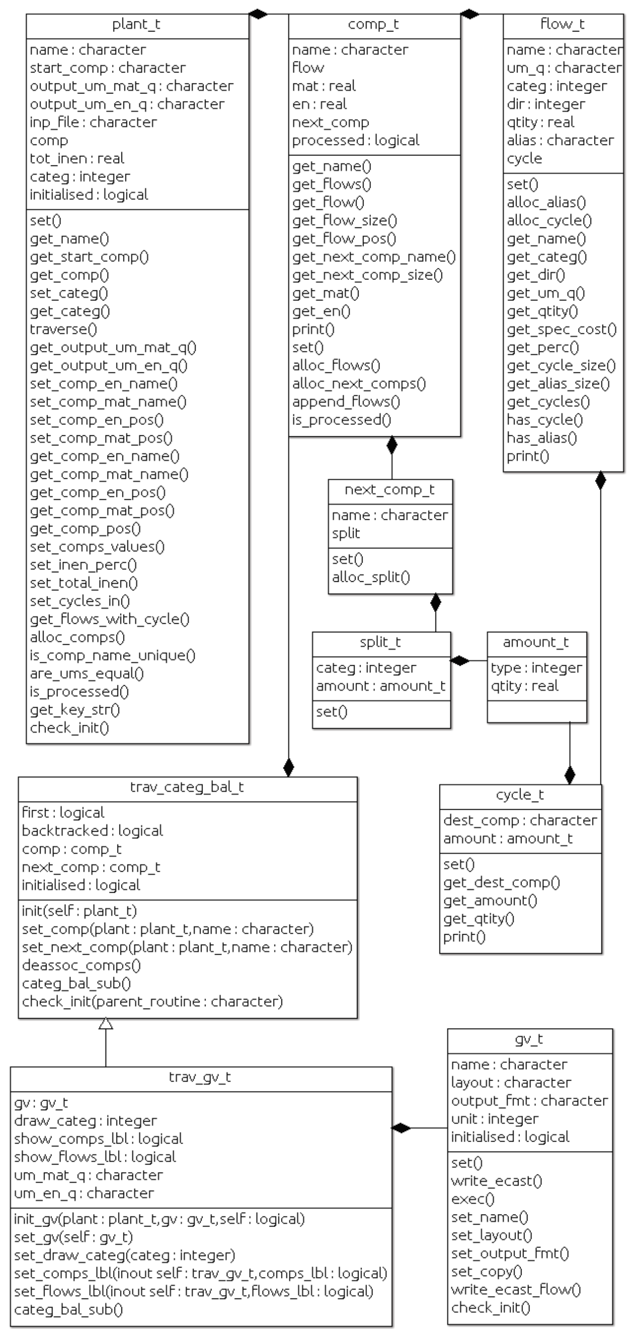

Figure 3: Simplified UML class diagram of the software under development showing the derived data types, their methods and inter-connections.

Figure 3 presents a simplified UML class graph which describes the main data types, their processes and interconnections. Figures 3 show. The nature of this work would go beyond a comprehensive analysis of the image, but there is a succinct summary. The derived data form methods mostly have self-explanatory names and follow the pattern of traditional object-oriented naming "grab" and "load" procedures.

Along with simple variables such as the label, system name for the evaluated start(start comp), the input name(inp file), the predicted material / energy flow output unit (output um mat q and output um en q), the initializer flag (initialized), the whole plant data model plant t contains the number of components component of the comp t form. The software also calculates and stores internally the total energy input value (tot inen variable), an important quantity for the software, and the category of the flows that have been selected for analysis (category), which can currently be set for material, (as components of the plant t type).

Each component of the plant (type Comp t) is connected by a specific derived data type next comp t to its next component(s) and includes a certain number of flow (type flow t), along with its name, its quantity of matter and power (mat and en) including the flag processed.

The next comp t data type contains the names of the next component(s) and a split t data structure needed to describe how the amounts in the current component are distributed to the following component(s) in case of multiple forward pathways.

In every comp t vector the flow data structure is of a flow t form. The second one includes the name, measuring unit (um q), the category and direction indicator (categ and dir), its quantity (qtity) and the optional alia element needed to indicate the current flow as the physical process of other flows. The details of the implementation of the logic for managing "aliased" fluxes go beyond the scope of the present article. Ultimately, flow t is the flow t form that capsulates the cycle of the product (sort cycle t) into the flow model, which is recycled back.

Potential applications:

In order to integrate the software with existing manufactured systems, several scenarios have been designed to provide additional benefits, apart from the visual representation of the flows in the foundry. The alternatives are listed and compared in Table 1. If the system is attached to advanced equipment to precisely plan or model different process phases (e.g. Casting phase electronic fluid dynamic codes), a thorough analysis of changes to the production line would be feasible or a further creation.

Automatic optimization features can also be applied in this sense. In addition the best return on investment changes possible after the simple Pareto analysis could be defined by using a sample of comparison foundries. Certain incentives are created when the program provides real-time data enabling the execution, in the most energy intensive phases (or a mixture, of process control steps or the training of foundry personnel). Finally, a complete life cycle study of the drug might be done using a catalog of the incarnated energy in the materials involved.

Table 1: Main Features of the Scenarios for the Integration of the Tool with Legacy System

Scenario	Input	Additional benefit
Production improvement	Audited data	Accurate specifications (via interfaced tools, e.g. CFD)
Product design	Manufacturing processes database	Accurate specifications (via interfaced tools, e.g. CFD)
Benchmarking	Reference plants database	Basic Pareto analysis (i.e. find "low-hanging fruits")
Process monitoring	Real-time data	Process monitoring tool
Training	Real-time data	Personnel didactic tool
Life cycle assessment	Materials life cycle database	Product life cycle analysis

Validation:

A confirmation of data gathered from actual foundries is shown based on the PFD representation (Figure4). The plant produces low-pressure, sand-casting aluminum alloy, passenger car components. For the fusion of 1000 kg aluminum alloy, material and energy details are identical, and there is no difference in thermal and electrical capacity. Plant components that reflect a certain step of the cycle are represented as linear, light-blue objects, while material flows are red and elliptically shaped.

Virgin metal is mixed with "external scratch" before melting; that is to say, metal supplied to an external contractor which returns the quantity of raw material equal to that obtained in subsequent stages of the process. The performance flows of "machining" and "inspection" stages are directly connected to the "raw material processing" stages in the PFD for the sakes of convenience. In the melting phase, recycled matter (i.e. internal shredding) from both' footing' and' inspection' phases will also be added in-house and at the same time, oxidation causes the majority of unrecoverable metal losses. Melting requires nearly 44% of the total energy input of the process.

With two main reasons, the subsequent holding process takes place in a different oven. First, it functions as a buffer for different production rates and enables the molten aluminum alloy to float metal oxides to the surface to become finished. In this way, the so-called "dross," a cause of potentially recovered material waste, is quickly subsequently removed. The holding phase also accounts for a large fraction of the entire process ' energy input (approximately 28%).

The core and molding system is a shut-off subsystem connected to metalworking. The sand mould has the objective of forming the external limits of the cast and supporting the core package. The core comes by a cold box operation, where the silica sand and resin are "curative" by a binder method. Approximately 6 percent of the total energy input is needed for the whole mold.

The casting step is the most common step in the entire process where the molten metal fills and solidifies the prepared mold. The mold is then detached, the core sand shook out, and in the fettling process the gating and runners are stripped off. The extracted metal is recycled internally in the smelting furnace, as previously mentioned. Although the energy consumed at this stage is not large, it is not insignificant (around 1.6%). A thermal treatment is needed to boost the motor blocks ' fatigue and wear properties, which require a substantial amount of input power, i.e. 16% of the total.

Many surfaces are cast with 2-3 mm excess material, which is removed during the machining step in accordance with the design specifications to achieve dimensional accuracy and surface finish. Several processes produce a portion of the recyclable scrap that an outside company is working on alongside a smaller portion of unrecoverable deteriorated metal (i.e. "external scrape" described above). The total energy input is roughly 4.4% for machining.

The next stage is impregnation: introduction by the imperfect solidification of a polymer sealant in the pores and cracks produced by the casting.

The main causes of porosity are a metal flow turbulence, gas pitching and uneven metal retrieval, which is promoted by significant volumetric retrieval and hydrogen content in particular in aluminum alloys. Impregnation is necessary to ensure the required sealing capacities of high pressure components. A small 0.1 percent of the total energy input is required to produce a vacuum dry process introduced during this step of the project

.

CONCLUSION

A computer program is presented and validated against data from real world data to assist foundries in the transition to a more sustainable way of production. The key areas of action that can be planned in relation to technologic approaches in foundry equipment and a didactic method for the instruction of staff in order to change their behavior, can be clearly identified through the graphical representation of procedures.

With a modular architecture and maximum flexibility, the program can be built into a limited-size GUI. A more thorough analysis is to be carried out on the implementation of an economic analytical module. Likewise, the capacities for life-cycle research are of concern and can be carried out as embedded energy flows, for example. Ultimately, it is important to incorporate the codes for casting applications developed with the computer fluid dynamics.

REFERENCES

1. R. C. Creese, Introduction to manufacturing processes and materials. 2017.
2. N. Panwar and A. Chauhan, "Fabrication methods of particulate reinforced Aluminium metal matrix composite-A review," in Materials Today: Proceedings, 2018.
3. F. Bonollo, N. Gramegna, and G. Timelli, "High-pressure die-casting: Contradictions and challenges," JOM, 2015.
4. K. Salonitis, B. Zeng, H. A. Mehrabi, and M. Jolly, "The Challenges for Energy Efficient Casting Processes," in Procedia CIRP, 2016.
5. S. Kumar, P. S. Satsangi, and D. R. Prajapati, "Optimization of green sand casting process parameters of a foundry by using Taguchi's method," Int. J. Adv. Manuf. Technol., 2011.
6. N. J. Jeon, J. H. Noh, Y. C. Kim, W. S. Yang, S. Ryu, and S. Il Seok, "Solvent engineering for high-performance inorganic-organic hybrid perovskite solar cells," Nat. Mater., 2014.
7. J. F. Wang e al., "Surface engineering of perovskite films for efficient solar cells," Sci. Rep., 2017.
8. C. Reilly, N. R. Green, and M. R. Jolly, "The present state of modeling entrainment defects in the shape casting process," Applied Mathematical Modelling. 2013.
9. R. Rajkolhe, J. G. Khan, and A. Professor, "Defects, Causes and Their Remedies in Casting Process: A Review," Int. J. Res. Advent Technol., 2014.
10. S. Pattnaik, D. B. Karunakar, and P. K. Jha, "Developments in investment casting process - A review," Journal of Materials Processing Technology. 2012.
11. S. Soltani, R. Azari Khosroshahi, R. Taherzadeh Mousavian, Z. Y. Jiang, A. Fadavi Boostani, and D. Brabazon, "Stir casting process for manufacture of Al–SiC composites," Rare Met., 2017.
12. Dipti Mishra, Mohamed Hashim Minver, Bhagwan Das, Nisha Pandey and Vishal Jain, "An Efficient Face Detection and Recognition for Video Surveillance", Indian Journal of Science and Technology, Volume 9, Issue 48, December 2016, page no. 1-10 having ISSN No. 0974-6846.
13. Dr. Priya Gupta, Aditi Kamra, Richa Thakral, Mayank Aggarwal, Sohail Bhatti, Dr. Vishal Jain, "A Proposed Framework to Analyze Abusive Tweets on the Social Networks", International Journal of Modern Education and Computer Science, having ISSN No. 2075-017X, Vol. 10, No. 1, January, 2018 .