A Non-Invasive Throughput Monitor for Molten Metal Processing

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NI Products Used:
CompactDAQ
LabVIEW 2012

Category:
Automated Test

The Challenge:
Accurately measure the mass throughput of molten metal entering a crucible over a 24-hr period to determine the efficiency of the crucible.

The Solution:
A LabVIEW and CompactDAQ-based measurement system that uses a laser sensor and filtering/mass calculation methods to measure efficiency.

Introduction
Data Science Automation (DSA) is a premier National Instruments (NI) Alliance Partner that specializes in automating and educating the world leading companies. Clients choose DSA because of DSA's deep knowledge of National Instruments products, disciplined process of developing adaptive project solutions, staff of skilled Certified LabVIEW Architects and Certified Professional Instructors, and unique focus on empowerment through education and co-development.

A Hot Problem
A manufacturer of crucibles for metal casting operations needed an application that measures the changing level of molten metal in their crucible product as it changes during casting of molded metal parts (usually aluminum). This, in turn, can be recorded as a "daily throughput" and used as part of an efficiency calculation to show their customers how much they save by using their products. The software would serve as a sales, marketing, and research tool.

The crucible sits over a furnace and metal is added via a robotic device. The metal is melted inside the crucible to produce castings. When pouring a casting, the crucible is tilted and metal is poured out (Figure 1). Over a 24 hour period, metal may be added and removed from the crucible many times, in different amounts. By measuring the mass of the metal that enters, the daily "throughput" of the oven can be calculated. This throughput can then be combined with other information about oven performance, and the energy efficiency of the crucible materials and construction can be indirectly determined for a specific site and application. This efficiency measurement can then be used to promote the client's crucible products with individual customers. The measurement system must be non-invasive so that it can be easily attached to a customer's oven setup.

One non-invasive method of measuring metal mass through the oven is to point a distance-measuring laser at the opaque surface of the metal and measure the distance of the metal surface from the laser head. By knowing the dimensions of the crucible, this distance can then be converted to a metal volume, and from there, mass. Knowing the change in mass over time allows calculation of the throughput.

The laser reading is provided as a 4-20mA process current signal and interpreted by an NI single slot Ethernet CompactDAQ carrier with a 4-20mA current input module. This system

can be moved easily to a customer site with a laptop computer, and even attached to a customer's LAN if desired.

DSA designed a LabVIEW application that can be installed at a customer site on a laptop computer for portability and easy installation. The application is paired with a distance-measuring laser to gather information about how much metal enters and leaves the crucible over a 24-hour period. This information is then used to calculate throughput of the metal, and can be used to indirectly determine efficiency of the system. The software application also has additional features that help the client's customers run their processes better, and can act as a product marketing tool.

The LabVIEW software application gathers the distance readings, converts them to height readings, and calculates mass change using crucible design data and metal density. The mass changes are accumulated over a 24 hour period to come up with a "24 hour total". These totals are logged over several months without requiring interaction from personnel. (Figure 2)

In addition, the display allows site personnel to view a plot of the mass changes over time and alerts personnel if the metal reaches an overflow level or if the crucible is nearing empty.

Any laser readings that are over a certain height are discarded, as sampling ladles and robotic filling devices can interrupt the laser beam causing erroneous readings. Also, laser measurements must be filtered and averaged to remove noise caused by turbulence in the liquid metal surface. Since any positive change in the metal height is counted as an addition to the throughput, it is important not to accumulate turbulence errors. (Figure 3)

Efficient and Able to Prove It

The project resulted in the crucible customer receiving a "kit" that allows them to prove the superior efficiency of client's products over the competition with actual measured data in various environments that are otherwise too harsh for traditional measurement techniques. In addition, the end user gets additional benefits such as process monitoring and alarming that increases their eagerness to have the system installed at their site.The visual ease and impact of using LabVIEW allow the client to have a marketing tool that is both attractive and technically impressive. With the help of Data Science Automation and National Instruments products, the client is able to prove the superior efficiency of their crucible product over other competitors in the marketplace.

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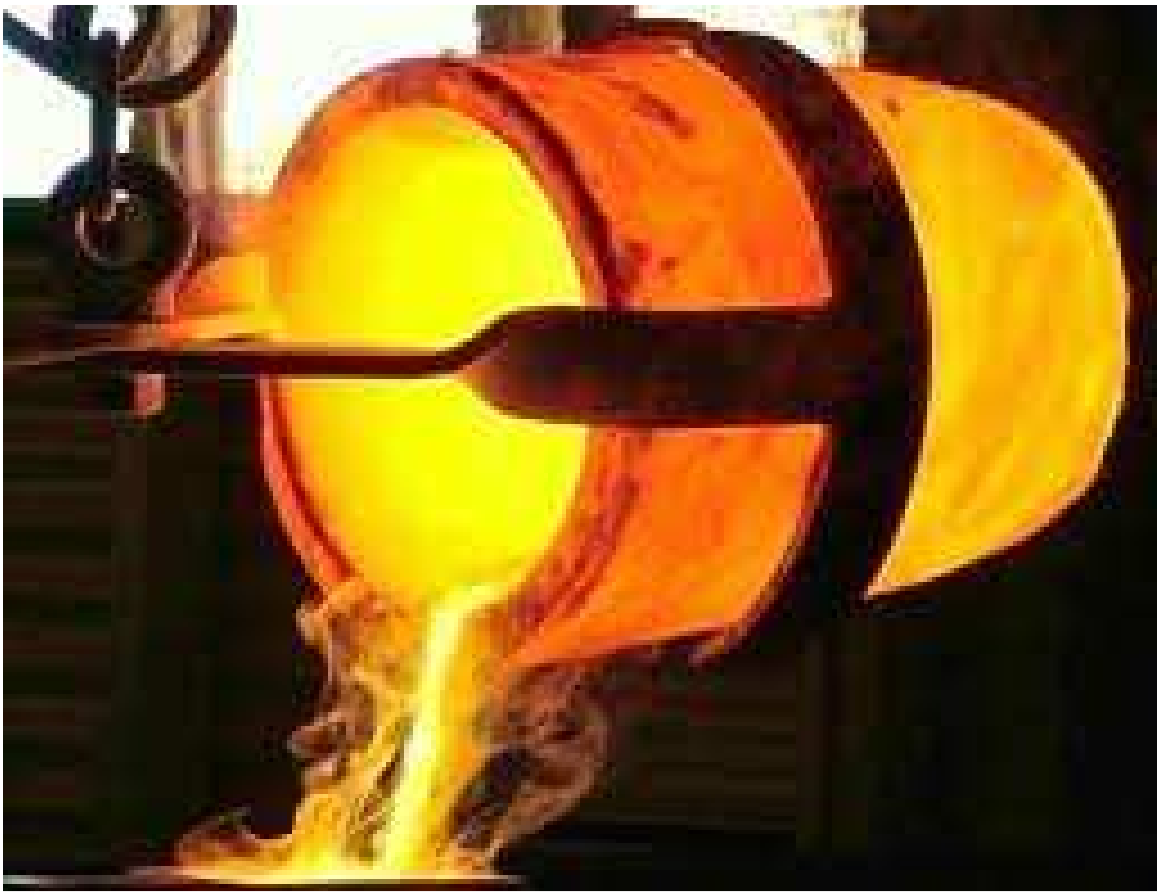

Figure 1 - Molten metal being poured out of a crucible into a mold for casting.

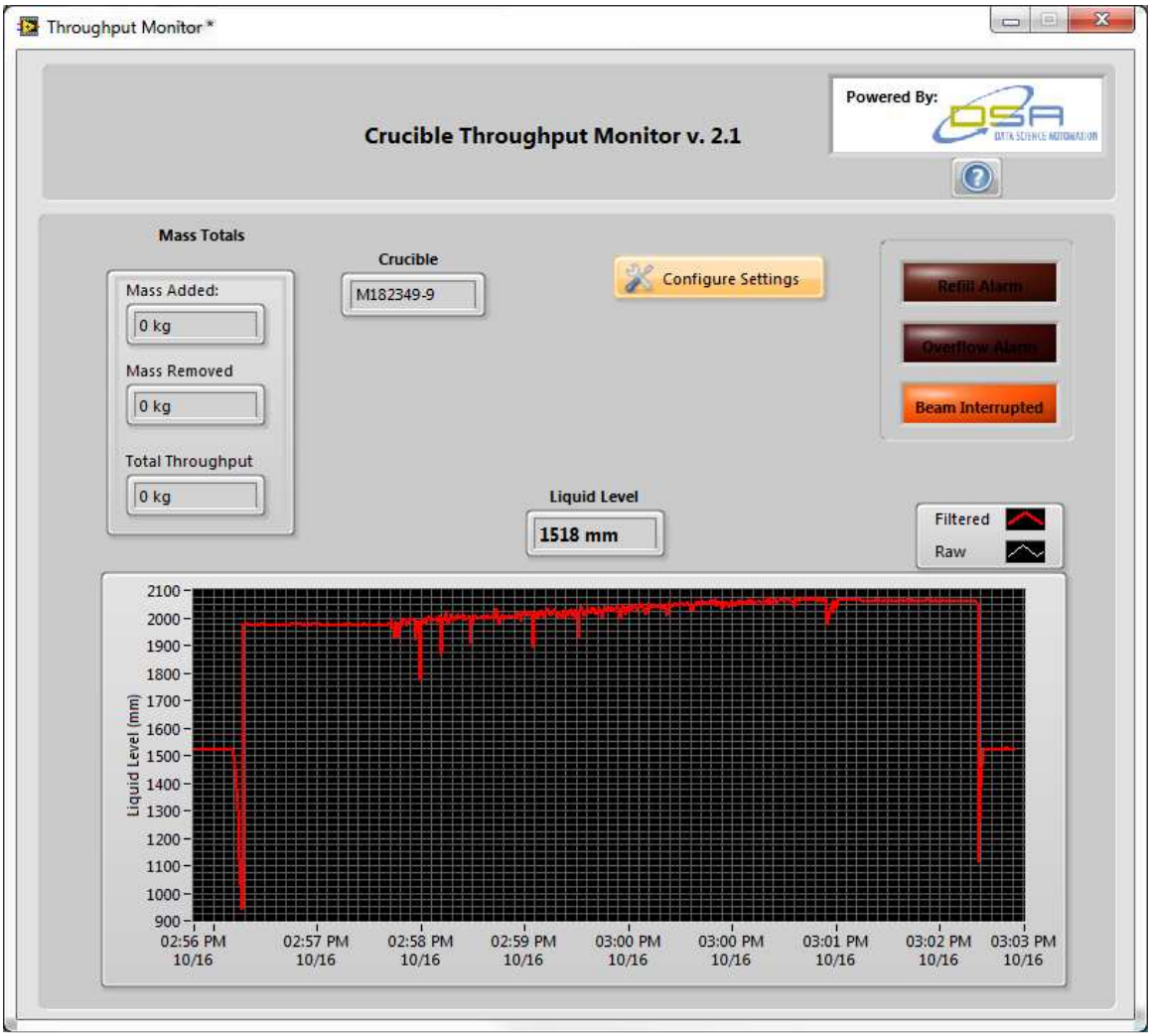

Figure 2: Main Data Display

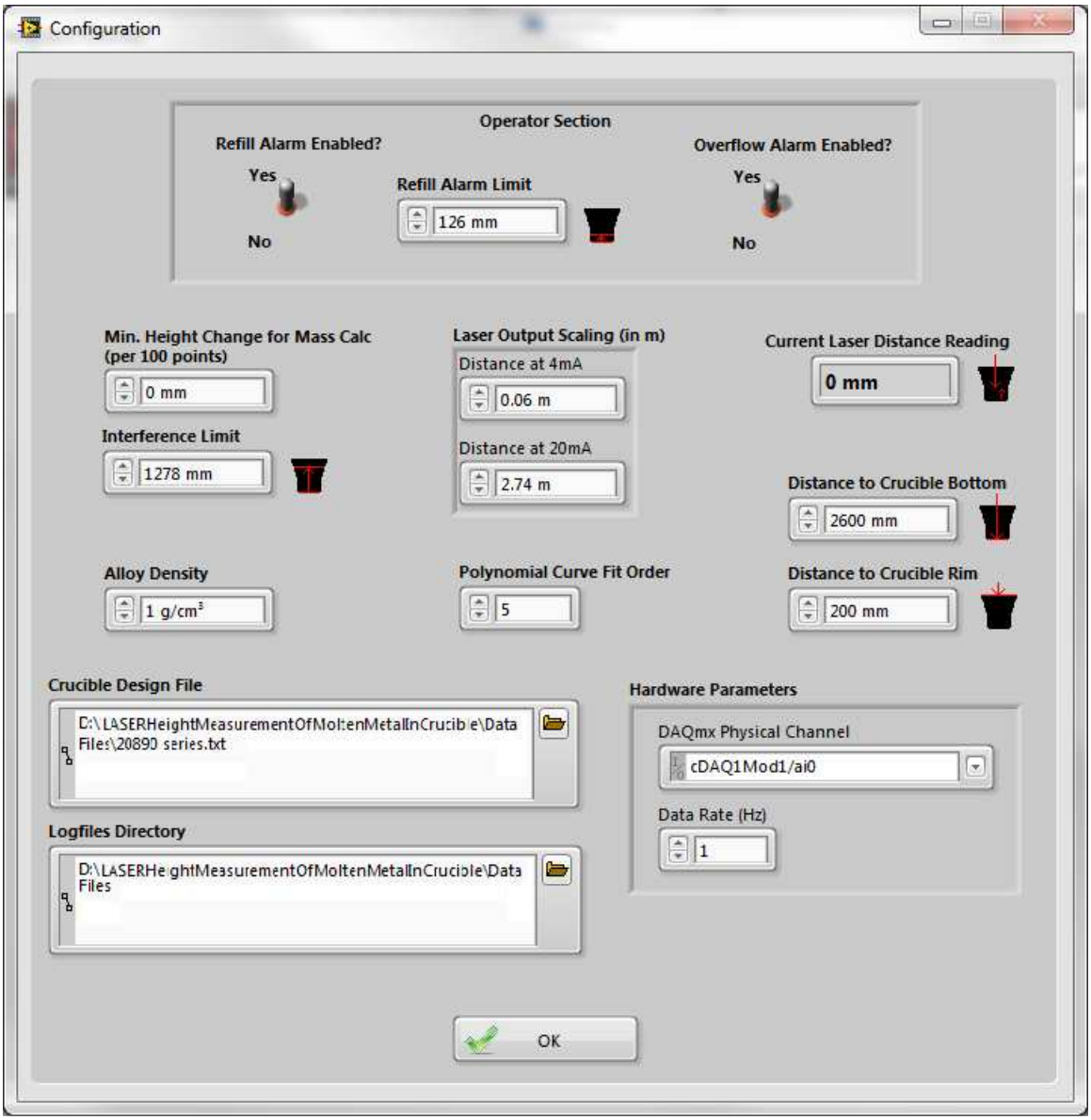

Figure 3: Configuration Screen