Optical measuring system in a foundry plant

Non-contact online measurement of pouring stream temperature

In most foundries, the temperature of the melt is usually measured by immersion (lance measurement). Even for parts of high complexity or components serving safety functions in the automotive industry or in aviation and space travel, this often seemed to be the only way of determining the casting temperature. Immersion measurements can only be made in the crucible or the transfer ladle but not in the pouring stream. However, the temperature in the pouring stream is critical to the continuous monitoring and control of the casting process and therefore to the quality of the casting. The temperature of the pouring stream can only be measured by non-contact method with pyrometers **(cf. Figure above)**.

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Where castings are made of different alloys, conventional pyrometers and traditional quotient pyrometers often cannot be used for the contactless measurement of temperature in the pouring stream due to considerable differences in the measuring conditions and the characteristics of the metal.

For logging the exact casting temperature of each pouring process and casting, the company IMPAC Infrared GmbH, Frankfurt/Main developed the measuring system ISR 12-LO/GS, a pouring stream pyrometer with optical waveguide system **(Figure 1)** for non-contact, continuous temperature measurement of the pouring stream. The temperature in the pouring stream is displayed online and corrective action can be taken immediately if defined limits are exceeded. In this way, the narrow process window for quality castings can be maintained.

The system for online measurement of the temperature of the pouring stream with data visualisation and data archiving was installed and went into operation at August Küpper GmbH & Co. KG in Heiligenhaus in November 2005. The available experience and results of the system will be discussed in the following paragraphs.

ISR 12-LO/GS in industrial service

The objectives of installing the measuring system at the company August Küpper were the following:

- To measure the temperature of the pouring stream for every casting; thereby substantially increasing the total number of measurements;
- To improve the accuracy of temperature measurement in comparison to known systems;
- To detect bad castings automatically;
- To enable statistical analysis of casting data;
- To optimize the operation of the casting equipment;
- To save costs (e.g., for repairs, personnel);
- To improve safety in comparison with lance measurement and avoid accidents;
- To save energy by controlled energy input;
- To establish comprehensive documentation of all process data.

Setup of the measuring system: The company August Küpper has three automatic casting machines, each with a pouring stream pyrometer type ISR 12-LO/GS with optical waveguide system **(Figure 2)**. The optical waveguide system is protected from mechanical impact and iron spillage by an enclosure **(Figure 3)**. The optical system is air-purged to keep it clean. The optical fibre cable and the optical equipment can operate in environments up to 250 °C without active cooling. The pyrometer is aligned with the pouring stream by a laser mark. The measuring field of the pyrometer ensures that deviations in the position or diameter of the pouring stream during the measurement have no negative effect on the measuring result.

The temperature of the pouring stream and therefore the temperature of every casting can be measured fully automatically with the ISR 12-LO/GS pouring stream pyrometer. The instrument identifies the beginning and end of the pouring stream automatically and masks disturbing factors such as brief afterpour or drops of molten metal. The temperature of each pouring process is displayed online enabling corrective action to be taken immediately if a defined limit is exceeded **(Figure 4)**.

Figure 1

Pouring stream pyrometer ISR 12-LO/GS with optical waveguide system

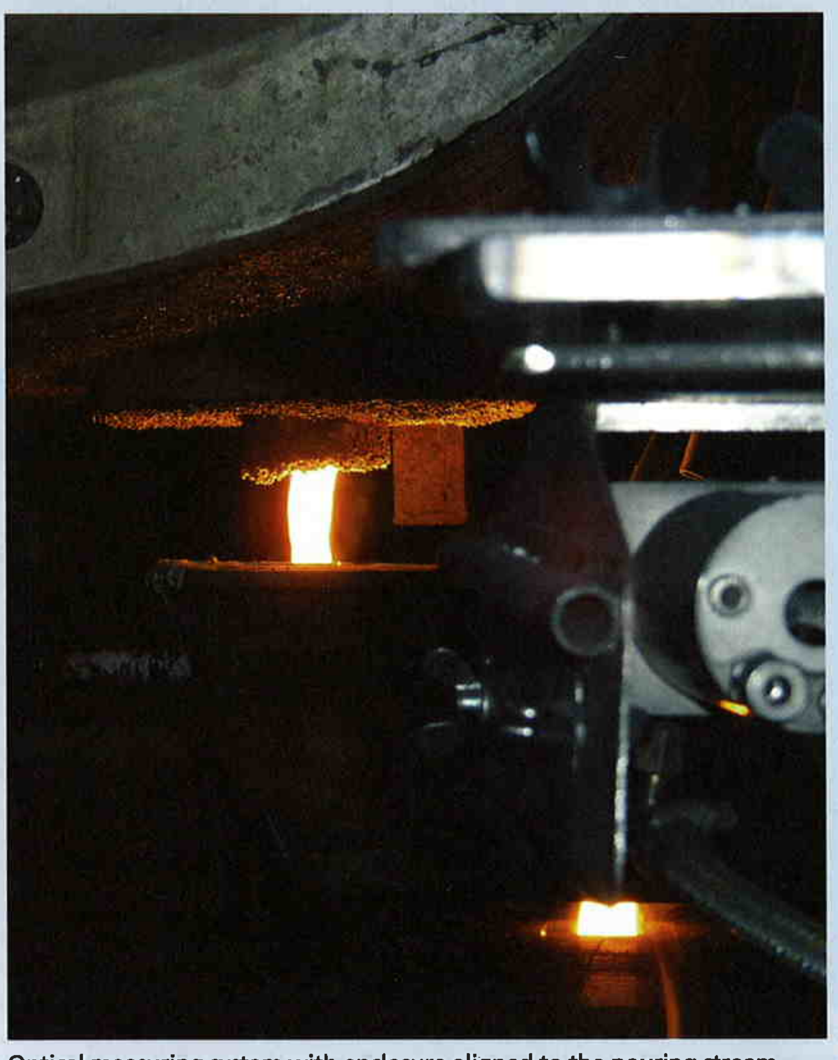
Measuring data for each pouring job can be documented and visualized by digital signal processing. All equipment parameters are also documented during the pouring process which makes the measurement traceable. The digital equipment of the IMPAC pyrometer supports linkup with the customer's database systems.

Temperature quality control system (TQCS): In combination with the TQCS from IMPAC Systems GmbH, the measur-

Figure 2

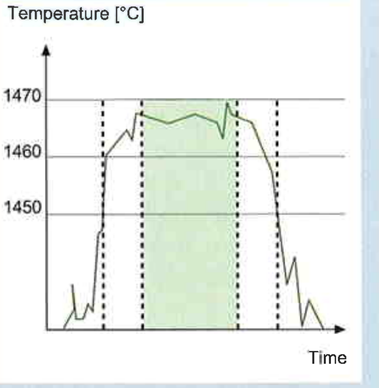
Operator cubicle with TQCS software surface (a); large displays at every machine (b)

Figure 3



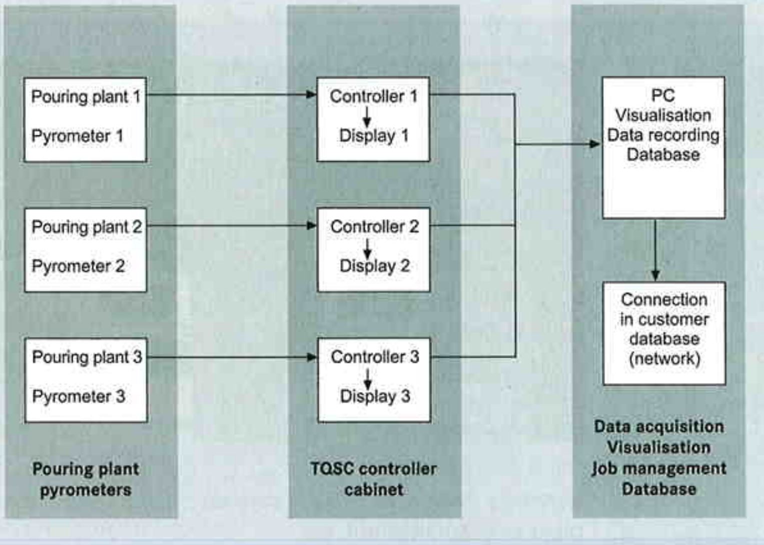
Optical measuring system with enclosure aligned to the pouring stream

Figure 4



Pouring stream temperature curve: The pouring stream temperature which is output after every pouring process is calculated from the temperature progression.

Figure 5



Possible TQCS configuration

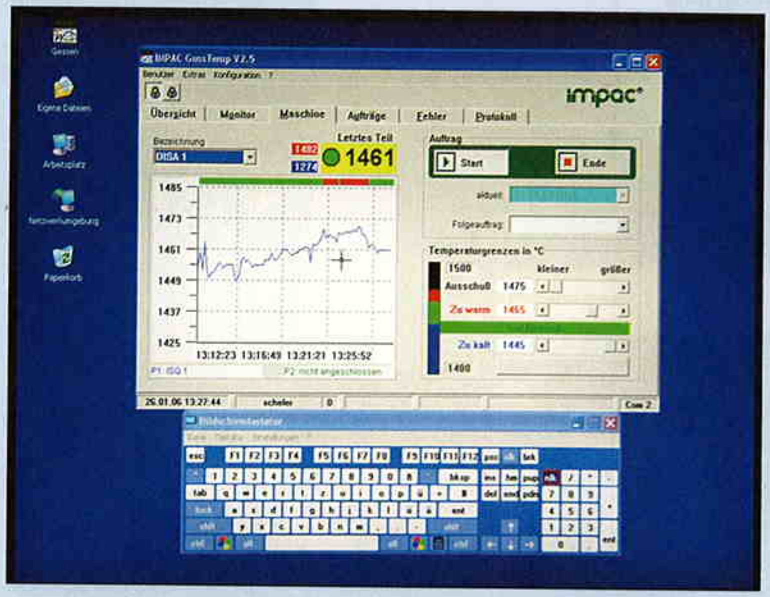
ing time is triggered by the control of the casting plant and temperatures, pouring time, measuring variables and job information saved and visualized in a fully automatic and tamperproof process. Linkup with a database permits direct access to data at any time. If required, the system can be extended to include up to 30 machines. In the meantime, numerous systems give reliable service in forging plants, rolling mills and foundries. Figure 5 illustrates a possible TQCS configuration.

Measuring results: The company August Küpper has three automatic casting machines each with a pouring stream pyrometer type ISR 12-LO/GS with optical waveguide system. The measuring results of some jobs will be discussed in the following.

Figure 6 is the TQCS visualisation surface (original machine screen). In addition to an overview of all machines / pyrometers, it shows a temperature graph (of the last 100 to 200 castings) and the job status. Jobs defined in a prior operation are started or stopped from this screen. At most, 30 machines can be defined; each can be assigned a current job and a follow-up job.

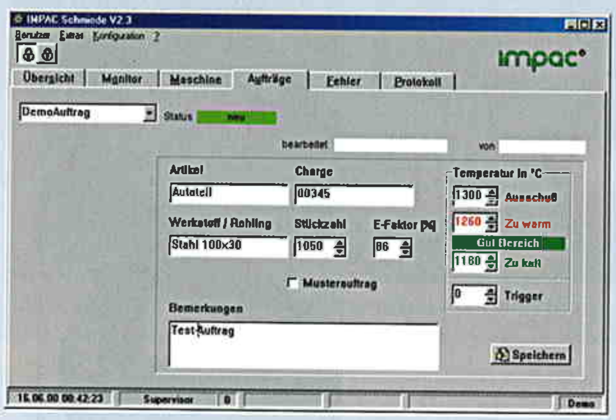
Figure 7 shows the TQCS job management screen. The system can manage up to 250 jobs. Data fields contain 15 characters; comments up to 80 characters and

Figure 6



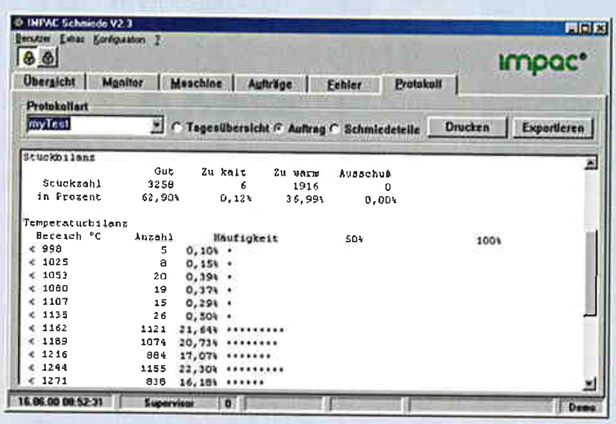
TQSC visualisation surface (original screen)

Figure 7



TQSC job management, example 1

Figure 8



TQSC job management, example 2

order numbers not exceeding 24 characters are supported. The maximum number of parts for one job is limited to 65,000. Job templates can be defined.

Several types of protocol (Figure 8) can be printed out or exported in ASCII file format. The day log contains a list of all jobs by machine, totals of good, cold and bad parts, for each job and the total number of parts made on that day. Shift protocols can contain up to four different shift timings. The day log contains all jobs by shift.

Job protocols, in addition to job data, record the temperature of each part, with running part number, time and date, status and the pouring time. Data is saved in the database and can be passed on by SAP or BDE system.

Practical experience with the online measurement and documentation of the pouring stream: Manfred Scheler, of the company August Küpper, regards the measuring system as a major step towards a modern, controlled process and continuous improvement of quality: "...with the new measuring system, you see many things you did not see before. Hidden defects are detected and can be avoided by controlled action...".

The possibility of the direct measurement of changes in the process has already resulted in several improvements. For example, the discharge holes were made smaller, which resulted in a better focus of the pouring stream, avoids hollow stream and improves the uniformity of the pouring temperature. Besides, the rate of wear of the pouring bricks is reduced substantially.

Adjustment of the transformer steps of the induction coils went a long way in improving the temperature continuity (reduction of the electrical energy from 140 kW to 120 kW).

Comprehensive documentation of the measuring data makes it possible to "visualize" the effects of changes in the process. The non-contact temperature measurement supplies direct information of whether the process runs smoothly or some failure has occurred. As data is recorded, all batches, days, shifts, etc. can be traced and are available even after a long period of time. The system also charts the development of temperature in the

Table 1

	Lance measurement Measuring probes	Maintenance / repairs	Personnel Data entry	Total
Costs without pouring stream measuring system (2 or 3 automatic casting machines)	120/day 0.69 €/casting = 82.80 €/day = 19,044 €/year	approx. 30 lance changes Material: 100 €/lance Personnel : 1 h at 50 € = 4500 €/year	Approx. 0.5 hr/day, 25 € each, approx. 5750 €	
Costs with pouring streammeasuring system (2 or 3 automatic casting machines)	approx. 40/day 0.69 €/casting = 27.60 €/day = 6348 €/year	approx. 10 lance changes material: 100 €/lance Personnel : 1 h at 50 € = 1500 €/year	Not applicable due to direct linkup with database by TCP/IP	
Approx. annual saving (230 days) (2 or 3 automatic casting machines)	12,696 €	3000 €	5750 €	21,446 €

Example of an approximate cost account of the use of the pouring stream measuring system (August Küpper)

process. Once these factors are known, preventive action is taken automatically. This yields information specific to every foundry. As levels and types of equipment, type of production and the nature of failures are different, every foundry can develop internal regulating mechanisms.

The positive effects of the adoption of a pouring stream measuring system on costs can be seen from Table 1 below.

Outlook

The great aim is the automatic control of the [SM5] plant. This would not only save cost, energy and human resources, quality would improve and the statistical evaluation of production make progress. If that was achieved, not only the usual material and batch-related data but also the pouring temperature and pouring time of every pouring process could be saved.

References:

Application booklet "Gießerei-Anwendungen", IMPAC Infrared GmbH