

# Precise and Rugged Measurement System for Red-Hot Metals

Increasing the economic efficiency of the continuous casting process

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**Fig. 1** In the continuous casting of steel, copper alloys or aluminium, materials losses must be kept as small as possible in order to produce economically. (Source: Polytec)

When casting steel, copper alloys or aluminium in the continuous casting process, the losses of material must be kept as small as possible in order to guarantee economic production. Therefore, measurement systems which control the cutting length are mandatory. Often, however, the inaccuracy inherent in the working principle – caused, for example, by slippage, wear or dirt – is the reason that producers have to add a significant surplus quantity to the minimum length which is guaranteed to the customer; this, however, means that with each cut the producer “gives away” a certain quantity of material. Thanks to high-precision, non-contact measurement systems, which withstand also the rough operating conditions directly above the red-hot strand, this savings potential can be used and the economic efficiency of the continuous casting method can be considerably increased.

Nowadays, steel, copper alloys and aluminium are usually continuously casted at typical speeds of about 0.5 to 5 m/min and then cut into parts (Fig. 1). The core element of each such continuous casting plant is the mould which determines the format of the strand. The liquid metal is poured into the mould and starts to cool down and solidify while the strand is moving onwards. Its speed has an effect on the cooling and solidification process. So the speed is crucial for the quality of the final product. In the worst case, the strand can break when the outer skin did not have sufficient time to solidify. Both effects can be avoided when the speed of the slab is continuously measured and regulated in accordance with the process requirements.

## How long and how fast is the strand?

When cutting off the slabs, also the velocity measurement has an important role as a complement to the length measure-

ment: That is because the strand is moving continuously forward while being cut by the cutting device. In order to get a clean and straight cutting edge, the speed of the cutting tool must be adjusted to the speed of the moving strand. Otherwise, the slant of the cut would have to be taken into account in addition to the minimum length. Therefore, knowing precisely the speed and the length of the slab is an important factor for the process optimisation and consequently also the cost reduction. In principle, several methods can be used for the relevant measurements.

Most of these methods, however, have serious disadvantages: When the length and the speed of the slab are recorded with measuring wheels, inaccuracies must be necessarily accepted. They result from the fact that the diameter of the wheel changes because of wear or contaminations such as scale. Therefore continuous maintenance, examination and calibration are required. Moreover, such a tactile measurement is always influenced by slippage as the oscillating

## Company

### Polytec

Waldbronn, Germany

As an innovative high-tech company, Polytec has been developing, producing and distributing laser-based measurement solutions for research and industry for more than 40 years. Building on the success of its distribution business, Polytec began to develop and manufacture their own laser-based measurement instruments in the 1970s. Today, the company with headquarters in Waldbronn near Karlsruhe is one of the world market leaders in the area of optical vibration measurement with laser vibrometers. Systems for length and speed measurement, surface measurement, analytical measurement as well as process automation are also part of the widely spread range of innovative proprietary products by now. At the same time, the distribution of high-tech products from other innovative manufacturers is another core competency of Polytec.

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Fig. 2 The Laser Surface Velocimeter LSV-2000 has been specifically developed for the precise speed and length measurement in rough environments. No additional protection measures are required by the user. (Source: Polytec)

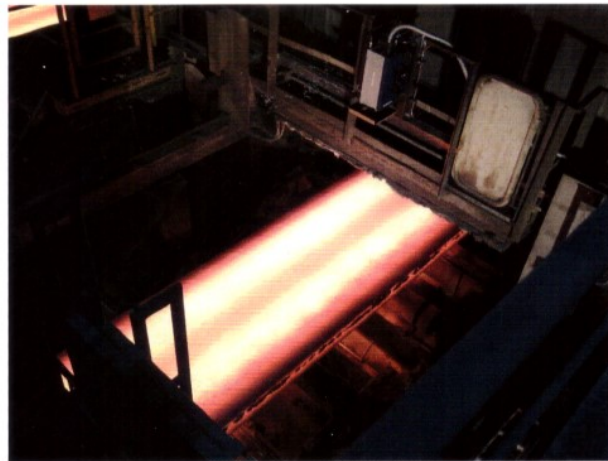


Fig. 3 Position of the measurement system above the strand. At the front to the left a part of the bridge with the torch cutters can be seen (Source: Polytec)

movements of the mould are transferred to the strand. Therefore, there is a slight “jerk” from time to time. The same applies when speed and length measurements are derived from the rotational speed of the driving rollers recorded and evaluated by rotary encoders.

### The most effective solution: Optical, non-contact and wearfree

No wonder, then, that non-contact optical measurement systems prevail more and more in steel mills. The Laser Surface Velocimeters LSV-2000 from Polytec, for example, have been specifically developed for the precise speed and length measurement in rough environments (Fig. 2). These systems do not wear

out and are also maintenance free when in operation around the clock. Moreover, their reliable measurement data can easily be integrated into the process control.

A laser surface velocimeter uses the differential laser Doppler principle and evaluates the laser light scattered back from a moving object (see box below). Unlike conventional non-contact methods, the LSV recognizes stand-still of the strand and detects reliably the direction of movement.

### Short amortization times and no additional cooling measures

Due to the high precision and reproducibility of this non-contact measurement, quality and profit are increased.

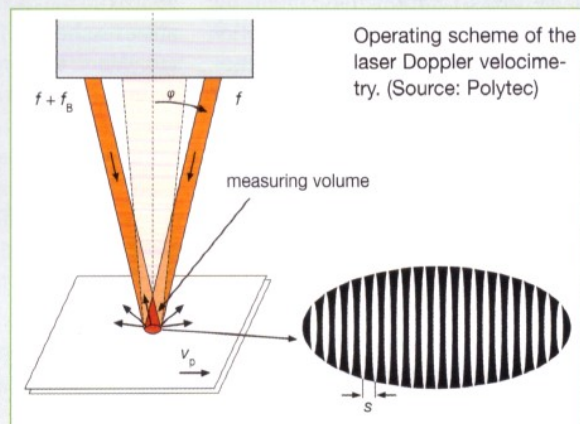
For the user, this pays off quickly. When the additional quantity of material foreseen for cutting inaccuracies is reduced by only a few millimeters, payback periods of about one year can usually be achieved. Moreover, installation and commissioning of the optical measurement system are easy. The device is mounted about 1.5 m above the strand and immediately ready for use. Only the application-specific parameters still have to be entered. The training expenditure for this is insignificant; once in operation, the LSV does not require any operator input; the commissioning is carried out by the experts from Waldbronn. And there is still an additional advantage: Despite the hot operation environment there is no need for the

## The Laser Doppler Velocimetry

The velocimeters work according to the so-called difference Doppler technique. This involves that two laser beams which come in each at an angle  $\varphi$  with the optical axis overlap on the surface of the measurement object. There they generate an interference pattern of bright and dark fringes. The fringe spacing  $\Delta s$  is a technical constant of the instrument and depends on the laser wavelength  $\lambda$  and the angle between the measurement beams  $2\varphi$ . It can be said:  $\Delta s = \lambda / (2 \sin \varphi)$ . If a particle moves through the fringe pattern, the intensity of the light scattered back by the particle is modulated. A photo receiver in the measurement head generates an AC signal whose frequency  $f_D$  is directly proportional to the velocity component of the surface in measurement direction  $v_p$  and it can be said:

$$f_D = v_p / \Delta s = (2 v_p / \lambda) \sin \varphi$$

with  $f_D$  being the Doppler frequency,  $v_p$  the velocity component in direction of the measurement and  $\Delta s$  the fringe spacing in the measurement volume. The value  $\lambda / \sin \varphi$



makes up the basic measure for the velocity and length measurement. It is precisely measured for every measuring head and printed on the identification label.

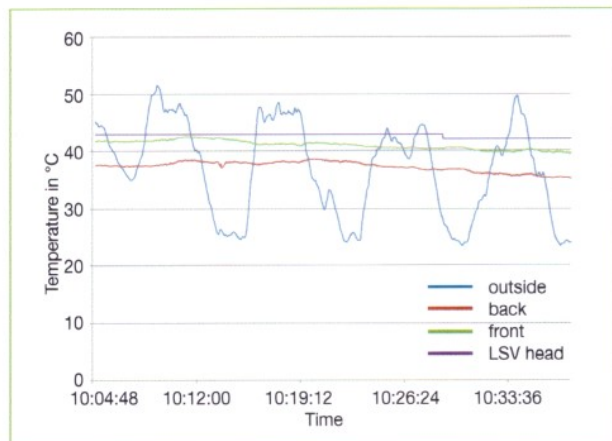


Fig. 4 Temperature curve during the casting period. The temperature outside (blue curve) shows an increase each time the bridge with torch cutters is moving with the strand. (Source: Polytec)

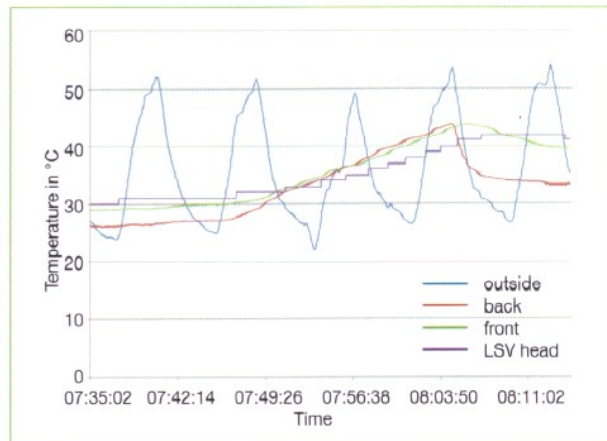


Fig. 5 During an interruption of the cooling water supply the temperatures increase significantly. When the water supply is opened again, the temperatures drop immediately. The temperature at the LSV head shows a high inertia. (Source: Polytec)

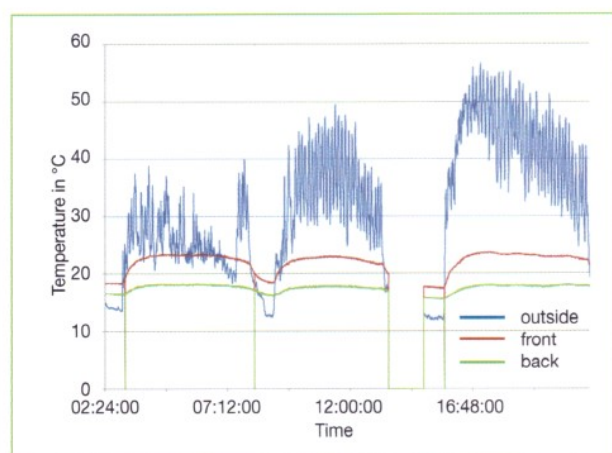


Fig. 6 Trend of the temperatures during a day after water supply had been changed to tap water supply. (Source: Polytec)

user to protect the measurement system by additional cooling measures. The protective housing made of aluminium with cast-in stainless steel cooling water pipes is so effective regarding its cooling performance that there is no need for additional protective measures. The user does not need to take responsibility for design, production, mounting and operation of additional protection measures thus saving effort and costs.

implemented for the test. Despite the high inlet temperature, the cooling performance was sufficient to protect the measurement system.

In order to simulate a problem in the cooling water supply, the water supply was interrupted and the temperature development was observed. Only after approximately 15 minutes, the temperature reached a critical value for the sensor. When the cooling water was flow-

ing again, the temperature dropped to a safe level within a few minutes (Fig. 5).

As – especially during the summer – process water can get too warm, the water supply was changed to tap water for a further test. The temperature curve of a day is illustrated in Fig. 6. The temperature in the cooled protective housing never exceeds the level of 25 °C; the temperature in the measurement head, which should not exceed 45 °C, therefore is less than 30 °C. The massive housing has sufficient reserves to work reliably in environments with even higher temperatures than in the test environment.

Due to the robust, high-precision non-contact measurement systems, the economic efficiency and the process safety can clearly be increased with each continuous casting process without requiring additional cooling measures on the part of the user.

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### Proven in rough practice

The measurement systems is designed for environment temperatures up to 200 °C and has also proven itself in harsh industrial applications. Such an LSV, for example, was installed in a steel mill directly at a cross beam near the outlet of the strand, directly in front of the torch cutters (Fig. 3). For the cooling, process water at a temperature of 31 °C from the water cycle was fed into the housing. Fig. 4 shows the temperature curve of the three sensors which had been

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