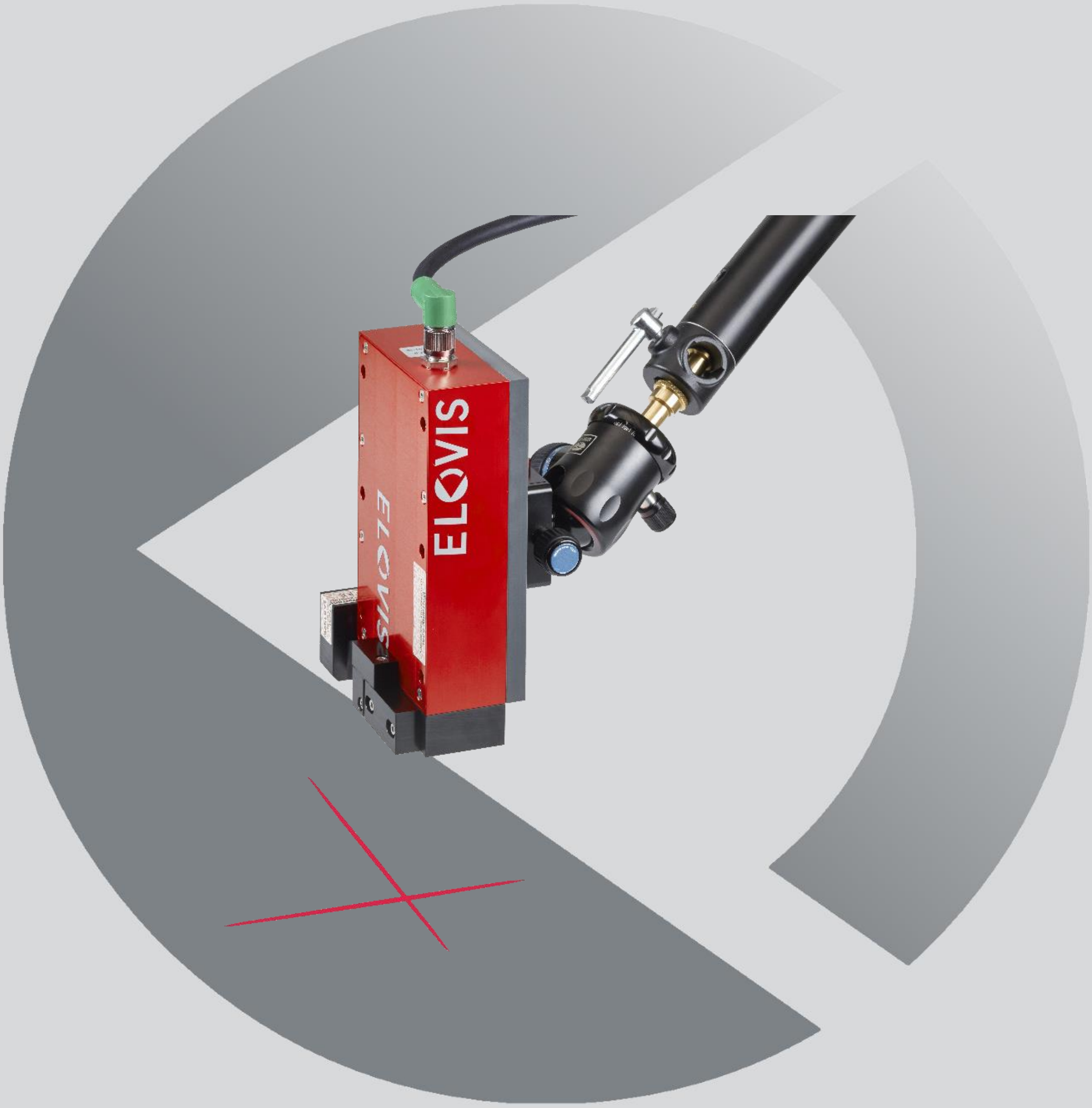


µSPEED – Pulp Jet-/Wire Speed Measurement

Non-contact speed measurement in the paper industry
Measurement of pulp jet and wire speed

Q1/2021 - Version 1.0

Version 1.0

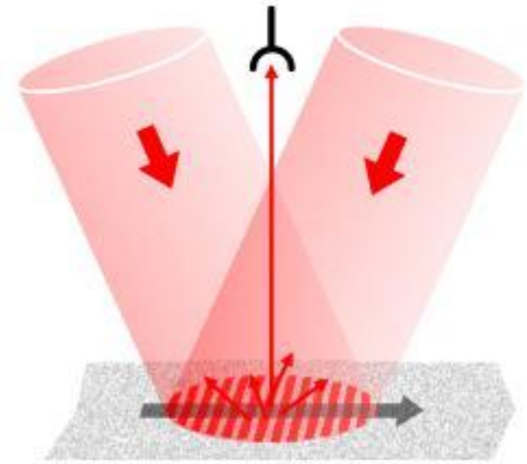
Non-contact measurements on paper machines are often the only way to determine speeds. Normally, the rotational speeds of rolls and cylinders are measured and used to calculate the speeds via diameters and gear factors. By the use of this method, errors can occur which can lead to strong deviations and thus to problems with the paper machine.
Speed settings in paper machines are extremely important, indispensable parameters for optimizing paper quality and increasing efficiency. For this reason, ELOVIS carrys-out speed measurements **on the pulp jet** with a speed sensor that operates **contactless**, based on a laser.

1. Metrological basics

The µSPEED laser encoder from ELOVIS GmbH is the suitable measuring technique. This system can be used mobile and is able to measure velocities and lengths of structured and smooth surfaces as well as of flowing material suspensions. The recorded data is displayed in mobile use either via a display device or by software via a PC, where the data is also archived and evaluated.

2. Measurement Principle Non-contact Length and Speed measurement

A strip pattern is generated on the medium to be measured with the aid of two laser beams. The intensity of the light scattered back into the detector is modulated by the movement of the measuring material surface, whereby the frequency of the brightness modulation is directly proportional to the speed of the medium and thus to the Doppler frequency. The use of special markings or scales on the target is not necessary. The scattered light is converted into an electrical signal by a photodetector and fed to a digital signal processor via an analog/digital converter. The current speed and the length are then calculated from the digitized signal.



3. Special Features

Compared to other non-contact measuring systems, the µSPEED laser encoder offers impressive **material independence**. Even change-reflecting materials can be measured.

4. System Description

The sensor head contains the complete measuring system. This is why we speak of a so-called "intelligent" sensor head or a smart sensor. It is possible to display the measured values via a serial display or a controller. The collected data can be graphically displayed, evaluated and stored from the PC using the evaluation software.

5. System Use

A basic requirement is the correct alignment of the sensor. The measurement distance is 240 mm (+/- 10 mm). The deviation from the running direction of the material to be measured must not exceed +/- 1°. An optical adjustment device (OAJ) is used to adjust the sensor. The OAJ is mounted fixed to the sensor and equipped with three line lasers. The line lasers are used **for system distance adjustment and for checking the alignment**.

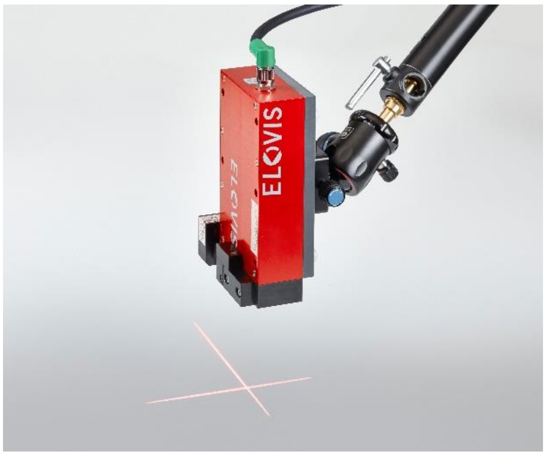


Fig. 1: sensor mounted correctly

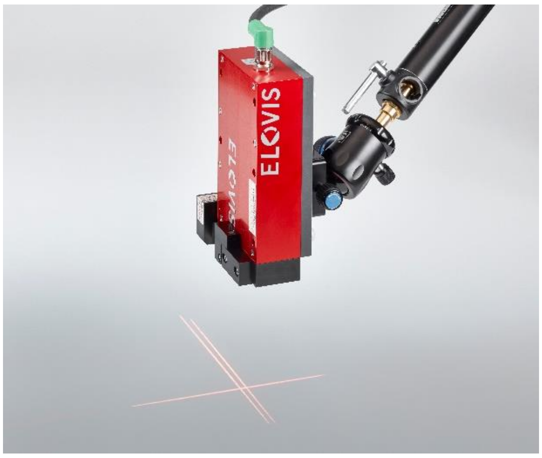


Fig. 2: wrong measurement distance

Sensor is mounted correctly, if:

- Individual line must be aligned at an angle of 90° to the material running direction.
- Double line must be aligned in material direction
- Double lines must appear parallel on the measuring surface when the distance of the sensor changes.
- Double lines must unite to form a line at the correct measuring distance.

6. Practical use for Paper Machine Head Box Measurement

The sheet formation is decisively determined by the exit velocity of the pulp suspension from the headbox, the angle of impact on the forming fabric and the speed of the forming fabric. The speed of the forming fabric is relatively easy to determine using various methods. A high accuracy is achieved by the use of the speed sensor, because slippage does not play a role for the µSPEED measuring method. **Pulp jet can only be measured directly without contact.**

In order to realize the measurement of the pulp jet, some boundary parameters have to be considered:
In order to deliver realistic values, the laser needs a minimum opacity of the measuring material, which is usually achieved from 40 g/m^2 (square weight after the dryer) in the beam. Of course, this opacity also depends on the fillers used and on surface turbulances, so that a suitable minimum opacity can be achieved even under 40 g/m^2. If the material beam is not opaque enough, the laser beams penetrate through it and no velocity values can be determined. Also the minimum speed of the line should exceed 300 m/min.

Under certain conditions, e.g. on very slow machines, where the material beam flows very "smoothly" and turbulence-free, stronger scattering in the signal quality can occur. The sensor can be parameterized and can therefore be optimized for the individual case. In exceptional cases, however, a measurement may not be possible.

In general, no measurement of the material beam is possible on gap formers, because the laser cannot be aligned to the surface of the material beam due to the machine design.

7. Measuring setup in the paper machine

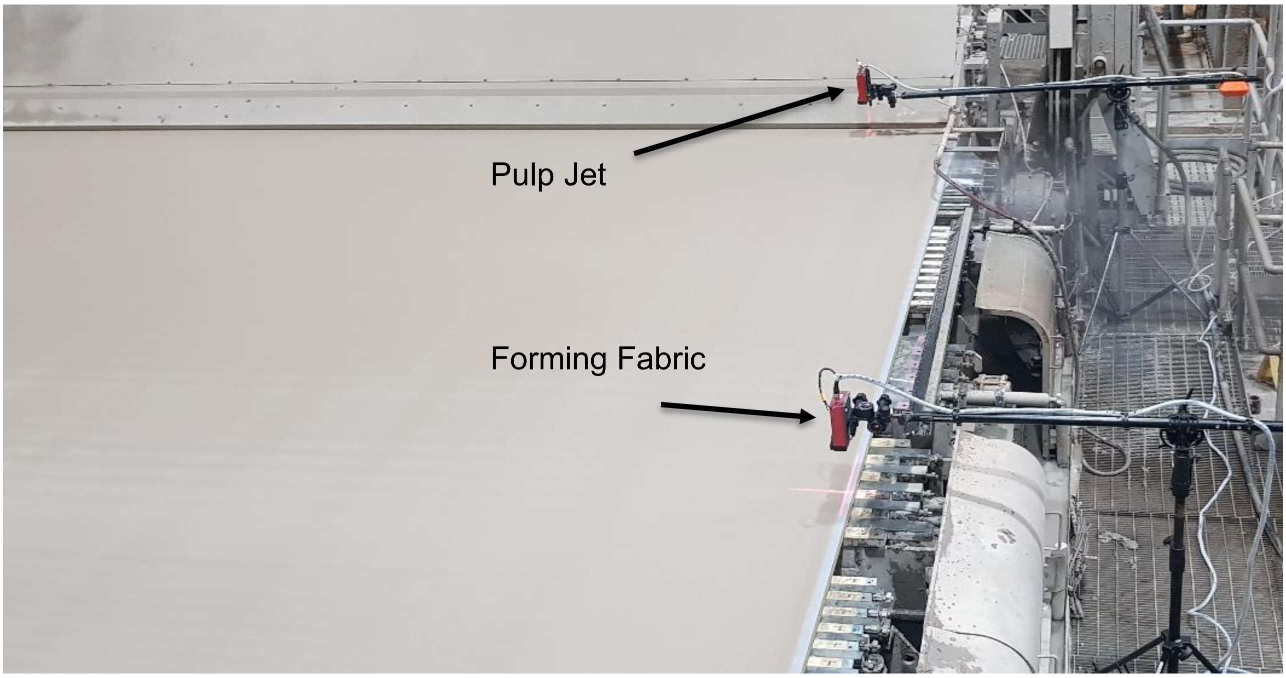


Fig. 5:
Paper machine head box with forming fabric and two µSPEED laser sensors. One for pulp speed and one for wire speed measurement.

Two sensors have been installed on this machine. The first sensor permanently measures the speed of the forming fabric, the second sensor is aligned to the fabric jet. This measuring setup is preferred in order to record the changes in the jet-wire ratio at different fabric jet speeds and to determine the jet speed when the lip opening changes. The measurement results obtained in this way can be used to correct the stored dynamic pressure formula for the headbox.

8. Case Study

In the following case study, a situation of the paper machine that is often encountered is presented:
According to the process control system (PCS), the forming fabric speed was 695 m/min. The measurement with the µSPEED system showed a value of 693 m/min. The sieving speed specified in the PCS is taken from the sieve drive roller. The sieving speed is measured by the use of the µSPEED laser sensor close to the headbox (HBX). The wire is accelerated from the HBX to the drive roll. The data in the PCS is therefore correct.
According to the PCS, the pulp jet velocity is 716 m/min. The measurement with the optical µSPEED laser encoder results in a beam velocity of 681 m/min.

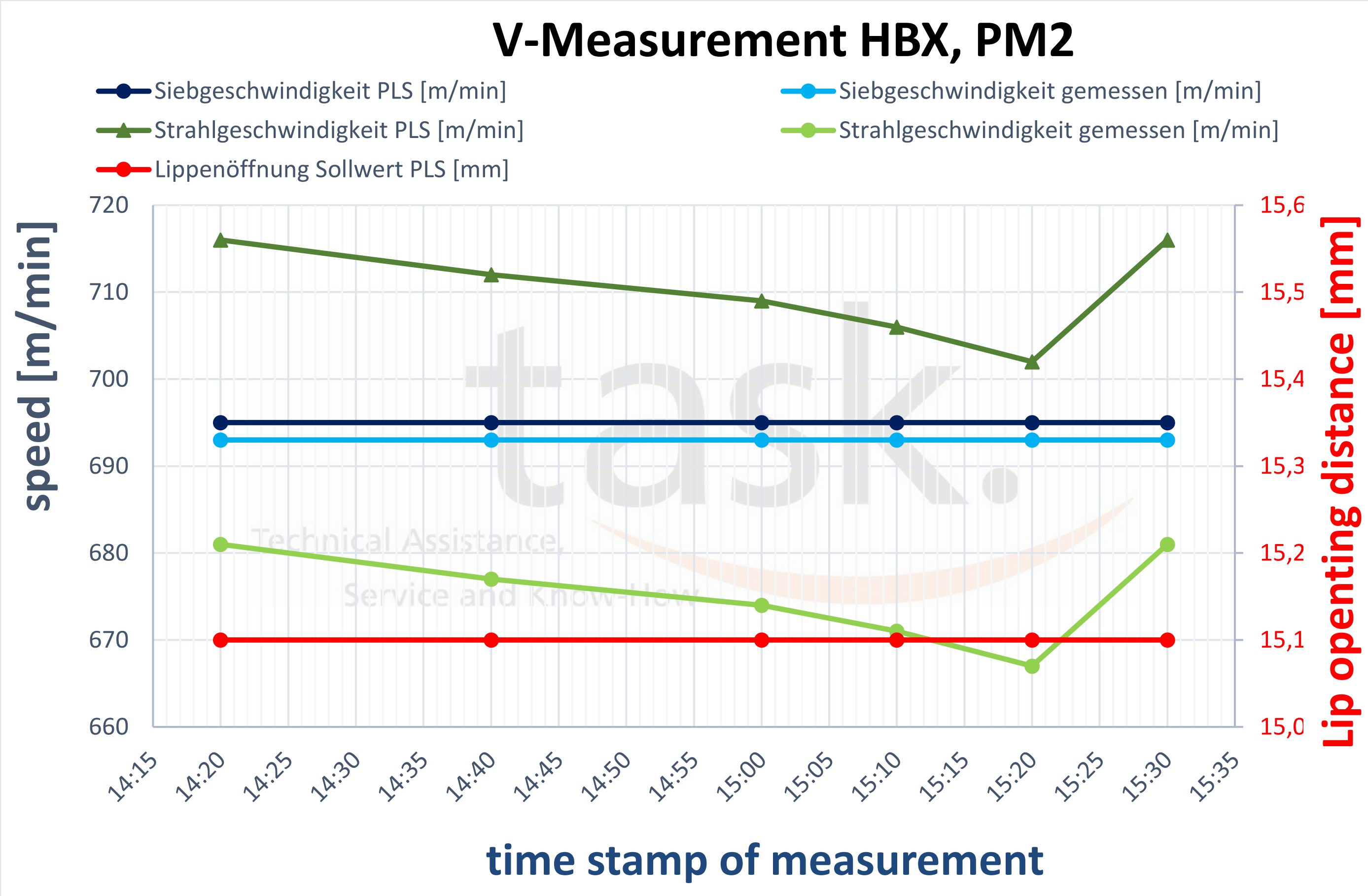


Figure 6: **SPEED-Measurement HBX, PM2**
Siebgeschwindigkeit = wire speed ; Strahlgeschwindigkeit = jet speed
PLS = PCS; gemessen = measurement by µSPEED laser encoder

Consider Fig. 6.
If the beam velocity changes, the difference between the measured and the values displayed in the PCS remains the same. This means that the headbox pump control works correctly. This difference is found in many paper machines and can easily be corrected by an offset in the PCS programming.

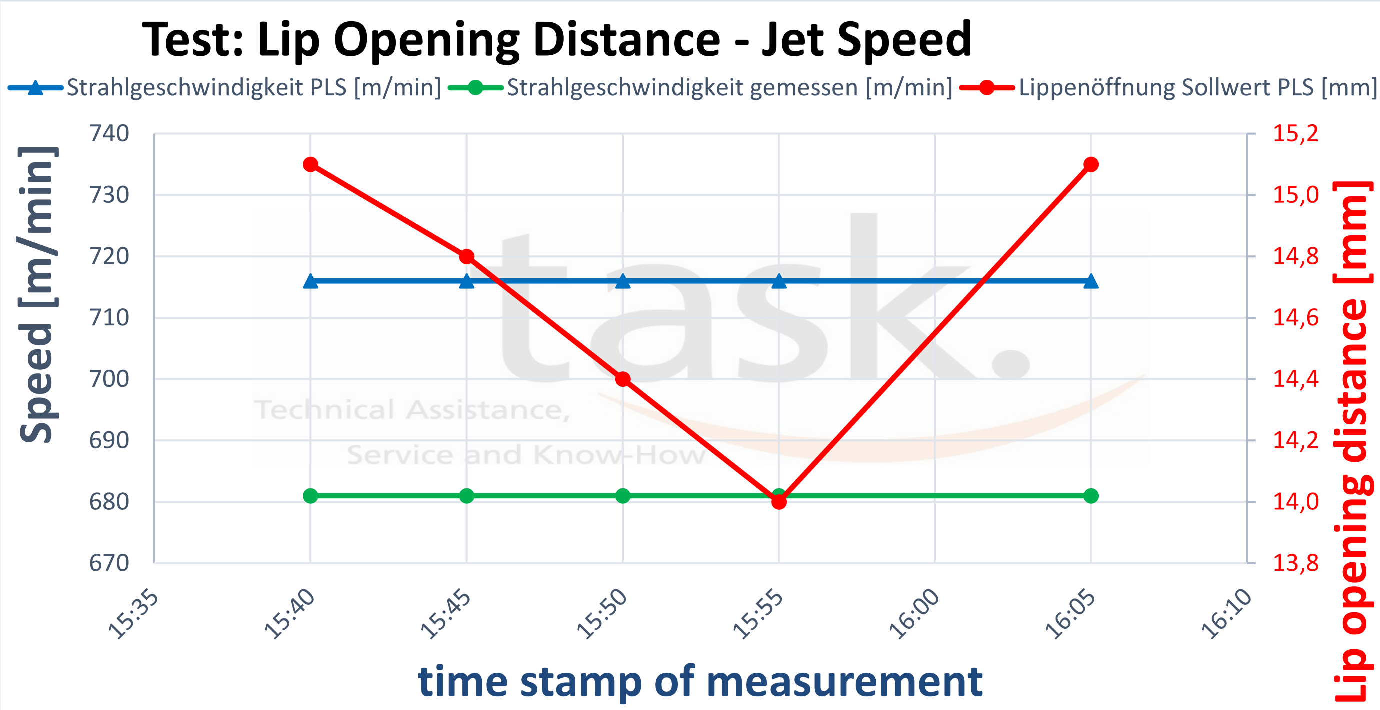


Figure 7: **Lip (Gap) Openting Disctance – Jet Speed**
Geschwindigkeit = speed; Lippenöffnung = lip (gap) opening distance
PLS = PCS; gemessen = measurement by µSPEED laser encoder

Fig.7 shows that the jet speed (setpoint constant) does not change with different lip (gap) openings. This is a correct behaviour or so we expect. If the jet velocity were to change, an incorrect dynamic pressure table would be present, for example, or the mixing pump control would not function correctly.

9. Distribution over the Speed Values

The following diagram shows the distribution of the µSPEED measured values.

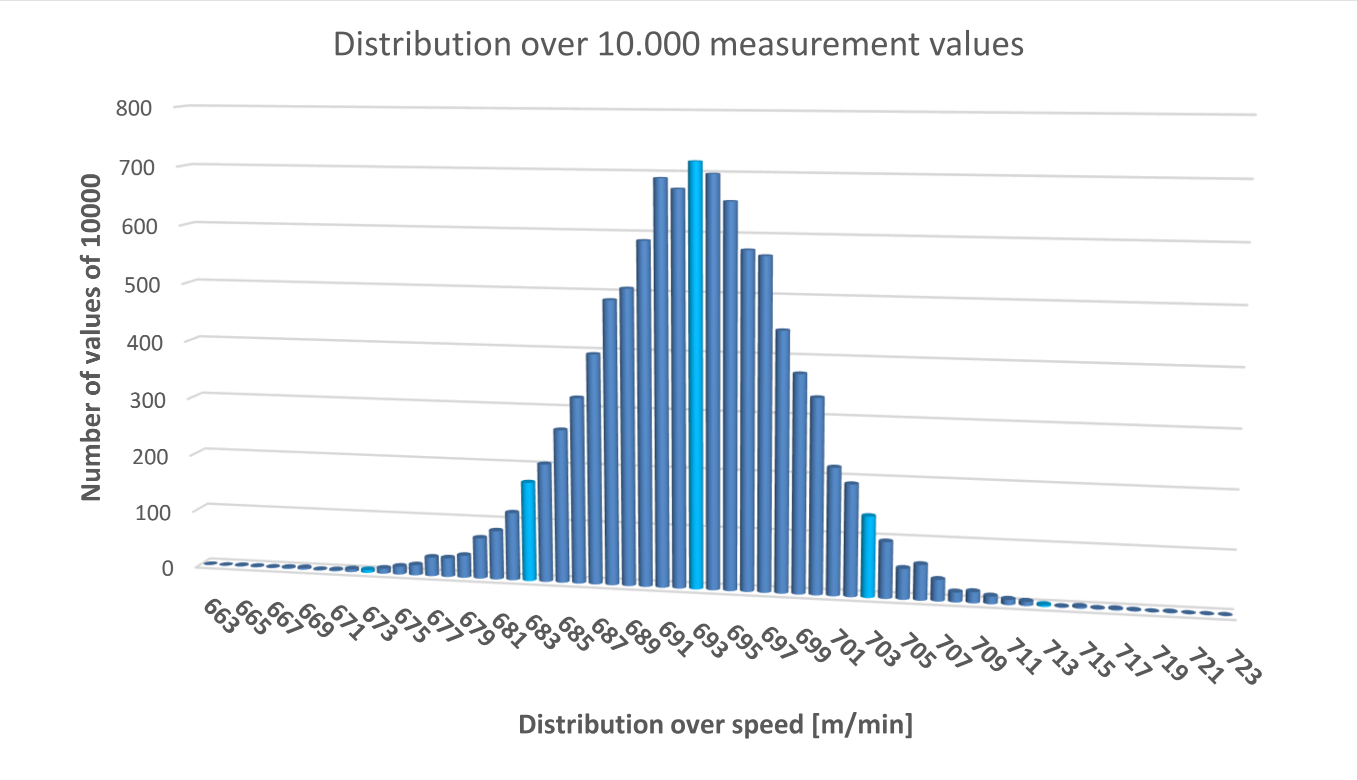


Figure 8: **Distribution over the Speed Values**

This graph shows a typical distribution of 10,000 measured values around the calculated mean value. The measured value outliers upwards and downwards are equally distributed. Thus the mean value of the read out speed values is to be regarded as very reliable.

10. The jet-wire ratio as control element for the papermaker

Each operator/papermaker works with the jet/wire ratio to influence certain quality parameters of the paper. These include: the longitudinal/transverse ratio, formation, tensile stiffness orientation (TSO) and thus also strength properties such as flat crush resistance (CMT), strip crush resistance (SCT) or breaking load.
It is crucial for the papermaker to know whether his HBX is under- or overstowed, i.e. whether the pulp jet is slower than the wire speed or faster.
Let us look again at the above case study (Fig. 1).
According to the PCS, the HBX was in overflow at all measuring points, but our measurement showed that the jet velocity at each measuring point was slower than the sieving velocity. Thus, the HBX always operated in the underflow.

If the papermaker at this machine trusts the values displayed in the PCS, he can never set a real jet-to-screen ratio of 1.0, since he would reduce the jet velocity accordingly and would thus get further into the backlog. For this reason, it is essential to determine the actual jet velocity in a series of measurements and then adjust the programming of the dynamic pressure formula.

11. How accurate is the measurement? Is the speed the same everywhere in the pulp jet? What happens on impact with the sieve?

For this purpose, we will look at the following two pictures.

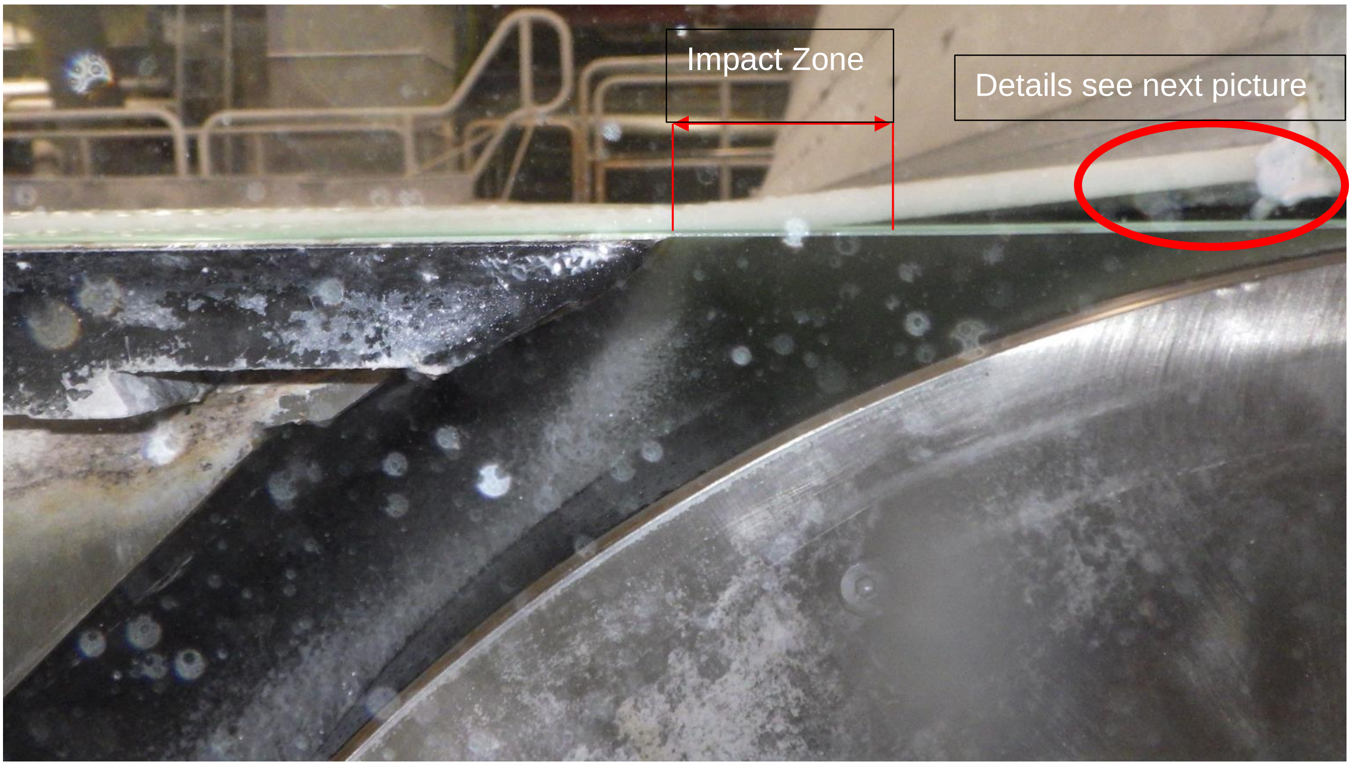


Figure 9

The jet leaves the headbox with a thickness of approx. 10mm (lip – gap opening).

It can be assumed that the speed in the jet thickness profile increases from the top / bottom to the middle (Fig. 10).
In addition, the jet is always turbulent at the top and bottom due to friction at the headbox wall and in the air, while we assume that the flow in the middle is laminar.

The jet speed is generally measured with the µSPEED system before the impact zone of the forming fabric. Where exactly the speed of the pulp jet is measured with the µSPEED system cannot be clearly determined, since the exact penetration depth of the laser depends on a number of factors. The penetration depth, however, depends largely on the suspension properties.

If one assumes that the penetration depth of the laser into the jet beam is approx. 2-3 mm, it can be assumed that the top speed of the beam is more likely to be measured.

The pulp jet hits the forming sieve a few centimeters before the edge of the sieve table. On impact, the jet geometry and thus the velocity structure are changed again. For our measurements, we give averaged average speeds from many measured values. With these measured values, the papermaker is able to adjust his jet speed in such a way that the quality parameters of the paper can be reproducibly adjusted.

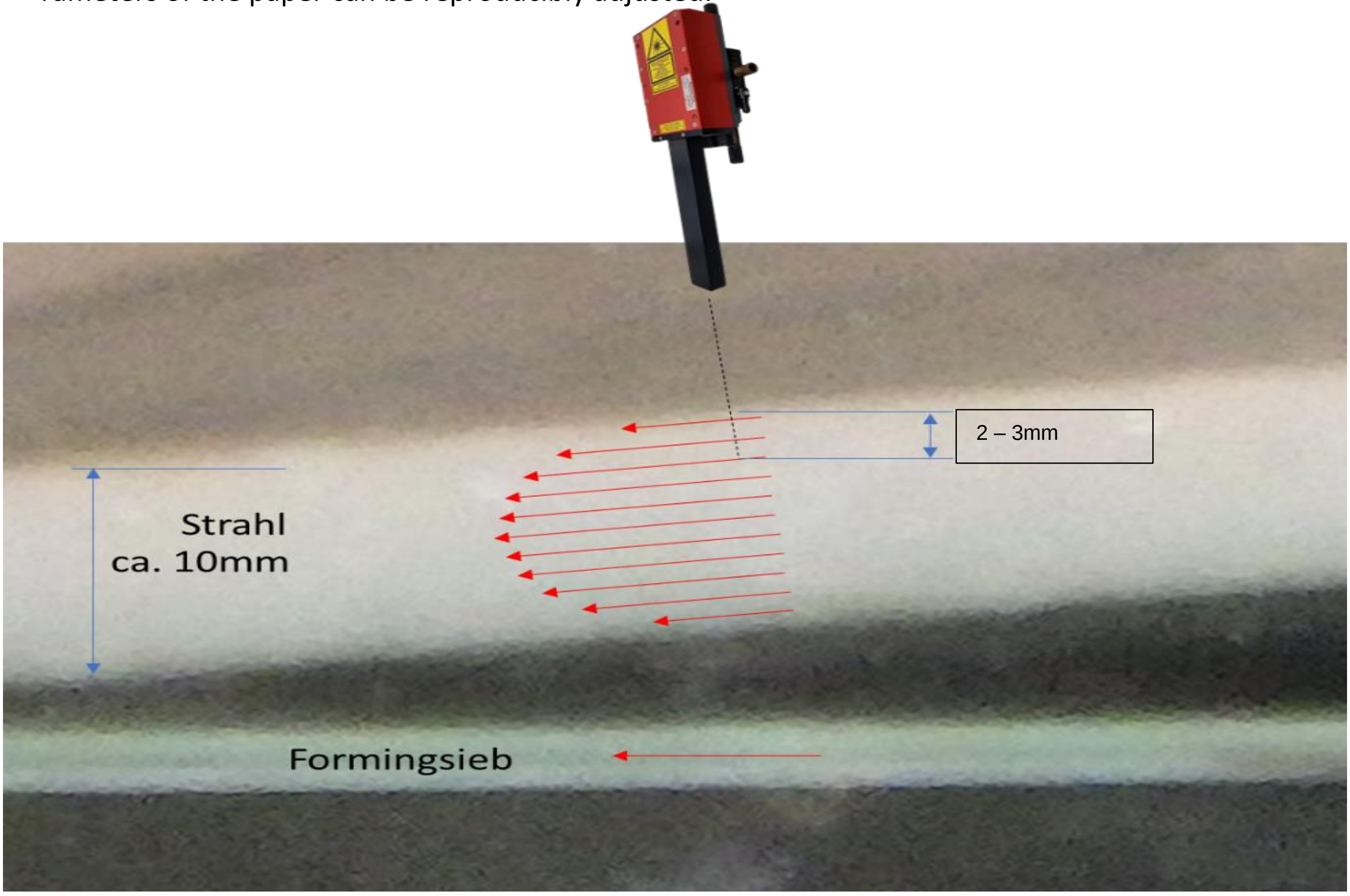


Figure 10: Strahl = Jet thickness; Formingsieb = forming wire

The measuring method thus provides valuable and easily usable results for practical use on the paper machine.

- A speed value deviation of typically +/- 1m/min that can be achieved with the µSPEED system is absolutely tolerable.
- The speed fluctuations of the mixing pump control are higher in most cases.
- The screen speed at the headbox is always 1 - 4 m/min slower than at the suction roll/sieve drive roll; depending on the design and distribution of the drives.

Finally, we would like to point out that the beam velocity can be reproducibly and correctly set with the help of the measured values obtained with our µSPEED laser encoder. This has improved the paper quality already in many cases.
In addition, the machine operator is given additional security to set his machine correctly. This significantly reduces grade change times. In most cases, the machine runs more quietly and with significantly fewer malfunctions.

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Version 1.0