INOEX
INSPIRE BEYOND MEASUREMENT

Contactless, non-destructive

WALL THICKNESS MEASUREMENT

for the blow molding market

Your guide to potential assessment and implementation

- For applications from 2 mm wall thickness
- Radar technology reduces material usage by up to 5 %

At one glance

This is how you leverage your material savings potential and reduce destructive quality assurance steps by means of the latest radar technology

CURRENT CHALLENGES:

- Rising material prices and strict sustainability targets
- Incomplete, labour-intensive component testing
- Skilled labour shortage diminishes process knowledge in production
- Digitalisation of the production environment

In addition to global challenges in the area of international supply chains and macroeconomic development, the above-mentioned challenges are currently decisive for a large part of the plastics processing industry and thus also for blow molding.

The basis for mastering these challenges is process transparency. Clarity about wall thickness distribution in the component, process stability and component characteristics are essential for the implementation of digital, automatable control loops. The contactless, radar-based wall thickness measurement technology is a key technology for precisely this purpose. Due to its flexibility, it covers a wide range of applications and, thanks to its precision and robustness, it has already been established in pipe extrusion for years.

The claim of our WARP radar technology for the blow molding market is to not only replace often manual or destructive quality assurance processes, but to go one step further and and for the first time provide a database for automated process control. In this way, component quality is improved and process efficiency is increased. Realisable material savings and drastically reduced quality assurance costs ensure a quick return on investment. Likewise, in times of of a growing shortage of skilled workers, the dependency on long-term, personal process knowledge of the plant operators is reduced.

This white paper focuses on the potential applications of radar technology for the blow molding market and looks at the following topics in detail:

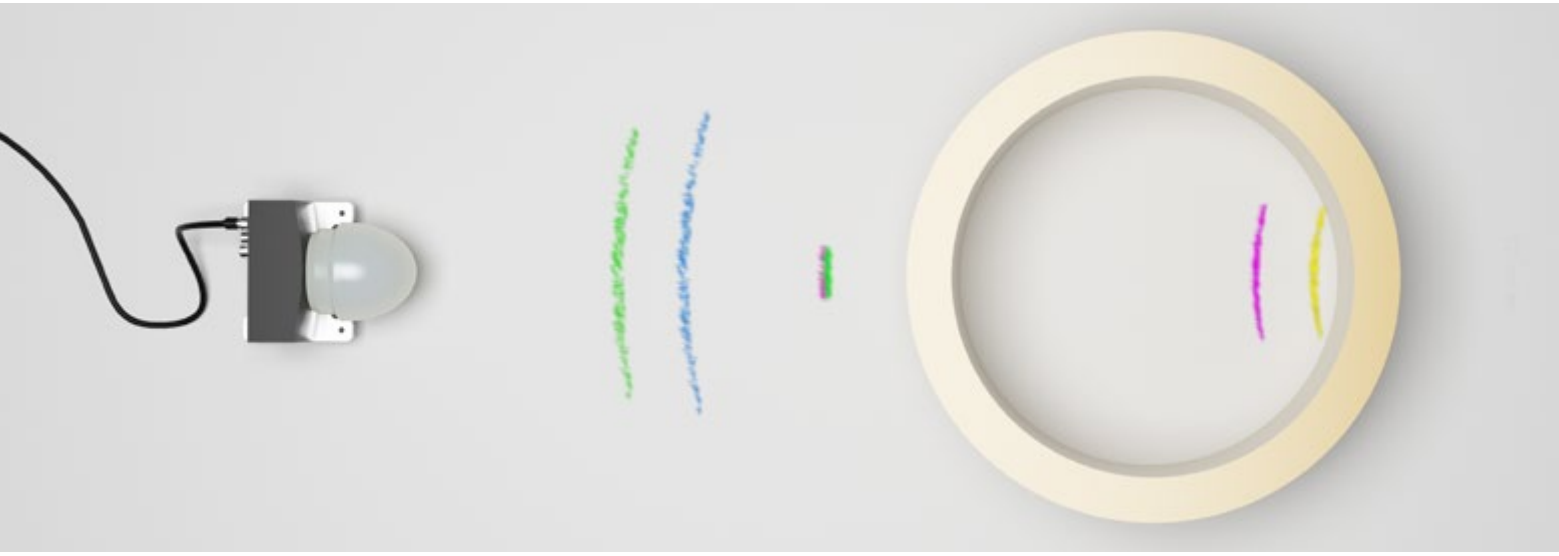
- ***What added value state-of-the-art radar technology can provide for you***
- ***Which applications are suitable for the use of radar technology***
- ***How you can successfully integrate WARP radar technology into your production process***
- ***Where radar measurement systems are already being used successfully today***

What is radar technology?

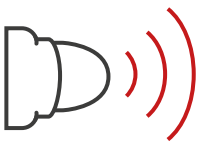
Functional principle and placement of radar technology

Sustainability and material savings are closely linked in blow molding. Every modern production line aims to reduce the weight of the component while maintaining the specification. Today, compliance with the minimum wall thickness defined in the specification is usually carried out on a random basis. For this purpose, both non-destructive, manual methods such as ultrasonic or magnetic measurements as well as destructive component tests are available. In destructive testing, selected containers are cut into pieces and measured by means of measuring probes.

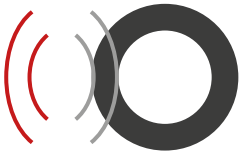
This type of quality assurance is time-consuming and in some cases also labour-intensive and reduces the productivity of the process due to the regular destruction of defect-free components. In addition deviations from the specification lead to rejects, since all containers are usually discarded until the last measurement. Control of the blow-molding process is only possible to a limited extent on the basis of such isolated measurements.



The radar technology presented in this white paper solves the above-mentioned challenges and also makes it possible to further automate the blow molding process through control loops. Here are the most important facts about radar technology:



Radar is **contactless** and **non-destructive**



Radar is partially reflected at the interfaces and thus allows **thickness measurement**

Radar radiation is **harmless** and can be used without occupational safety

Radar is almost **temperature-independent** and thus minimises the calibration effort

Advantages through measurement technology

Five reasons why you should invest in WARP radar technology

Material savings

Gain transparency about local wall thickness differences and counteract them. An unevenly distributed wall thickness increases the cooling time and thus reduces productivity. Homogeneous wall thickness distribution makes it possible to **use up to 5 % less material**. Sustainability increases and energy and material costs are reduced.

Process control

The new dimension in data quality and quantity makes it possible for the first time to carry out **inline and automated process control**. This makes it possible to react immediately to batch fluctuations or drifts in the process. Manual component checks are no longer necessary and the dependence on employees' many years of process knowledge is reduced.

Plug & Play

The WARP GAUGE sensor has a browser-based, **integrated user interface** for visualising the measurement results. Alternatively, the measurement data can be read out via an **OPC-UA interface**, processed and combined with other data. This simplifies integration and makes the measuring system flexible.

Transparency

WARP radar technology measures geometry properties such as **wall thickness** and **distance** and diameter. In combination with the sensor position data, further component properties such as **contour** and **ovality** are derived.

With a measuring frequency of up to 8 Hz, a comprehensive picture of your component is created and local deviations are identified. The **measuring accuracy** and reproducibility of the technology is in the range of **a few hundredths of a millimetre**.

Quality improvement

Constantly **increasing demands on component quality**, process efficiency and the **documentation** of process and quality data makes it necessary to reduce manual quality assurance processes and to push ahead with **digitalisation**.

The high **precision** and extreme **robustness** of radar-based measurement technology makes a decisive contribution to this, as components can be measured automatically and without the need for a significant amount of manpower.

Your solutions in detail

Two measuring instruments, two applications

WARP GAUGE

Component measurement

The WARP GAUGE sensor, which can be used independently, allows in combination with a simple kinematic system to measure your blow-molded parts fully automatically after demolding. The sensor is guided perpendicularlyto the part surface and, depending on the frequency and speed of movement a grid of measuring points is created. For the measuring points distance, wall thickness and diameter of the component are measured. In combination with the sensor position, the contour of the component can also be recorded and statements can be made about the distortion or ovality of the component.

Parison measurement

In addition to measuring parts that have already been demoulded, the WARP GAUGE sensor can also be integrated directly into the blow molding line and provide measurement data during the extrusion of continuously produced parisons with cylindrical shape.

Due to the small size of the WARP GAUGE (170 x 125 x 85 mm), it can be flexibly integrated into the line depending on the process control and component geometry. The decisive factor is the point at which the measurement data generated for your application and the number of measured data that is sufficient to allow conclusions about the process and to actively implement process control.

WARP portable

WARP portable is a mobile, intuitive hand-held measuring device for point-by-point wall thickness measurement. The integrated centering aid always ensures the ideal measuring distance.

The measurement is carried out at the touch of a button. The last 500 measured values including the measuring angle and the time stamp are stored and can be exported via USB as a CSV file for further.

The WARP portable thus offers a contactless, non-destructive alternative to previous measuring technologies that either had to be carried out destructively or which are complicated and time-consuming with regard to the measuring process.

Flexible measurement technology

For which products is WARP GAUGE suitable?

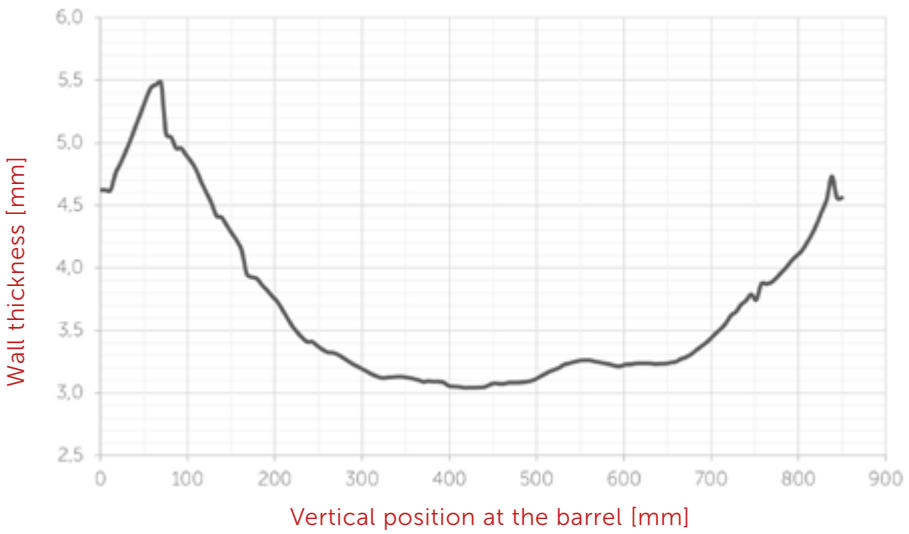
In order to obtain robust and precise measurement results, the following characteristics should be fulfilled for your application:

- **Wall thickness of the component is > 2 mm**
- **Sensor can be positioned perpendicular to the desired measuring points without covering the measuring point (e.g. undercut)**
- **Component wall has two parallel border surfaces, which reflect the radar wave back to the sensor**

APPLICATION: Barrel

Barrels are manufactured in a wide range of sizes and for a multitude of of applications. A central role in the quality of barrels play mechanical properties (e.g. stacking pressure resistance or bursting pressure), chemical resistance and dimensional accuracy. For economic reasons, all these properties should be reliably achieved with minimum material input.

WARP GAUGE makes exactly this possible. Measure the barrels through simple kinematics and obtain wall thickness information about the barrel height (see picture) and the circumference (cf. hydrogen pressure vessel). In addition to the wall thickness information, distance data is also recorded in order to evaluate the shape accuracy. In the case shown here of a 220 l barrel bought from a free distributor an unintentionally high wall thickness, especially at the barrel edges, was identified. If the wall thickness measured in the middle of the barrel is sufficient for the application, more than 10 % material could be saved by optimizing the wall thickness. Further random samples from this segment show up to 5 % material saving potential.



With a measuring rate of 8 Hz as shown in the example, a scan time of 50 s (circumferential measurement and vertical scan) with a 5 mm measuring point distance can be realised. This means that 100 % of the products can be measured without limiting the cycle time. A short signal acquisition time of 4 ms guarantees a measurement with negligible motion blur.

y for a wide range of applications

APPLICATION: Hydrogen pressure vessel

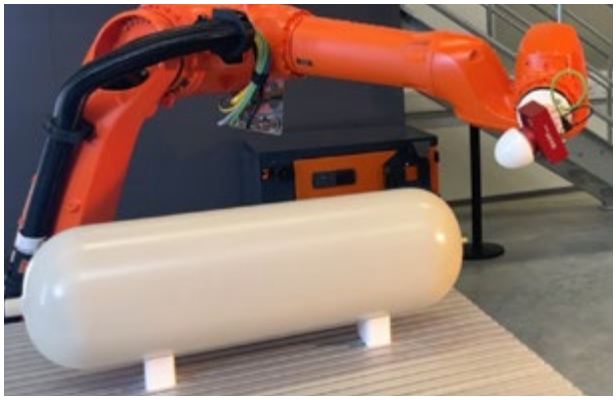
Particularly for mobile applications such as vehicles or mobile storage modules, fibre composite containers (Type IV) offer an alternative to steel cylinders that is up to 70 % lighter.

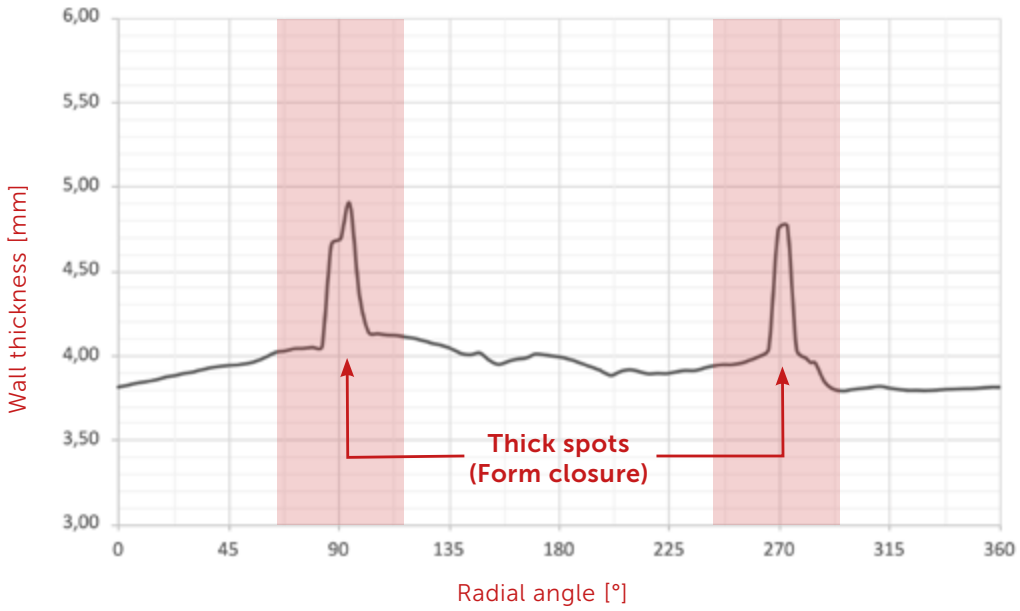
The liner plays a central role here: It forms the actual pressure vessel, provides the necessary hydrogen barrier and is thus responsible for the tightness of the high-pressure container (up to 700 bar operating pressure). The liner is subject to the strictest quality requirements and ensures safety, efficiency and durability of the Type IV tank.

Radar measurement technology makes a decisive contribution to ensuring your liner quality. In the cylindrical area, WARP GAUGE (in combination with a kinematic system, see picture) automatically measures wall thickness, diameter and eccentricity. In the dome area, the contour, wall thickness and deviations from the target geometry can be determined.

Reliably measure quality-critical products:

- Reproducibility and automation of the measured value acquisition
- Targeted analysis of critical areas
- Identification of quality-critical thin spots and process fluctuations
- Recording of the container contour and analysis of deviations from the target contour
- Measurement technology can be flexibly adapted to different sizes and materials





The diagram shows the wall thickness of a liner around the circumference. You can clearly see the thicknesses at the seams of the tool with an otherwise homogeneous wall thickness distribution around the circumference. A scan along the cylinder (cf. barrel measurement) is also possible for the reliable identification of pressure fluctuations in the extruder, for example, which manifest in wall thickness fluctuations.

Individual process control

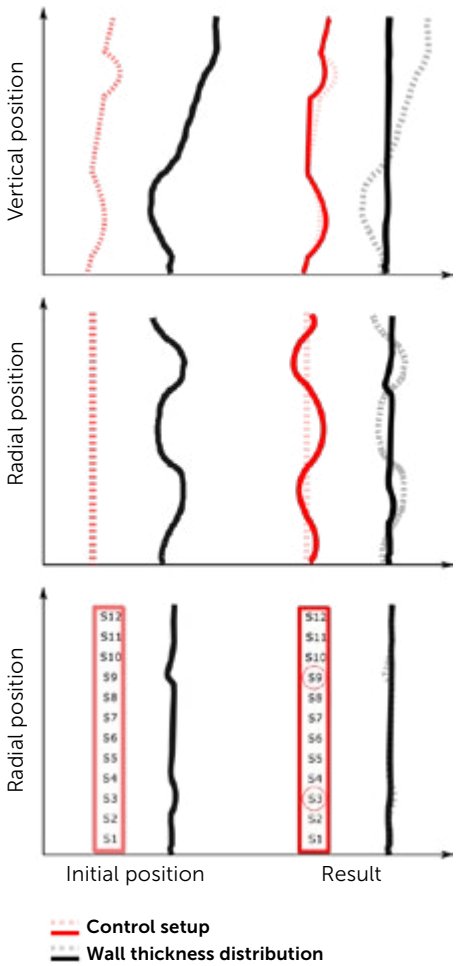
How high-quality measured values contribute to automation

Starting point and instruments of process control

The basic prerequisite for a functioning and automated process control is a measured value basis that is accurate in terms of data quality and quantity. This measurement basis is provided by WARP GAUGE. If deviations from the nominal wall thickness are detected in the part during the measurement, e.g. due to material fluctuations or not optimally adjusted dies, the blow molding process offers various possibilities by which local wall thickness differences or the overall wall thickness of the component can be adjusted.

- The wall thickness control (WDS) compensates for different pull patterns in the product and for the gravity-induced thinning of the melting hose. For an optimal preform adapted to the product.
- By means of a controllable radial nozzle ring (PWDS®), the plastic melt is redistributed around the circumference and the preform is optimised.
- A statically flexible, deformable nozzle ring (SFDR®) enables differentiated, radial profile changes and to achieve an optimal radial melt distribution, especially for non-circular end products.

EXAMPLE OF PROCESS CONTROL



1

» Initial WDS profile results in non-uniform wall thickness distribution - thin spot at the bottom, thick spot at the top (picture left)

» WARP GAUGE measurement data allow continuous, automatic adjustment/optimisation of the WDS profile

» Equalisation of the wall thickness distribution over the component height through optimised WDS profile (picture right)

2

» Without a correctly adjusted PWDS®, critical thin spots can occur in areas of high stretching (picture left)

» WARP GAUGE detects wall thickness differences even over the circumference and in critical product areas

» Optimum PWDS® control homogenises the radial wall thickness distribution (picture right)

3

» The best possible adjustment of the flexibly deformable nozzle ring is used for the final optimisation (picture left)

» WARP GAUGE measurement data can be used as a starting point for manual adjustment

» After the manual adjustment of two adjusting screws of the SFDR®, the result is an ideal wall thickness distribution (picture right)

Your sensor integration

Successfully implement radar measurement technology in 3 steps

As-is analysis

To estimate the savings potential and the automation possibilities that radar technology offers for your blow molding process, we need the following information:

- **How do you currently perform quality assurance and how much effort does it require?**
- **What component variability do you want to cover?**
- **Which measuring points are particularly decisive for a high component quality?**
- **What is the cycle time of the components concerned and what proportion of the components do you want to measure automatically?**

Feasibility study and goal

Based on the above information we evaluate for you the benefits of radar technology for your application:

- **We would be pleased to measure your components/ samples in our laboratory and present the measurement results to you.**
- **Try the hand-held radar measurement system WARP portable on site and convince yourself of its simplicity and accuracy.**
- **Define the target picture together with us: Degree of automation, return on investment, level of information detail, quality, etc.**
- **Receive your individual offer for the targeted WARP radar technology measurement solution for your products.**

Implementation

Depending on the use case and the target concept, the implementation and the necessary steps may differ. Central implementation aspects are the following:

- **Sensor integration in your machine incl. automated process control usually takes place in close coordination with the machine manufacturer.**
- **The kinematics required to guide the sensor varies with the component complexity and measuring task. The design of the kinematics can be done by you or by us.**
- **Establishment of a process control on the basis of the interpretation of the measurement data.**

Success Story

WARP GAUGE

The easiest way to achieve optimal product quality

KAUTEX MASCHINENBAU

Radar technology offers us the possibility to record quality characteristics in real time and use them for process optimisation.

This is Sustainable Innovation for plastic products of the highest quality.

Maurice Mielke

Director Engineering R&D
@ Kautex Maschinenbau

Motivation

As a leading supplier of extrusion blow molding technology, our focus is clearly on our customers' final plastic product. For us, it is therefore essential to measure quality features such as a good material distribution in the plastic product and to calibrate it. Unfortunately, this inspection is very time-consuming and is often only carried out after the product has been produced. In some cases, the product is also cut up in order to ensure that the correct product has been produced.

For us, the highest quality means that deviations are avoided. This is the only way to avoid expensive production waste. Therefore, a complete inline measurement would be ideal, which would detect anomalies in the wall thickness distribution at an early stage and prevent them.

Problem solver: Radar technology

Radar technology offers us the possibility to record quality characteristics such as wall thickness distribution in real time and to use them for process optimisation. This brings us one step closer to a "closed loop" control system. In this way, optimal product quality can always be ensured, even under difficult conditions, such as the use of recycled plastics known as post consumer (PCR) or post industrial regrind (PIR) materials.

For us, iNOEX WARP radar technology is an important step in inline process optimisation. This means that we can already capture the necessary information to secure and improve our processes.

About KAUTEX Maschinenbau

More than eight decades of innovative strength and performance for its customers, have made Kautex Maschinenbau one of the world's leading suppliers in extrusion blow molding technology. With its "Final Plastic Product Focus" philosophy, the company supports customers worldwide to produce sustainable plastic products of the highest quality.

Success Story

WARP Inline Measurement

Increasing material efficiency in pipe extrusion for several years now

JET STREAM by PipeLife

“The calculations that we have done on the savings through the WARP system were pretty much in line with the assumptions made by iNOEX.

It would be great to see this technology in every line.

Louie Bold

Plant Manager
@ Pipelife Jet Stream

Motivation

Among other products, PipeLife Jet Stream also produces C900 pipes (PVC pressure pipes), which are among the the most sophisticated and highest quality products on the market. C900 pipes are subject to stringent standards, including strict quality specifications for wall thickness, inner and outer diameter and length. The wall thickness is higher than for most other products on the market. These standards are underlined by the fact that 100 % of the products are hydrotested at the end of the production line.

Because Pipelife Jetstream manufactures such important products, the company strives to increase the production and quality data of the products and at the same time to reduce material consumption and scrap rates.

Problem solver: Radar technology

The iNOEX WARP radar technology is the ideal system for inline pipe inspection in the extrusion line. It enables a faster start-up of the line and at the same time provides an enormous amount of data for the ongoing production as well as the production history. The data makes it possible to detect necessary changes in the wall thickness before the pipe is out of tolerance.

Critical areas can be corrected specifically before the product reaches the saw. In addition WARP radar technology helps to control the extrusion process and produce high quality products faster.

About Pipelife Jet Stream

Jet Stream is the U.S. division of the General Shale, North America’s largest producer of clay brick and sustainable building materials. Jet Stream manufactures PVC pipe for municipal water and wastewater, well, plumbing and irrigation applications.

With over 50 years of experience in manufacturing products, Jet Stream by Pipelife looks forward to helping shape the future of plastic pipe.

CONVINCE YOURSELF OF THE ADVANTAGES OF **WARP RADAR TECHNOLOGY**

Our cooperation is characterised by a clear mission statement and a focus on customer needs. This is based on our values and principles. Every day, we work with enthusiasm and passion on our claim to "inspire beyond measurement".

Vision

We are the most innovative solution provider for measurement technology in the plastics industry. Today and in the future.

Mission

As pioneers and experts we offer our customers added value in the pipe, hose, film, cable blow molding and profile extrusion industries.

Our high quality products, equipped with outstanding user-friendliness, offer intelligent and innovative solutions that are key factors for sustainable success.

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