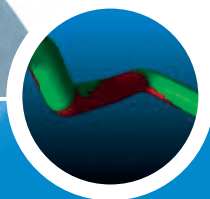


# TubeInspect

Efficient quality assurance for tube and wire bending

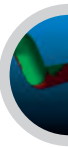
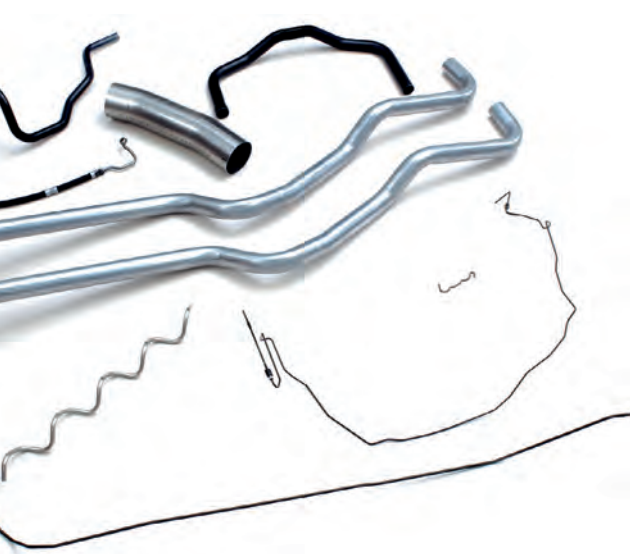


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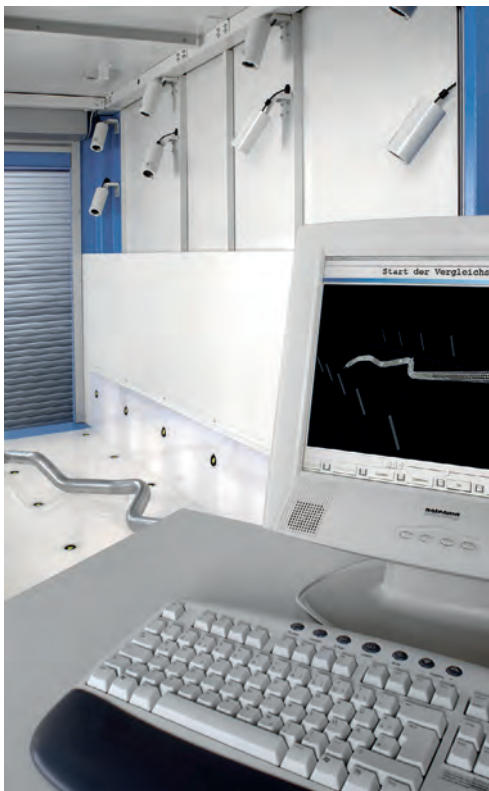
# TubeInspect

Efficient quality assurance for tube and wire bending

## Optical tube measuring system

The demand for ever more cost-effective tube production as well as the increasingly stringent requirement for product quality are constant challenges in today's tube bending industry.

TubeInspect, an optical tube measuring system, incorporates advanced technology for the high-precision measurement of tubes, the determination of set-up and correction data and quality assurance of the final product. TubeInspect can entirely replace mechanical gauges.



M E A S U R E T H E

## How TubeInspect works

TubeInspect, a non-contact measuring system, merely requires that the tube to be measured is placed in an optical measuring cell. Sixteen high-resolution digital cameras accurately measure the tube's geometry in a few seconds. The tube does not need to be moved. The geometry is reported in an easily understandable way, that is as sheath tolerance. The measuring range of TubeInspect is 2,500 mm x 1,100 mm x 700 mm (approx. 8.2 feet x 3.6 feet x 27.6 inches) and this can be extended by repositioning the tube.

TubeInspect measures tubes with diameters ranging from 3.2 mm to 200 mm. Bends between 1° and 180° can also be measured easily. Moreover TubeInspect has the capability of measuring tubes with connected bends or with flexible parts. For example tubes with hose-sections, shaped hoses, and tubes with fixtures or mounting attachments. Beyond that TubeInspect is able to measure free-form geometries.

Thus AICON extends the spectrum of optical measurement applications significantly. Tube measurements can be compared with a previously recorded sample part or with an imported CAD model.





## A D V A N T A G E

### Accuracy

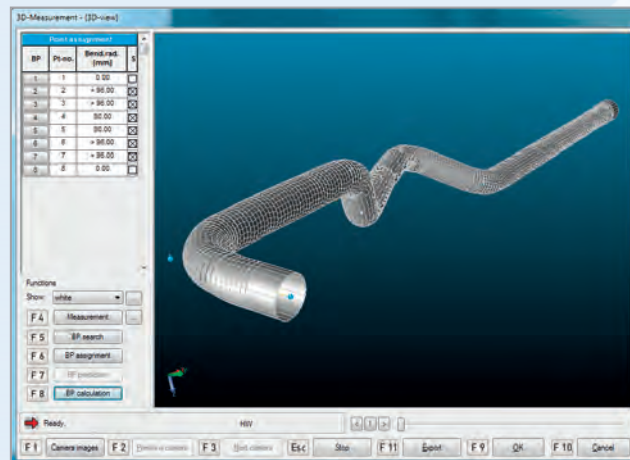
The system acquires information about the tube with sixteen permanently mounted high-resolution digital cameras. Therefore no movement of the part or the acquisition device is necessary.

A part can be measured without the need for special fixtures or clamping devices. Sheath tolerance can be determined to an accuracy of  $\pm 0.1\text{mm}$ .

### Tubelnspect is suitable for high volume production

High volume production requires that product quality be maintained. A further requirement is the ability to switch production to new models or model variants with minimal production delays.

Tubelnspect enables you to achieve this flexibility in tube manufacturing quality assurance. When production changes to new models or model variants, lengthy set-up procedures are no longer necessary: Tubelnspect is ready for use immediately after digital nominal data has been entered into the system. All component related measurements can be stored and analyzed with statistical process control programs.



The 3D cylinder model is compared against design data.

### Tubelnspect measures quickly and easily

Tubelnspect's unique measuring principle allows the measurement of any tube geometry without elaborate preparation, and is not affected by form, color or surface texture.

Tubes with varying diameters or changing radii (free-form tubes) can be measured along with attachments such as hangers and brackets. Components with cylindrical profiles, such as bent wires, moulded tubes or even subassemblies of tubes and flexible parts can also be measured.

### **Tubelnspect eliminates test equipment and reduces change-over time**

Tubelnspect eliminates the need for numerous bending gauges and reduces change-over time. Because Tubelnspect uses optical measuring technology, it has proved to be very reliable and requires little maintenance, even when being used in a continuous production environment.

### **Tubelnspect allows efficient prototype production**

Would you like to manufacture prototypes under production conditions? Tubelnspect, as an optical gauge for bending machine set-up and quality assurance, is particularly suitable for the manufacturing of prototypes. It is also suitable for the quick and precise measurement of sample tubes.



Long and thin tubes can also be measured without fixtures.

### **Tubelnspect is suitable for all types of tubes**

Tubelnspect is suitable for all types of industrial tube manufacturing, from highly flexible thin brake lines to large exhaust pipes for heavy trucks. It can also be used to measure tubes designed to carry hydraulic and cooling liquids or fuel.

### **Optimized data handling with BendingStudio**

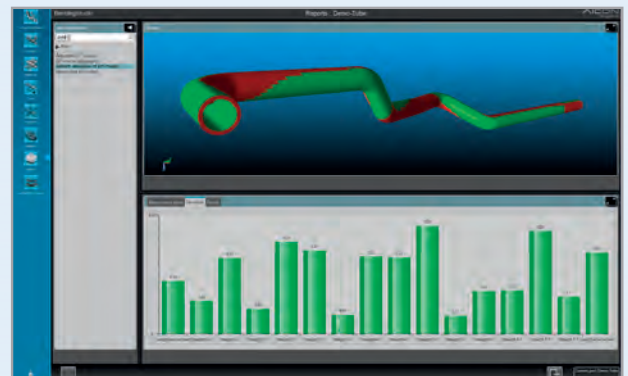
There are several steps between a drawing and an actual part, each one requiring different types of data: CAD data from design, bend programs and bend corrections for manufacturing, inspection plans and measurement reports for quality and data analysis for process control. BendingStudio bridges all these data types, enabling manufacturers to monitor, quantify, visualize and document all changes in the different process steps. All data stays together and nothing gets lost. And the required data are ready for quick access at any time.

Tubelnspect is totally integrated in BendingStudio and benefits from its various evaluation possibilities. BendingStudio supports the individual configuration of virtual optical gauges to measure the quality related measuring points of a component. This is also possible for further functional dimensions, such as distances and angles.

### **Tubelnspect provides online corrections to bending machines**

With BendingStudio Tubelnspect may be directly linked to Computer Numerically Controlled (CNC) bending machines. If tube measurements indicate that adjustments need to be made to the tube manufacturing process, corrections are directly transmitted to the bending machine via the CNC program.

Corrections will be made more quickly so that dimensionally correct tubes are produced with minimal waste. Machine set-up becomes predictable, and down time is drastically reduced.



Graphical output allows the user to quickly judge whether a tube is within tolerance or not.

## System Specifications

### TubeInspect



### TubeInspect S



### TubeInspect HS



Technical specifications			
Measurement area	2,500 mm x 1,100 mm x 700 mm	1,100 mm x 1,100 mm x 700 mm	1,080 mm x 980 mm x 500 mm
Cameras	16 metric cameras	10 metric cameras	10 high performance metric cameras
Tube diameter	3.2 mm - 200 mm	3.2 mm - 200 mm	2 mm - 100 mm
Bending angle	1° - 180°	1° - 180°	1° - 180°
Minimum push between two bends	bend in bend and free-form possible	bend in bend and free-form possible	bend in bend and free-form possible
Software	BendingStudio	BendingStudio	BendingStudio
Reference field	Stability optimized steel structure with LED reference targets	Stability optimized steel structure with LED reference targets	Stable glass reference including elevated targets for highest 3D position
Dimensions	3,200 mm x 1,680 mm x 2,300 mm	1,750 mm x 1,680 mm x 2,300 mm	1,750 mm x 1,680 mm x 2,300 mm
Weight	2,000 kg	1,200 kg	1,300 kg
Accuracy			
Sheath tolerance	± 0.1 mm	± 0.1 mm	± 0.050 mm (50 µm)

#### For all tubes up to 6 m in length

The TubeInspect optical gauge is the universal tube measurement system for all tube lengths. Tubes of up to 2,500 mm can be inspected in one step. Longer tubes are measured in several steps while the results are automatically connected.

TubeInspect has successfully run in various production facilities for several years and saves our clients the cost of buying expensive gauges.

#### Cost effective solution for the bulk of applications

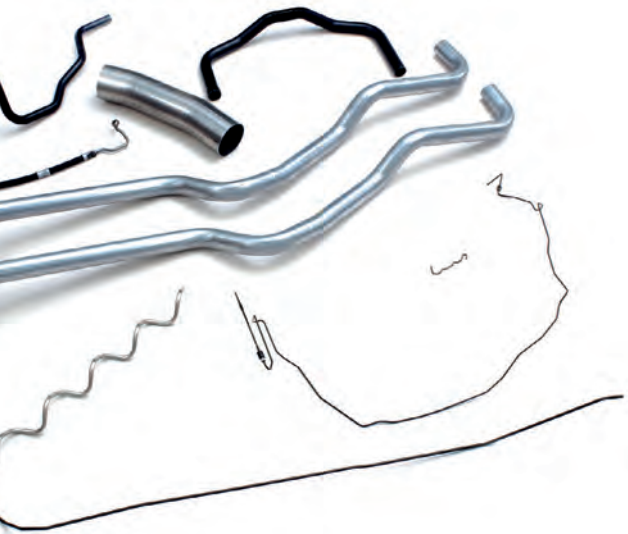
With TubeInspect S, producers of short tubes have a customized solution that provides TubeInspect's complete functionality with no constraints.

TubeInspect S measures tubes of up to 1,100 mm in one step. The ideal use is inspection of cooling-, gas- or hydraulic tubes or tubes with flexible parts.

#### Improved accuracy for tight quality requirements

TubeInspect HS is applied when especially high accuracies are requested (e. g. in case of injection pipes).





# TubeInspect

Efficient quality assurance for tube and wire bending

- Optical tube and wire inspection system
- Programmable optical gauge
- Set-up and correction of bending programs
- Reverse Engineering and inspection of sample tubes
- Automatic 100 % inspection in a robot cell

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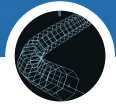
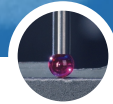
[www.aicon3d.com](http://www.aicon3d.com)  
[www.tubeinspect.com](http://www.tubeinspect.com)

# TubeInspect

## Testimonials



MEASURE THE ADVANTAGE



### Approval for production in record time

“With TubeInspect we are in the position to monitor our processes in a fast and effective way as the measuring system shows accuracy information for the bent tubes after only a few seconds. Therefore, the approval for production can now be given in record time. In the past, when the measurement was tactile, we had to wait for the approval for a really long time. Moreover we have reduced the setup time of our bending machines considerably. The gained free machine capacities mean hard cash to us.“

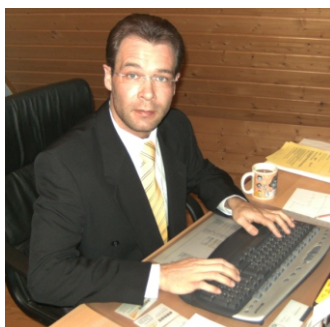
[Ralf Unger, Quality Assurance at König Metall GmbH & Co. KG, Gaggenau \(Germany\)](#)



### Enormous saving of time

“When starting the series production of a new product, we have to measure 30 to 50 tubes in a sequence. While this has taken us five to six hours with our CMM, we only need one hour or less now. This implies an enormous saving of time, allowing us to be a lot more flexible with respect to customer demands.“

[Mikael Karlsson, Ekenäs Mekaniska, Vetlanda \(Sweden\)](#)



### Gigantic improvement

“In the past, we inspected our tubes with CNC coordinate measurement machines. It took us averagely 45 minutes to measure a tube. However, the measurement of tubes longer than 700mm and with more than 8 bends took up to four hours because we had to measure them in several clampings. Today, with TubeInspect S, a measurement is completed within several seconds: Put the tube into the measuring machine, select the tube model in the data base and the result is displayed instantly. I can't remember for how long I haven't been called any more at night because a tube bend hasn't been correct... TubeInspect has brought a gigantic improvement!”

[Alexander Schmidt, Technical Director at Argus Fluidtechnik, Ettlingen \(Germany\)](#)



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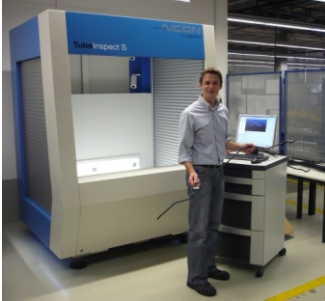
tel. +49 (0)531-58 000 58

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info@aicon.de

www.aicon3d.com

## TI Automotive



### Fast measurement of plastic pipes with checkable reports

“We at the location Fuldabrück are specialized in manufacturing prototypes of fuel pipes. TubelInspect was implemented in our plant in June 2008, and we can totally rely on this measuring machine. With TubelInspect, we can give our suppliers support for the production of the bending moulds at an incredibly early stage because already the first manufactured pipe is measurable without any difficulty. Furthermore, TubelInspect fulfills the requirements regarding the checkability of the measurement results. The automatically generated report doesn't leave any room for interpretation by the operator. TubelInspect outputs a coordinate table that can be controlled by everyone - that means also by our customers. That satisfies them much more than the old, usual reports. As some of our customers, for example Volkswagen, also own a TubelInspect system, we even profit from synergy effects.”

[Daniel Bock, Quality Engineer TI \(Fuldabrück\) GmbH \(Germany\)](#)



### Considerable decrease of material costs

“With TubelInspect, the number of deficient tubes has strikingly reduced. When a new production run starts, the second tube meets the requirements. As we mainly manufacture tubes made of expensive materials, we clearly notice the strong decrease of costs in this area. Moreover, we are very happy about TubelInspect's accuracy. The machine is much less susceptible to operator errors than a tactile system. TubelInspect has pushed us far forward in the area of quality assurance. And that's what our customers approve!”

[Joe Girtanner, Production Manager at Serto AG, Aadorf \(Switzerland\)](#)



### Fantastic

“TubelInspect is a fantastic machine. We use it at least ten hours per day. I periodically have customer visits. They are impressed.”

[Kent Marvin, Owner of STAM Inc., Grand River, OH \(USA\)](#)



### Fortunately we have come across TubelInspect

“For a long time, we have looked for a measuring system that would help us to determine the bending data of sample tubes faster, and to transfer them directly to the bending machines. So we have analyzed the market of tube measuring systems. We have taken a closer look at different articulated arms, partly with laser probes. However, not a single system could persuade us. Then, fortunately, we have come across TubelInspect.”

[Karl Eberl, Owner of EMW Rohrformtechnik, Türkenfeld \(Germany\)](#)



### Much faster

„The speed of the measurement is fascinating. With TubelInspect, we can measure our tubes faster and more frequently.“

[Klaus Landauer, Technical Director at GS-Hydro Austria, Pasching \(Austria\)](#)



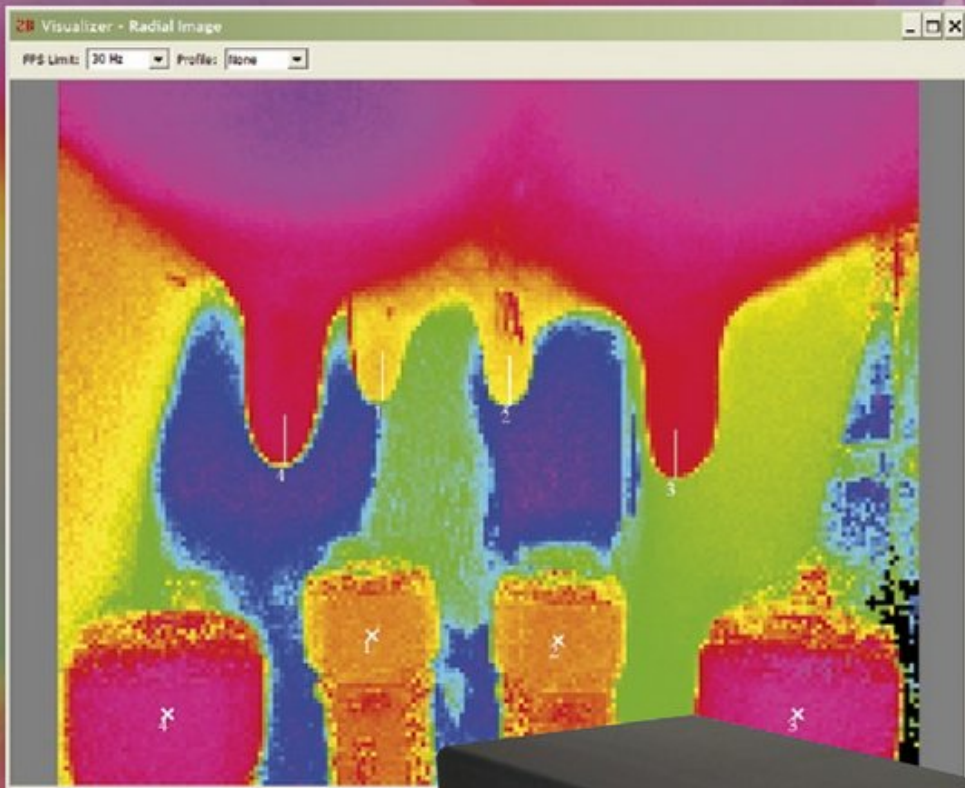
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# INSPECT

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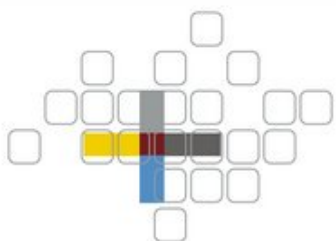
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# Cost Optimization of Tube Manufacturing

## Applying Cutting-edge Measurement Equipment to Improve Efficiency

“A penny saved is a penny earned” says a proverb. This is especially true when you are concerned with the success of your business. Therefore, reaching a high degree of efficiency is one of the main goals of a company. Manufacturing processes must be optimized continuously, and costs have to be reduced. However, where to start with cost savings? Businesses that produce tubes and pipes often mention four areas of costs that have a serious effect on total costs: gauge costs, material costs, storage costs and setup costs of bending machines.

### Exemplary calculation of possible savings due to replacement of gauges:

Need of new gauges per year	5 pieces at € 2,000
Cost of maintenance and inspection	€ 500 per gauge p. a.
Potential savings in first year	€ 10,000
Potential savings in second year	€ 12,500
Potential savings in third year	€ 15,000

In order to minimize these costs, it pays off to invest in modern measuring technology today. Based on the experiences of many tube and pipe manufacturers, especially the application of optical, tube-dedicated measurement equipment gives a good return. The camera-based measuring system TubeInspect, developed by Aicon 3D Systems from Germany, has been designed in cooperation with users from the automotive industry and accounts for the requirements of both manufacturing and construction departments.

TubeInspect measures a tube's geometry with high-resolution digital cameras in only a few seconds. For this, the tube to be measured is placed in the measuring cell. An illuminated measuring plate in the cell ensures that all parts of the tube are ideally visible. The digital cameras are positioned above the

**Ralf Unger, taking care of the quality assurance at König Metall GmbH & Co. KG in Gaggenau (Germany), appreciates the fast and effective process control with TubeInspect**



► The optical measuring system TubeInspect replaces cost-intensive mechanical gauges





Since applying the optical measuring system, Serto AG in Switzerland has been able to reduce material costs significantly

measuring plate and acquire images of the tube from different directions. Evenly distributed reference points on the measuring plate guarantee for the correct spatial orientation of the cameras. Aicon defines their positions accurately to a hundredth millimeter during the installation of the system. The result display is easily understandable, also for users without technical background. Thus it allows for flawless evaluation of the measurement.

But how is TubeInspect able to reduce costs?

### Elimination of Gauge Costs

Before a tube goes into series production, the prototype is changed many times with respect to its material and geometry until it will finally meet the requirements. Of course, also these prototypes have to come under scrutiny. This implies, when working with mechanical devices that an individual gauge has to be fabricated for each prototype. Depending on the tube, the costs for a gauge are between € 2,000 and € 4,000. Whenever a prototype is changed, the corresponding gauge has to be adapted, too. Including its final inspection by mea-

suring the geometry, this can take up to two weeks. Yet not only causes the gauge adaptation a high amount of costs; it also leads to long delivery times that are often unacceptable for the customer. When using TubeInspect, it is possible to completely renounce to manual gauges. The operator simply types the new data (X-, Y-, Z-coordinates of bending points) into the data base of the measuring system – and after only a few minutes the measurement of the changed prototype can begin. TubeInspect works as a virtual gauge for any type of tube, and it can be applied in series production, too.

The possible savings in series production can easily be clarified with the following example: Due to five new products per year, a production facility has a yearly need for five new gauges at the price of € 2,000 each. Their annual maintenance and periodic geometry check amount for approx. € 500 per gauge per annum. When applying a flexible measuring machine such as TubeInspect instead of gauges, savings of € 10,000 are generated within the first year because no new gauges have to be acquired. In the second year, the savings account for € 12,500 as both the

maintenance costs for the gauges of the previous year (five gauges for € 500) and the investment of € 10,000 in five additional gauges for new products are omitted. Accordingly, € 15,000 can be saved in the third year.

### Reduction of Setup Times for Bending Machines

In production, a new setup of the bending machines is necessary e.g. whenever the product is changed. Very often, well-experienced staff members have to attend to the setup as it demands great skills. And even then it can take several hours in case of complex tubes. Meanwhile production stops. At this point, TubeInspect can bail you out: With the help of the measuring system, correctional data is generated within a few seconds and transferred to the bending machines. As a consequence, their setup will only last a few minutes. The attained savings can be clarified using the example of a typical tube manufacturing plant as it is common in the supplier industry:

The exemplary company disposes of a manufacturing capacity of four bending machines. Thanks to its flexible production strategy, it is in the

## Intelligente OEM Kamera mit abgesetztem Sensor

Intelligent Components von VRmagic arbeiten autark mit eigenem Linux-Betriebssystem. Algorithmen werden über Cross-Compiler auf die Kamera übertragen.



- 300 MHz ARM9 Prozessor
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- FPGA optional
- 128 MB RAM
- 512 MB Flash-Speicher
- Standard Debian Linux
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- Auflösungen von VGA bis Megapixel

- 100 Mbit Ethernet
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- USB Host und RS232
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- Analog-Video-Ausgang

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position to deliver products in small batches right away. Over a longer period, setup procedure and time were analyzed with and without using TubeInspect. During the observed period, every bending machine was changed over twice a day on average. With TubeInspect, the setup time could be reduced by 0.75 h. The cost of machine downtime is calculated with €100 per hour. This results in potential savings of € 120,000 in the first year under the assumption of 200 manufacturing days per annum.

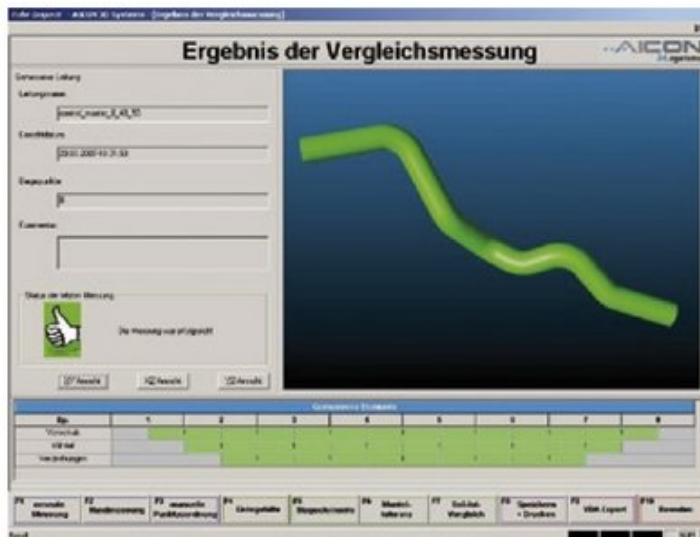
This observation is also affirmed by Ralf Unger, responsible for the quality assurance at König Metall GmbH & Co. KG in Gaggenau (Germany) who has applied TubeInspect since December 2006. "With TubeInspect we are in the position to monitor our processes in a fast and effective way as the measuring system shows accuracy information for the bent tubes after only a few seconds. Therefore, the approval for production can now be given in record time. In the past, when the measurement was tactile, we had to wait for the approval for a really long time. Moreover we have reduced the setup time of our bending machines considerably. The gained free machine capacities mean hard cash to us."

**Reduction of Material Costs**

Material prices increase steadily. Especially the high price for steel hits businesses where it hurts. Hence the reduction of reject parts gets more and more important. Thanks to the fast setup of the bending machines, TubeInspect also pays off in this issue. Joe Girtanner, Director of Production at the Swiss tube manufacturer Serto AG, reports about his experiences with TubeInspect: "The number of deficient tubes has been strikingly reduced. When a new production run starts,

**Exemplary calculation for savings thanks to shorter setup times of the bending machines:**

Number of bending machines (BM)	4 pieces
Number of changeovers per day per BM	2
Time savings per change over	0.75 h
Costs of machine downtime per hour	€ 100
Number of work days per year	200
Savings p. a.	
$E = 2 \text{ changeovers} \times 4 \text{ BM} \times 0.75 \text{ h} \times € 100 \times 200 \text{ work days}$	
	= € 120,000



Thanks to the clear display of the measuring result, the quality can be evaluated immediately

the second tube meets the requirements. And as we mainly manufacture tubes made of expensive materials, we clearly notice the strong decrease of costs in this area." Serto employs the material 1.45.71 for example (rust-acid-resistant, titanium-stabilized stainless-steel) in order to manufacture tubes for coffee machines. This material has, just as the whole stainless-steel market, experienced significant price increases in the last years. Due to the optimized material consumption, Serto can partially absorb the increased costs now.

**Storage Costs**

Particularly companies with a high percentage of in-house-manufactured components and with many active products have a huge need for

tion "master measurement" and measure the tube in two different positions. Thus TubeInspect can automatically generate the bending data. These data are then saved as nominal geometries in TubeInspect's data base.

What are the advantages of the master measurement? Joe Girtanner explains: "In the past we had to store samples of every manufactured tube, no matter if the batch size comprised 20 or 10,000 pieces. This was necessary to handle follow-up orders rapidly. Today we are in the position to send back the sample tubes to our customers as soon as the data are digitally saved. As a consequence, we have been able to reduce the storage capacity tremendously."

**Upshot**

Especially in view of the current economic situation and the increasing pressure of competition, it is worth to work hard on cost reduction. For a flexible measuring device such as TubeInspect, it is easy to calculate the return on investment. Many users realize after this calculation that an investment in optical measuring technology will amortize after only one year – and nothing is more convincing than bare figures.

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