

**3D LASER SYSTEM  
for large diameter pipes measurement**

**MRT1420-RF1420TB**

**User's manual**

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## 1. Purpose and scope of application

The Set of Measurement Systems for automatic control of geometrical parameters of large diameter pipes MRT1420-RF1420TB consists of the following independent systems:

- The system for measuring diameter, roundness and warping of the pipes;
- The system for measuring bevel edge and cutting angle of the pipes.

The set is designed to be used in the production line of the steel electric-welded line or spiral (as a hardware version) pipes for trunk oil and gas pipelines and products pipeline with a diameter from 18" to 60" with the wall thickness from 6.0 to 50.0 mm. the complex of devices provides the implementation of control over geometrical *parameters of pipes together with the specified productivity and accuracy*.



*Figure 1. The complex of devices measuring geometrical parameters of large diameter pipes: 1 - Bevel edge and cutting angle measuring device; 2 - Device measuring the diameter, roundness and warping of the pipe; 3 – personal workstation.*

### **Parameters measured by the device measuring the diameter, roundness and bowing:**

- Outer diameter of the pipe ends and body (middle);
- Outer diameter of the pipe ends and body (minimum, maximum);
- Total straightness (warping) of the pipe;
- Local straightness (warping) of the pipe;
- Deviation from the theoretical girth;
- Pipe ends roundness;
- Pipe body roundness;
- Difference between the outer diameters of pipe and its ends.

### **Measurements of the pipe bevel edge and cutting angle parameters measured by the device.**

- Inside diameter of the pipe ends (middle);

- Inside diameter of the pipe ends (minimum, maximum);
- Roundness of pipe ends to the inside diameter;
- Pipe ends wall thickness;
- Bevel angles;
- Bevel dulling;
- Length of the cleared parts of the weld (optional depending on the hardware version);
- Remaining height of the cleared parts of the weld (optional depending on the hardware version);
- Misalignment of outside and inside weld (optional depending on the hardware version);
- Pipe cutting angle;
- Pipe length;
- Pipe body wall thickness (optional);
- Parameters of the weld and weld-affected zone (optional, depending on the hardware version).

Each device has the following composition:

- Measuring part,
- Electronic equipment,
- Mechanical equipment,
- Computer controlled information complex (CCIC),
- Software,
- Control results signaling device,
- Set of spare parts, tools and equipment,
- Engineering specification.

## 2. Monitored item technical characteristics

Maximum allowable characteristics of the monitored item:

Parameter	Level
Length, m	9,0-18,5
Nominal diameter, mm	from 18" to 60"
Wall thickness, mm	from 6 to 50
Speed of monitoring, pipes per hour	Up to 25
Total pipe bowing to be measured	Up to 0,6 % of the pipe length
Maximum weight of the pipe	35 on

## 3. Equipment configuration

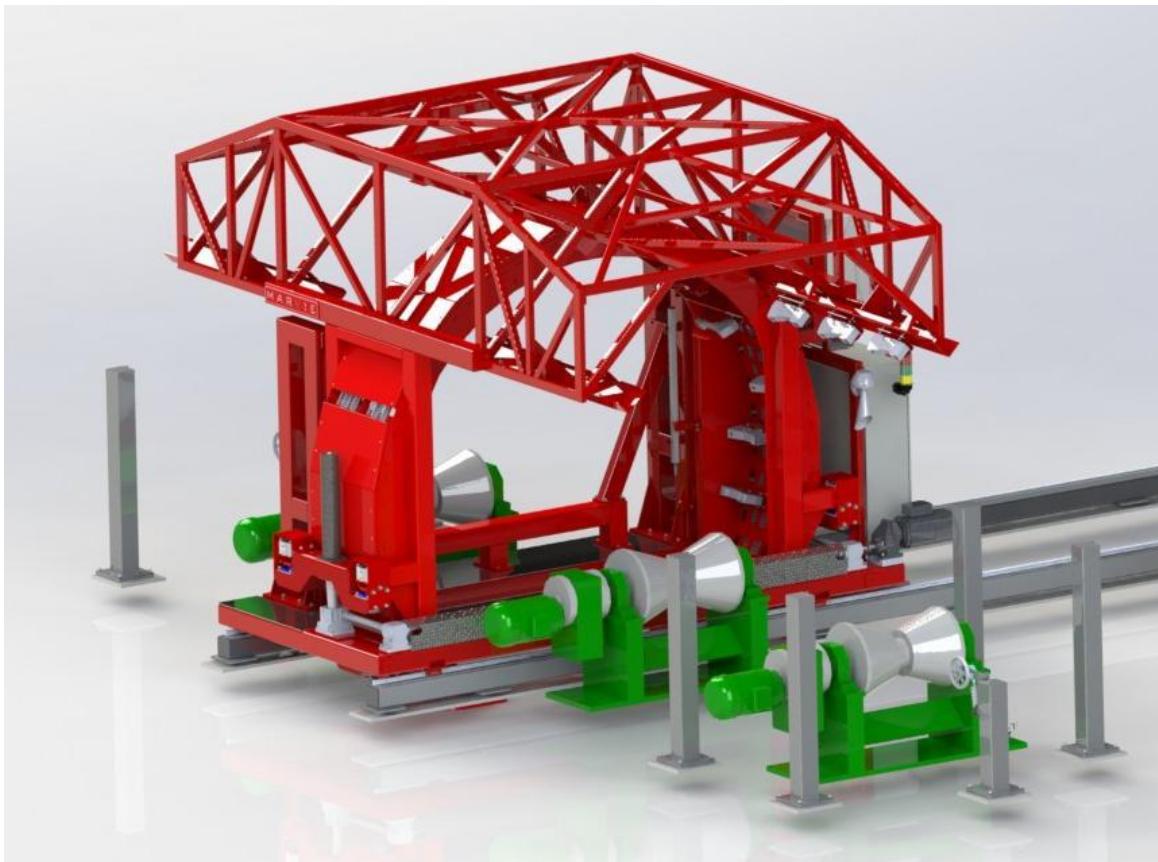
### 3.1. Testing (measuring) section

#### 3.1.1. Pipes diameter and roundness measuring module

The configuration of the module 1 on Figure 2 includes the mechanical equipment and a set of 2D-laser triangulation scanners with the depth of the measuring area of up to 750 mm. The module ensures the measurement of the pipe profile with resolution of up to 12,000 points on the perimeter at a pitch of up to 5 mm along the

pipe, which makes it possible to accurately calculate such parameters as diameter,

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roundness, deviation from the correct cylindrical shape and detect the weld.

*Figure 2. Diameter, roundness and warping device measuring.*

### 3.1.2. Pipes warping measuring module

The configuration of the module 2 on Figure 2 includes the mechanical equipment and a set of 2D-laser triangulation scanners with the depth of the measuring area of up to 750 mm. It measures the pipes sectors profiles located at 90° to the pipe axis on the basis of 1 m, 2 m, 4 m, which, in its turn, makes it possible to fix the spatial position of the pipe center, to build a three-dimensional model of the pipe and to calculate the warping parameters on the basis of 1 m, the total warping of the pipe, both along the surface of the pipe as well as along its axis.

### 3.1.3. Weld and weld-affected zone measuring module (Optional)

The configuration of the module 1 Figure 3 includes mechanical equipment and a set of 2D-laser triangulation scanners with the depth of the measuring area of up to 250 mm. The module ensures measurement of the weld and weld-affected zone profile with a resolution of up to 1000 points at a pitch of up to 5 mm along the pipe. Using the data collected from the module measuring the weld and the weld-affected zones are prepared the diagrams of the width and height of the weld, deviation from the theoretical girth, shift diagrams for the welded edges and there are detected the undercuts (optional).

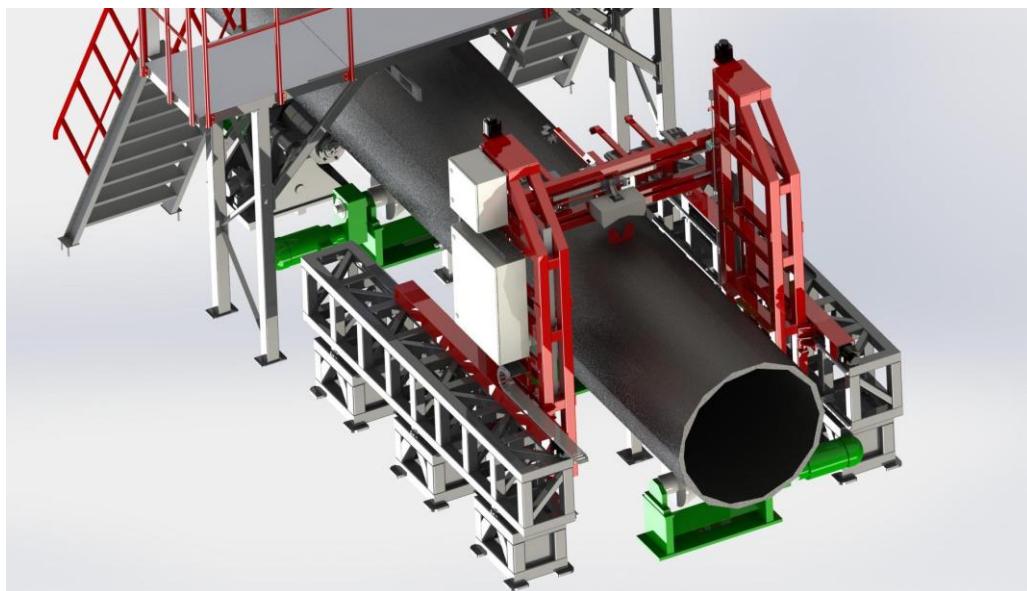


Figure 3. Device measuring bevel and cutting angle parameters (1st end of the pipe)

### 3.1.4. Bevel and cutting edges pipes parameters module measuring.

The configuration of the module 2 Figure 3 includes mechanical equipment and a set of 2D-laser triangulation scanners, point sensors with the depth of the measuring area of up to 200 mm. The module ensures measurement of the bevel profile and the adjacent surfaces along the pipe perimeter at a pitch along the perimeter of 5 mm. Using the measurement results the model of the pipe ends is constructed which makes it possible to calculate such parameters as bevel angles, dulling, pipe cutting edge, inside pipe diameter, wall thickness, difference between the inside diameters of the its ends.

### 3.1.5. Pipe body wall thickness measuring module. (Optional)

The configuration of the module includes mechanical equipment and a set of ultrasound (EMA) pipe wall thickness gauges with a drive and control units. The module receives the measurements along the perimeter of the pipe at a pitch of 1 mm, making it possible to accurately determine the variation in thickness of the pipe wall along the perimeter.

## 3.2. Electronic equipment

- Optical sensors synchronizers. Designed to synchronize the measurements of the optical sensors in order to eliminate the effects of pipe displacement and whipping during transportation on the measurement results.
- Linear displacement transducers.
- Encoders
- Light barriers

## 3.3. Machinery

Machinery. Provides translation of the measuring modules in the control zone, supply of SOP, supply of reference samples to check the correct operation of the device,

position adjustment of the measurement modules relative to the center of the pipe to measure pipes of various diameters.

### **3.4. Computer controlled information complex (CCIC)**

- Computer system;
- CCIC cabinet with UPS and air conditioning
- Control system (automatic) over mechanisms and calculation of coordinates of the detected errors (defects) in geometry;
- Software.

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### **3.5. Software**

- Devices software;
- Automation software;
- Software for review and evaluation of the test results;
- Software module for transmission of the results to the MES system;
- Pipes 3D models viewer (optional).

### **3.6. Control results signaling device**

- Aerosol defects marker,
- Sound signaling.

### **3.7. Pipes numbers reading and transmitting device.**

The device is equipped with the readers of the pipes numbers (printed in the manner as approved with the Customer).

### **3.8. Set of spare parts, tools and equipment**

- The device for automatic control over the geometrical parameters of the pipes does not have high-wear part. The set of spare parts, tools and equipment, required for safe operation of the device consists of technically sophisticated devices having a relatively long period of delivery.
- Composition of spare parts, tools and equipment:
- Laser triangulation scanner,
- Synchronizer.
- Amount of spare parts, tools and equipment according to the delivery completeness.

### **3.9. Engineering specification**

Together with the device is delivered a complete package of engineering specification required for operation, minor repairs, tuning and order of spare parts. Including:

- Passport,
- Operator's manual,
- Operation instructions,
- Calibration methods,
- Test procedure,
- Decomposition scheme.

Before the training of the Customer's personnel, there should be approved the plan of study, distributed the handouts (manuals, illustrations, descriptions of the device accessories).

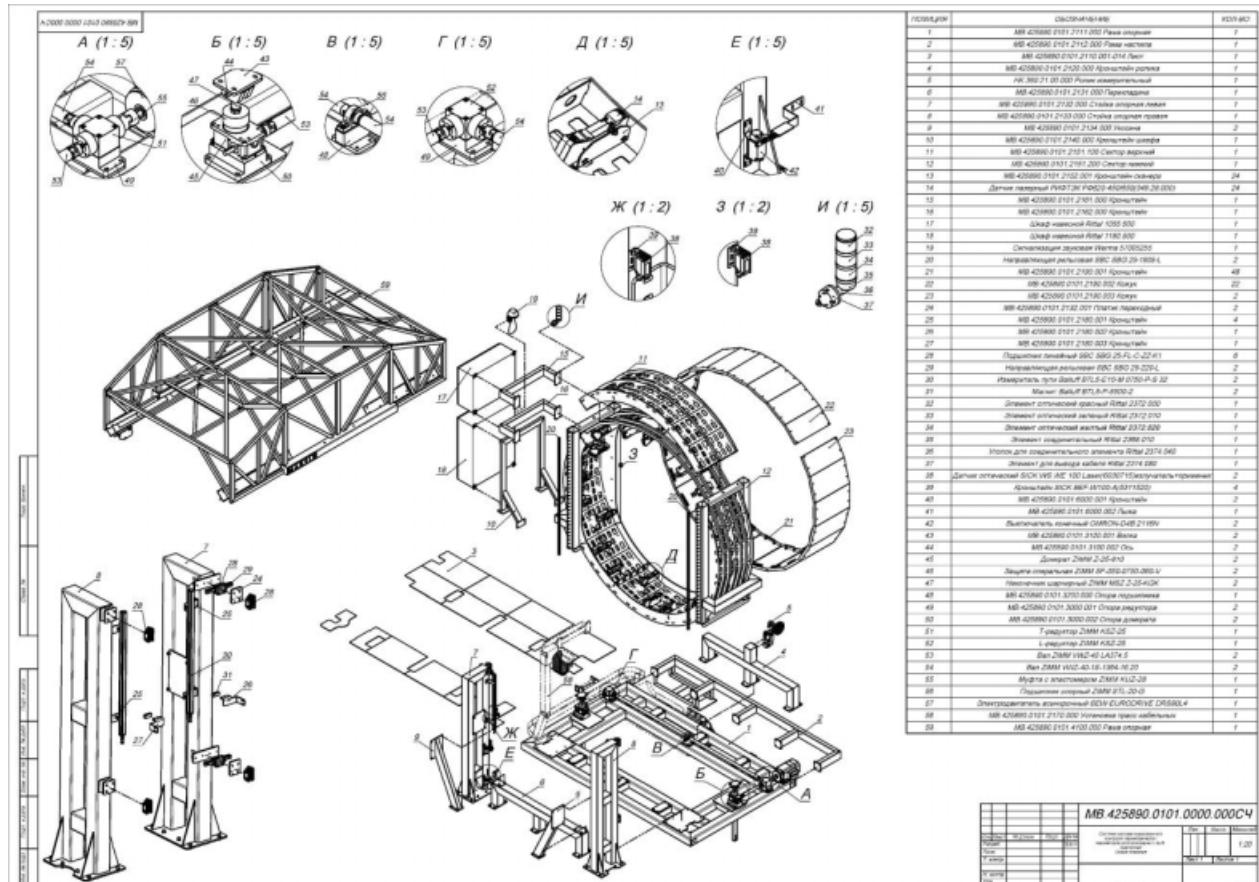
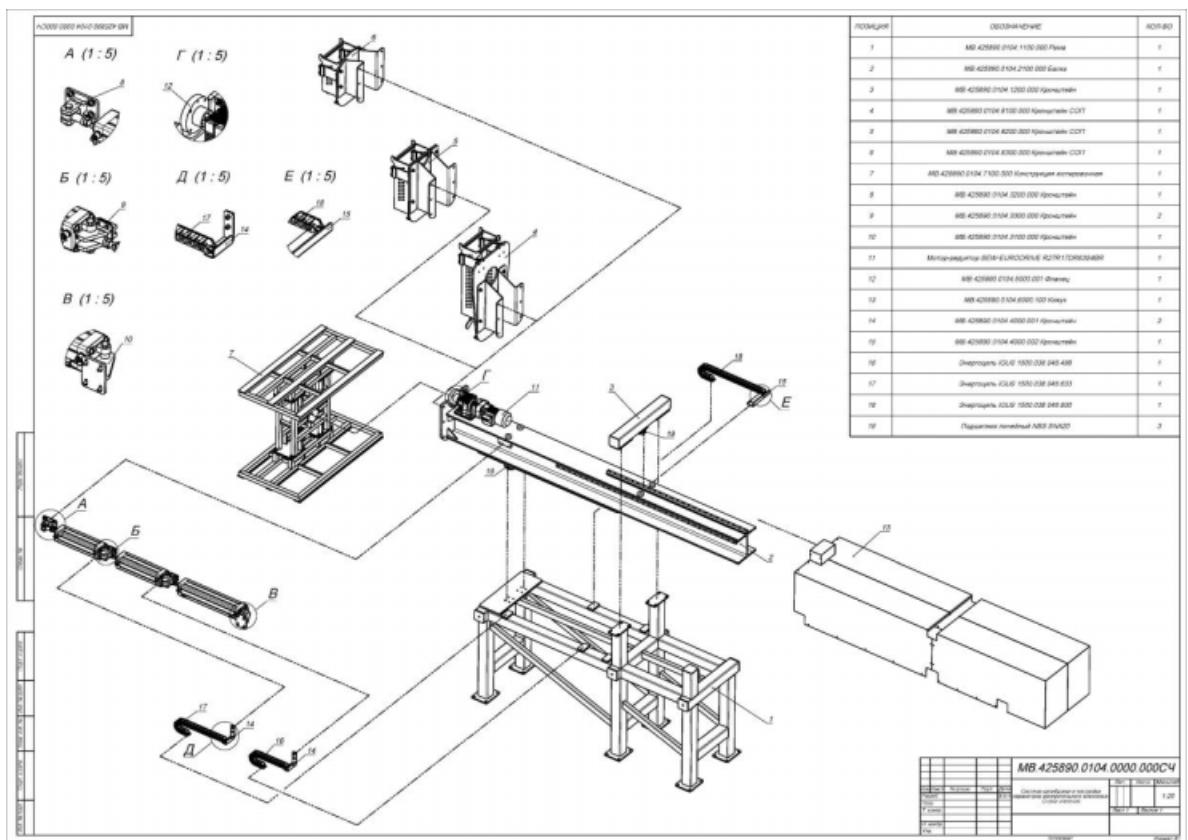
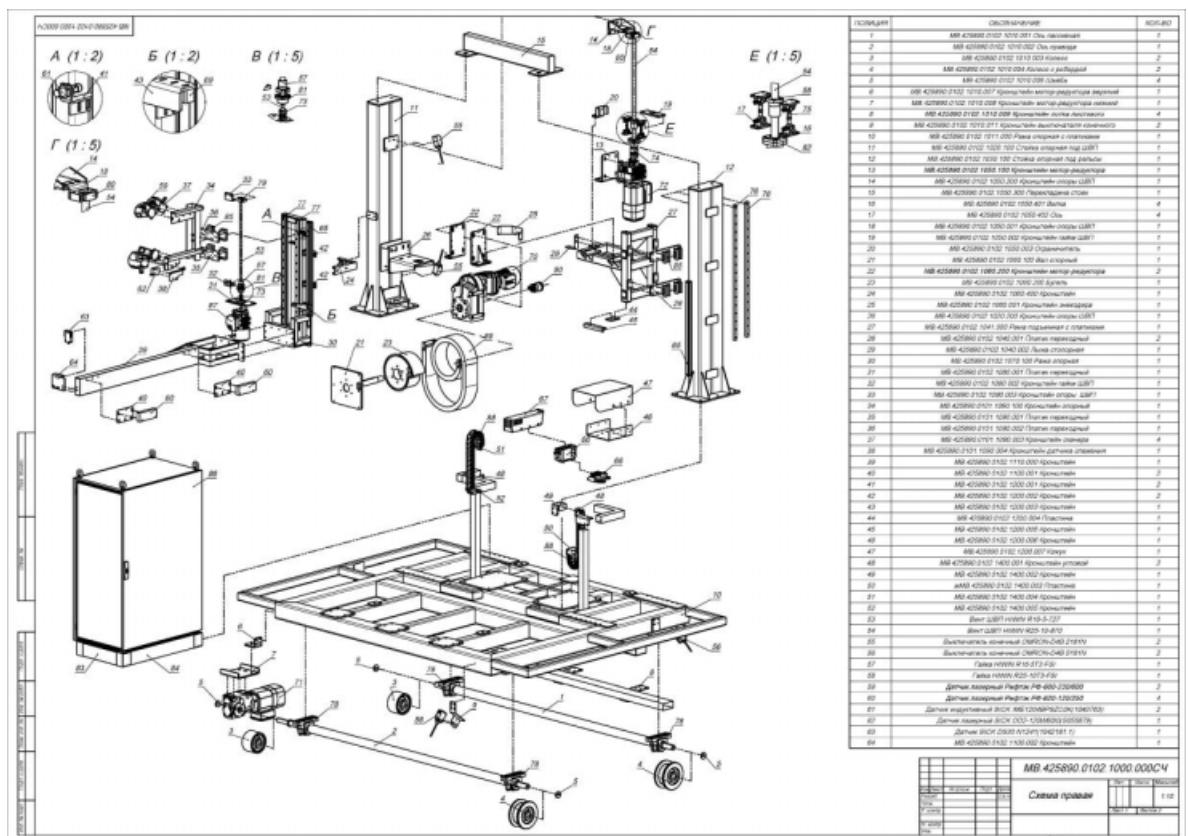


Figure 4. Base sheet of the decomposition scheme for the device measuring the diameter, roundness and warping of the pipe.



*Figure 5.* Scheme for decomposition of the calibration table of the device measuring the diameter, roundness and warping.



*Figure 6. Basic sheet of decomposition of the module measuring the bevel parameters and the cutting edge of the pipes ends (for parallel displacement of pipes)*

## 4. Main equipment specifications

Parameter	Value
Type of measurements	Diameter, roundness, warping of the pipe, length of the pipe.
Number of measurement points of the pipe profile (in transverse profile)	Up to 24 000 (the entire pipe profile is to be measured using 2D laser scanners), number of scanners: 24.
Method of measurement	laser triangulation
▪ Profile	
Measurements frequency	Up to 250 Hz
▪ Diameter, roundness	
▪ Pipe profile	
Measurements accuracy	<ul style="list-style-type: none"> <li>▪ Outer diameter</li> <li>▪ Inside diameter</li> <li>▪ Total straightness (pipe warping)</li> <li>▪ Deviation from pipe ends straightness on the basis of 1 m</li> <li>▪ Deviation from theoretical girth</li> <li>▪ Pipe ends roundness</li> <li>▪ Pipe body roundness</li> <li>▪ Bevel angle</li> <li>▪ Thickness of the pipe wall</li> <li>▪ Pipe cutting edge</li> <li>▪ Bevel dulling</li> <li>▪ Welded edges displacement</li> <li>▪ Deviation from theoretical girth</li> <li>▪ Weld height</li> <li>▪ Weld width</li> </ul>
▪ Diameter, roundness	<ul style="list-style-type: none"> <li>Not worse than <math>\pm 0,15</math> mm</li> <li>Not worse than <math>\pm 0,15</math> mm</li> <li>Not worse than <math>\pm 1</math> mm</li> <li>Not worse than <math>\pm 0,1</math> mm</li> <li>Not worse than <math>\pm 0,3</math> mm</li> <li>Not worse than <math>\pm 0,3</math> mm</li> <li>Not worse than <math>\pm 0,3</math> mm</li> <li>Not worse than <math>\pm 0,5^\circ</math></li> <li>Not worse than <math>\pm 0,1</math> mm</li> <li>Not worse than <math>\pm 0,15</math> mm</li> <li>Not worse than <math>\pm 0,15</math> mm</li> <li>Not worse than <math>\pm 0,1</math> mm</li> <li>Not worse than <math>\pm 0,1</math> mm</li> <li>Not worse than <math>\pm 0,3</math> mm</li> </ul>
Test speed, m/s	Up to 1,5
Uncontrolled zones in the beginning and end of the pipe at a speed of 1 m/s	
▪ Diameter, roundness	not more than 10 mm

## 5. Operation principle

### 5.1. Diameter, roundness and warping measuring.

During the pipe measuring, the system for collection and processing of the information, receives from the sensors the profiles of individual sections of the pipe in the coordinate system of sensors.

The received information is bound by the system to the common system of coordinates, then, takes place the process of pre-filtering and mathematical processing. Thus, is created a three-dimensional model of the tested pipe. Using the data of this model, a special software module calculates parameters using the specified methods, calculates the required geometrical parameters and pipe characteristics. This principle makes it

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Figure 5.1. Device measuring the diameter and roundness while testing the pipe

possible to make the system flexible, to modify the criteria and methodology for evaluation of the geometric parameters of the pipe at the program level depending on the Customer's requirements and the terms of pipes delivery.

The distance between the laser triangulation scanner and the pipe surface is about 450 mm, which ensures trouble-free passage of defective pipes and trouble-free passage of the pipes in case of automation failure. Each scanner is equipped with the debris and dust blow-off system.

The transverse profile of the pipe is measured by the system of 2D-scanners arranged in a circumferential direction in a plane of the perpendicular axis of the pipe. The transverse profile of the pipe is measured using laser triangulation sensors. There are 24 sensors (for maximum pipe diameter). The size of the point for the maximum pipe diameter is of approximately 0.3 mm. This resolution capability makes it possible to filter the data, to carry out mathematical processing of information, which is particularly important for complex surfaces.

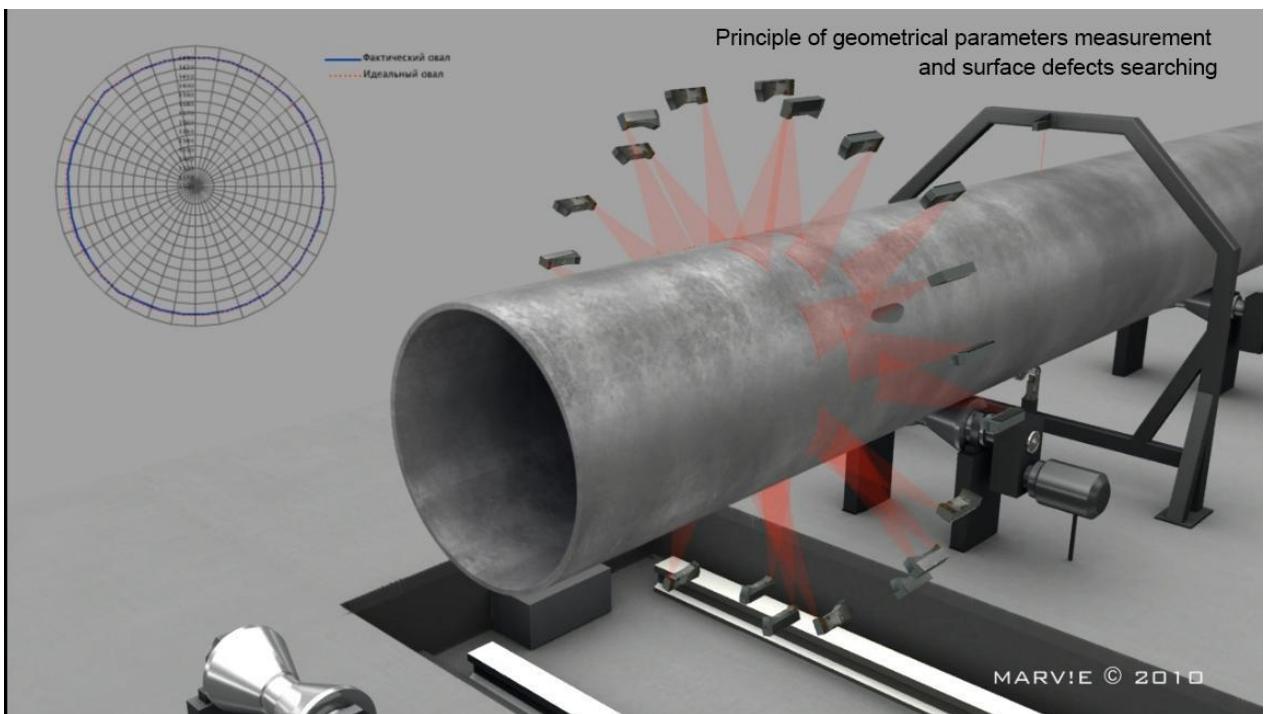


Figure 5.2. Explanation for the principle of pipe profile measurement. Scheme of sensors arrangement.

## 5.2. The pipe warping measuring subsystem

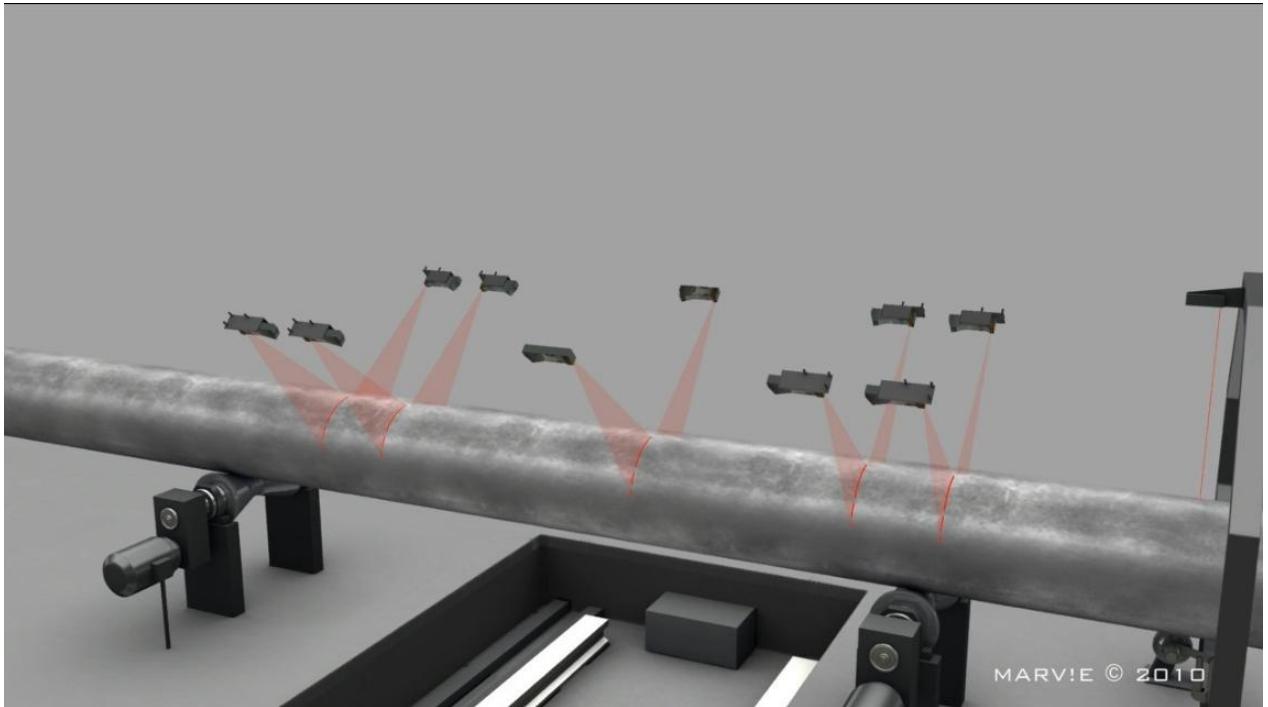


Figure 5.3. Explanation for the principle of pipe bowing measurement principle. Scheme of sensors arrangement.

The control of pipe warping is implemented by a three-point method on the symmetric and asymmetric measuring base of 4 m. The spatial position of the pipe axis is calculated by the method of restoration of the pipe axis location according to five measurement points. The warping at any selected direct axis moving line at any required

based is mathematically calculated based on the constructed three-dimensional model of the pipe.

Pipe straightness is calculated by the software module using the measuring results of part of the pipe profile by the sensors located in the measuring module. This approach helps to minimize the influence of the pipe whipping during transportation and deviation of the measurement points in one section relative to the measuring points in another section, during the dynamic control of the pipe warping.

The pipe warping measuring module is located on the module measuring the diameter and roundness Figure 7, which is located on the movable platform. Mobility of the platform makes it possible to move the measuring modules from the control zone to the zone of servicing and calibration, setting of the measuring modules to the current diameter of the pipe. The pipe warping measuring module and the profile, diameter and roundness measuring module are rigidly connected. This makes it possible to use one adjustment mechanism to the diameter of the measured pipe, resulting in the improved accuracy and increased system reliability. The use of the rigid connection between two measurement modules makes it possible to compensate natural pipe whipping during transportation when calculating the bowing.

These two modules are placed on a single rigid structure with the antivibration base. The solution makes it possible to measure the required parameters of the pipe with high accuracy, regardless of the external vibrations of the rolling surface or the pipe.

The use of two-dimensional scanners makes it possible to simplify the tuning process and the system calibration. If the scanner is out of order it is replaced in the workshop by the operational personnel, which takes not more than 25 minutes. Further calibration of the Device is made automatically according to the SOP (standard operating procedures).

Usage of a common rigid measuring base does not require precise positioning of the Measuring system relative to the center of the pipe, which, in case natural warping of the pipe and its inevitable jumps during transportation through the Device, in its turn, eliminates the necessity to use precision gear systems requiring regular maintenance and, if needed, their adjusting/calibration. The application of the common rigid structure reduces the maintenance requirements and increases the system reliability.

Absence of the mechanical control system makes it possible to reduce the time for adjusting and repair of the equipment in general.

### 5.3. Peculiarities of the 2D laser scanners used in the Device

Presence of the signal processor in the sensor makes it possible to make part of the functions for processing of the signal in the sensor. This is especially important when measuring on a complex surface with water and oil stains, with shiny areas.

Presence of the external synchronization of the measurements makes it possible to record the information in a single timing and exclude the effect of pipe vibration and its irregular transportation speed during the testing.

Scanners have a large work area in the measuring depth, which makes it possible to control the whole assortment of the pipes without any readjustment of the measurement system.

*Illustration of the general arrangement and principle of measurement of a two-dimensional scanner.*

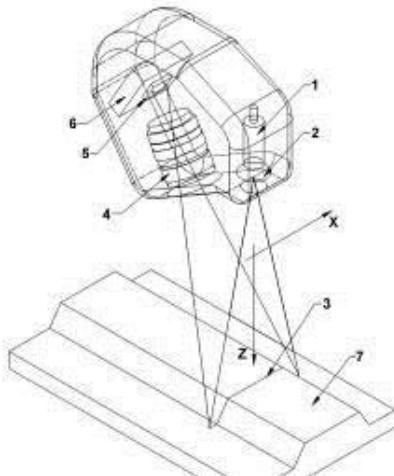


Figure 5.4. Illustration of the general arrangement and principle of measurement of a two-dimensional scanner.

The basis of the scanner operation is taken by the principle of optical triangulation (see Fig. 5.4). The radiation of a semiconductor laser 1 is formed by the lens 2 in the form of the line 3 and is projected onto the object 7. The scattered radiation on the object formed by the lens 4 is collected on a two-dimensional CMOS-matrix 5. The resulting image of the object contour is analyzed by the signal processor 6, which calculates the distance to the object (axis Z) for each of the set of points along the laser line on the object (axis X).

#### 5.4. Bevel parameters and cutting edges measuring (option with a longitudinal movement of the pipes)

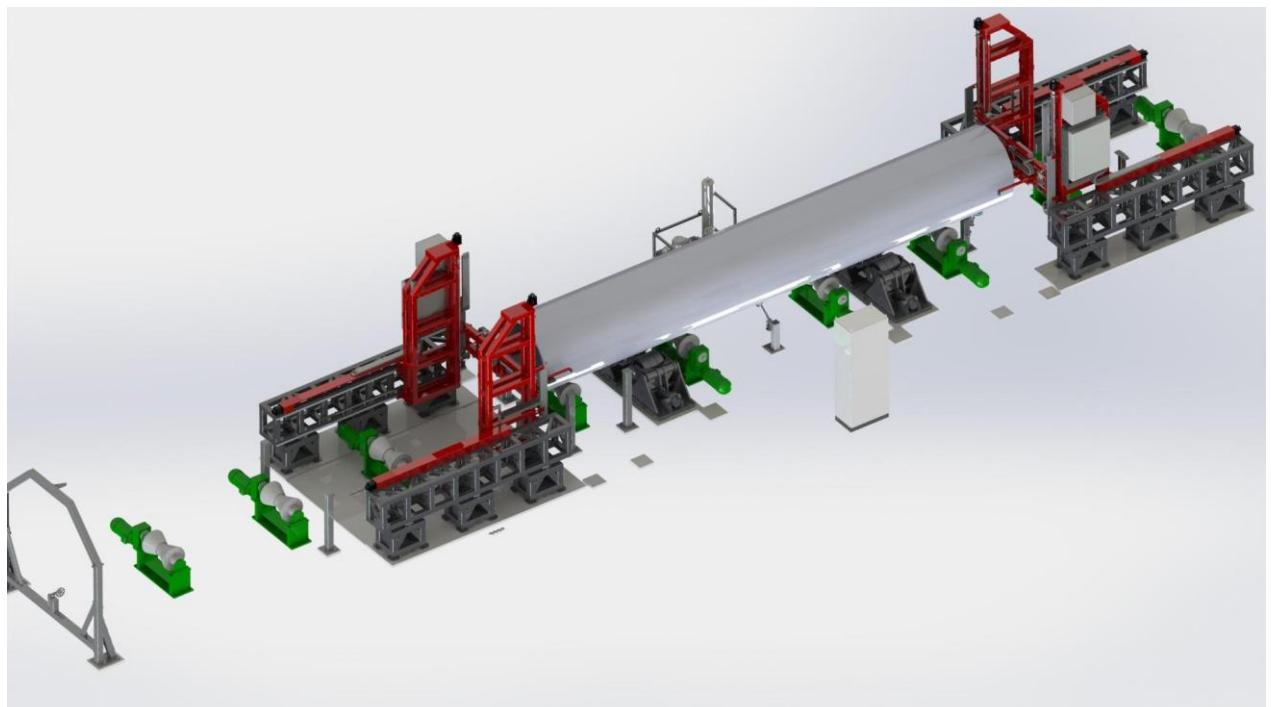
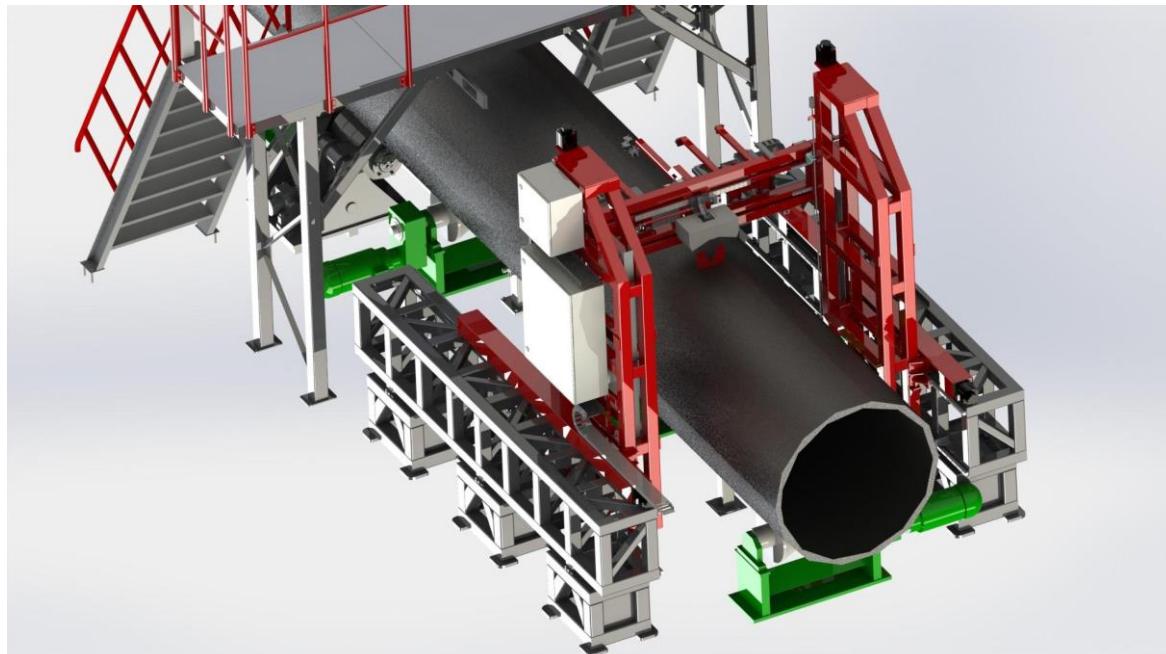


Figure 5.5. External view of the device testing the geometric parameters of the bevel and the

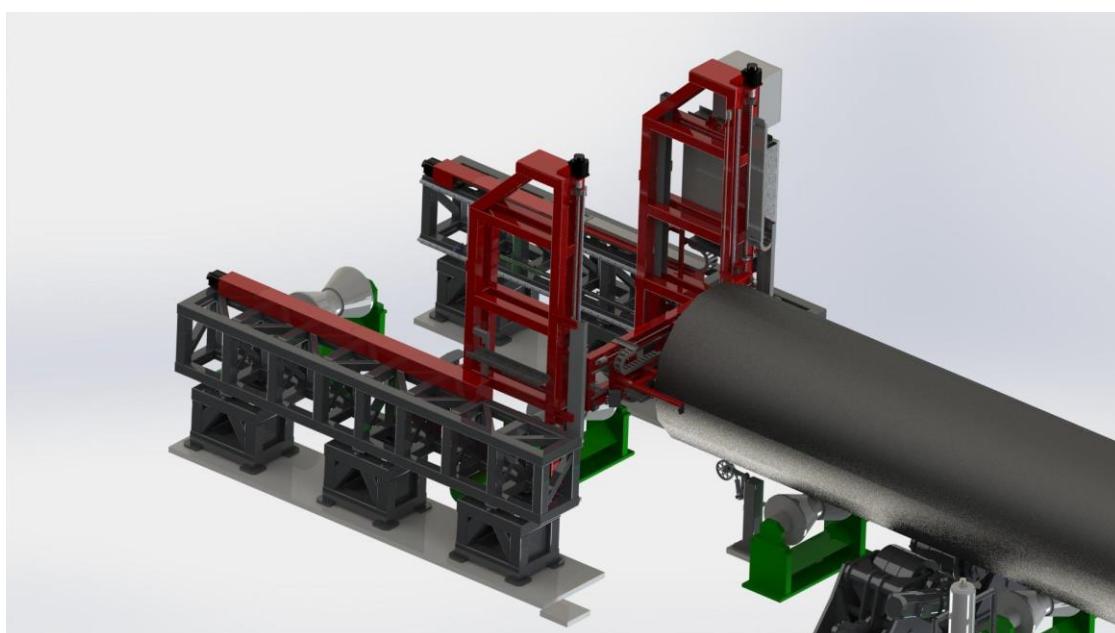
cutting edge: 1 - frame of predetermination of the diameter and length; 2 - module measuring the parameters of the bevel and the cutting edge; 3 - lifting and reversible rolls.

The pipe passes through the frame of predetermination of the diameter and length (1) towards the measurement modules (2), herewith, the beams with the sensors are raised as shown in the figure.



*Figure 5.6. The process of measuring the parameters of the pipe weld at its exit from the device controlling the bevel.*

Then, the pipe is positioned by the automatic equipment in the center of the platform and lifted by the lifting and reversible rolls (3). The measurement modules run into the control position.



*Figure 5.7. The process of control over the parameters of the bevel and the cutting edge during the pipe rotation.*

The pipe starts to rotate Figure 5.7, laser sensors measure the parameters of the bevel, thickness and pipe cutting edged all over the perimeter. After one turnover the pipe is either put down on the rolling surface or is put with the weld up in order to control the parameters of the weld and the weld-affected zone (in case of this option).

## 6. Provision, storage and use of the data

During the process of testing takes place the creation of a three-dimensional model of the pipe exactly matching the measured pipe. The data collected by the device, are synchronized in time, filtered, attached to the measuring data of the length of the path traveled by the pipe and the data of the automation system. Then, based on the collected data, takes place the creation of the three-dimensional spatial model of the pipe.

The resolution for construction of the three-dimensional model of the pipe up to 10 mm along the pipe length and up to 1.5 mm on perimeter.

The information about the tested pipes is stored in the database and can be moved to another computer, transmitted by the plant network in the MES system under any agreed protocol.

Using the software for viewing and processing of the results and databases data on the tested pipes, it is possible to get the required statistical information, to print the list of the tested pipes with the required set of parameters.

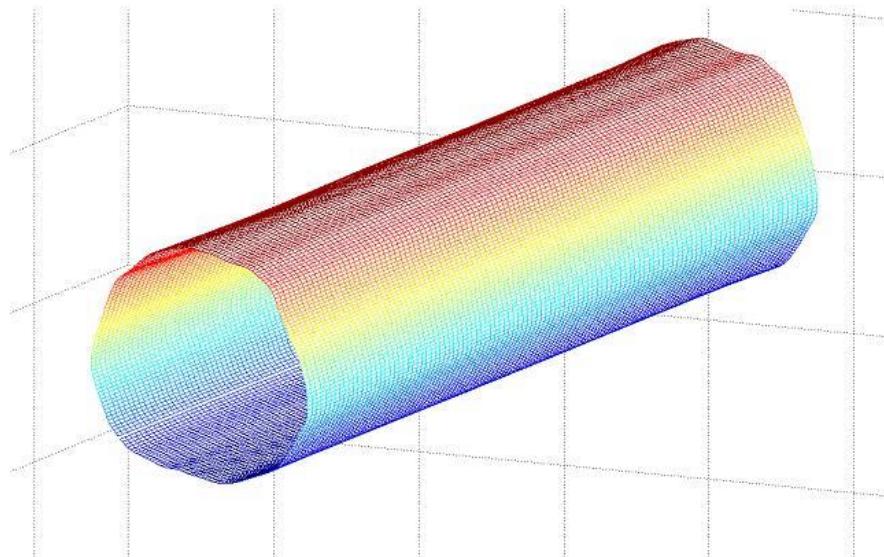


Figure 6.1. 3D model of the pipe (shown in the enlarged scale near the surface of the pipe)

The geometric parameters of the pipe are calculated by the 3-dimensional model with a given accuracy. For example, to obtain the parameters of the pipe profile at a given distance, from its beginning it is necessary to make a plane section in this place of the 3-dimensional model (figure 6.2, the pipe profile is shown in the enlarged scale radially). Having the profile it is possible to calculate the perimeter, the average diameter, the minimum and maximum diameters, and their corresponding angles of the profile sections.

Mathematical modules are used to calculate the parameters according to the three-dimensional model. The software modularity makes it possible, if necessary, to change the evaluation methodologies in accordance with the changes of the standards and specifications requirements of the customer, to add new modules for the receipt of the additional required information.

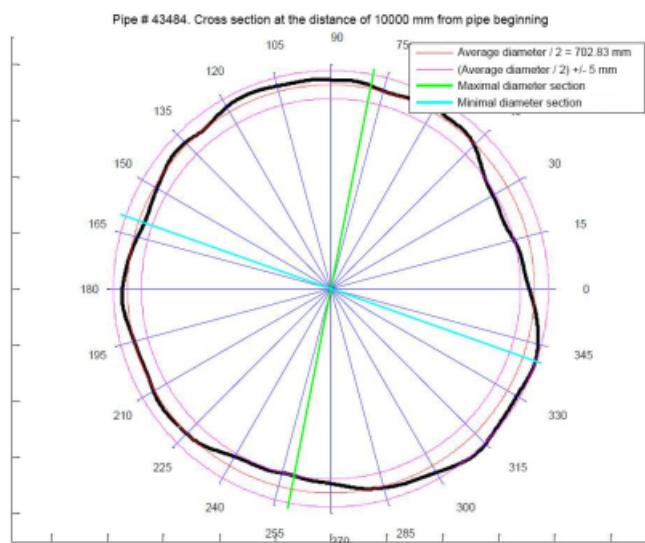


Figure 6.2. Pipe profile (shown in the enlarged scale near the pipe surface)

Analysis of the three-dimensional model of the pipe makes it possible to receive much more information than a set of geometrical parameters specified in the Technical Specifications (TS). The 3D model can be used, for example, to evaluate the operation of the press, optimum adjustment of its modes, pitch and operation speed. With a feedback in the form of the three-dimensional model of the pipe it is possible to measure the changes of these of those settings in the engineering process and make optimization. Using the data received from the device, it is also possible to make the statistical analysis and forecast the predictive and preventive maintenance activities, the timing of replacement of the consumables, etc. Below is given the example comparing the pipe profiles before and after expansion. The profiles received from the operation of the device in the workshop "Vysota 239" (Figure 6.3).

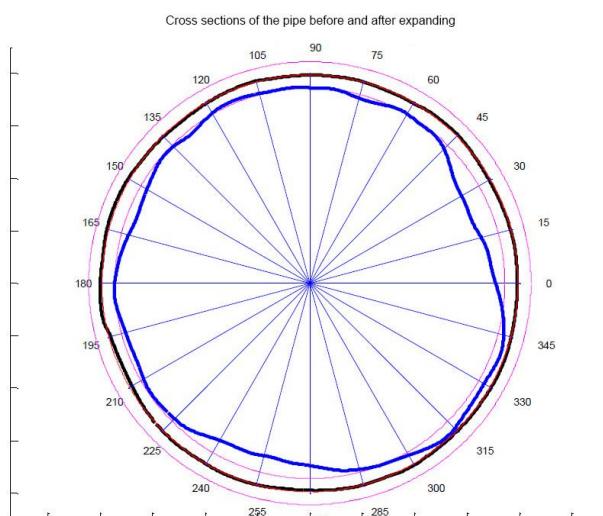


Figure 6.3. Comparison of the pipe profile before and after expansion

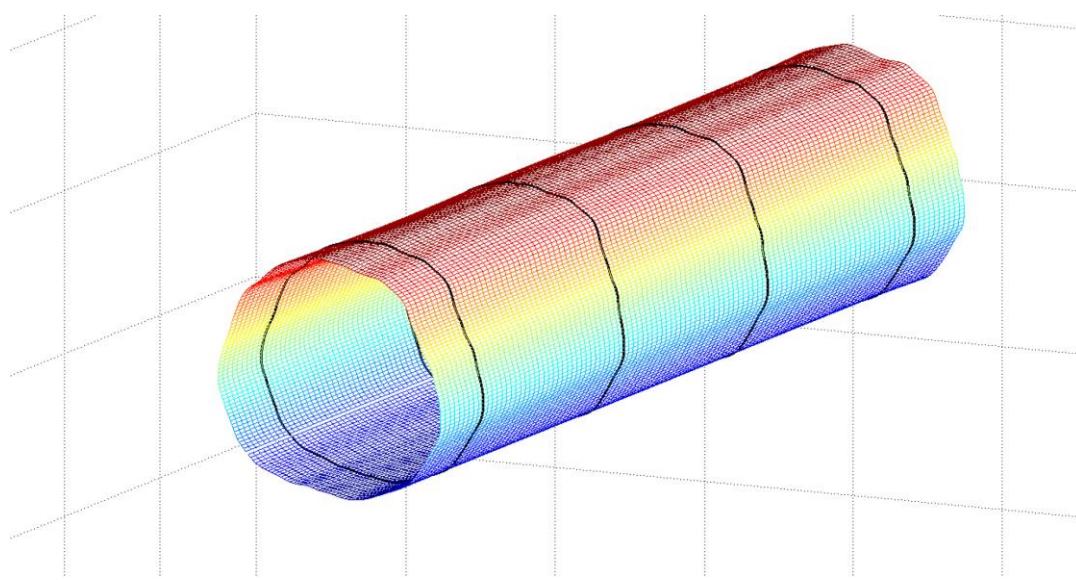


Figure 6.4. Section of the pipe by diametral planes.

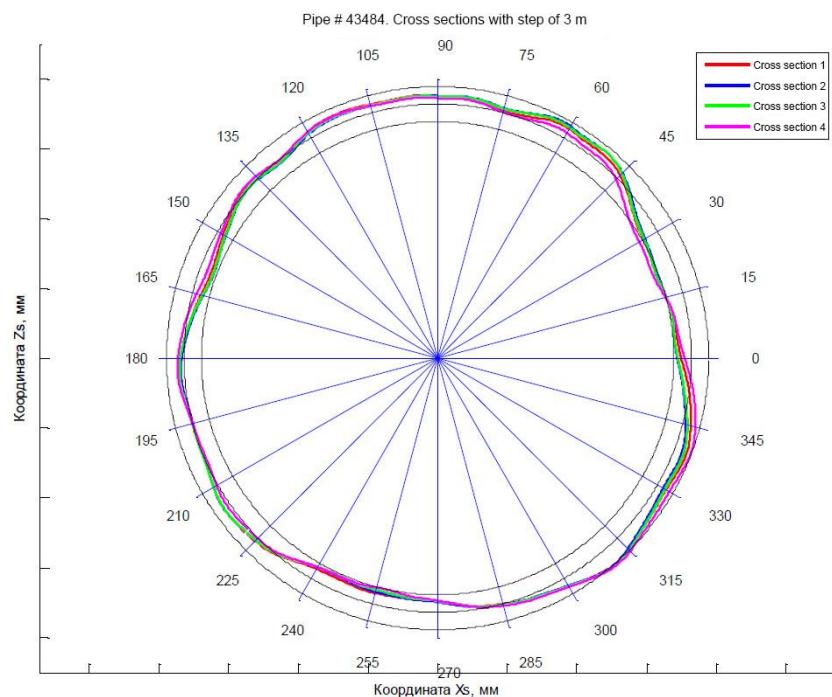


Figure 6.5. Pipe profiles in 4 sections.

With the help of the three-dimensional model of the pipe it is possible to get the section of the pipe in any point and to display the received profiles, for example, at one scheme (Fig. 6.5). Having these sections it is possible to determine the nature of the change in the surface of the pipe profiles at different angles, to draw conclusions about the settings of the press, etc.

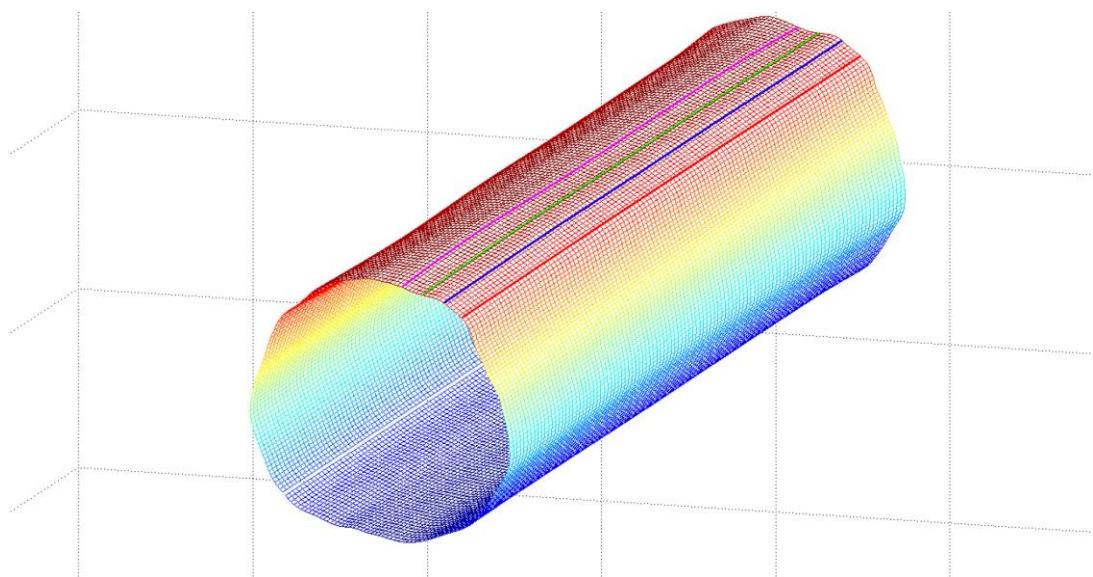


Figure 6.6. Section of the pipe with longitudinal planes (the planes are shown in color).

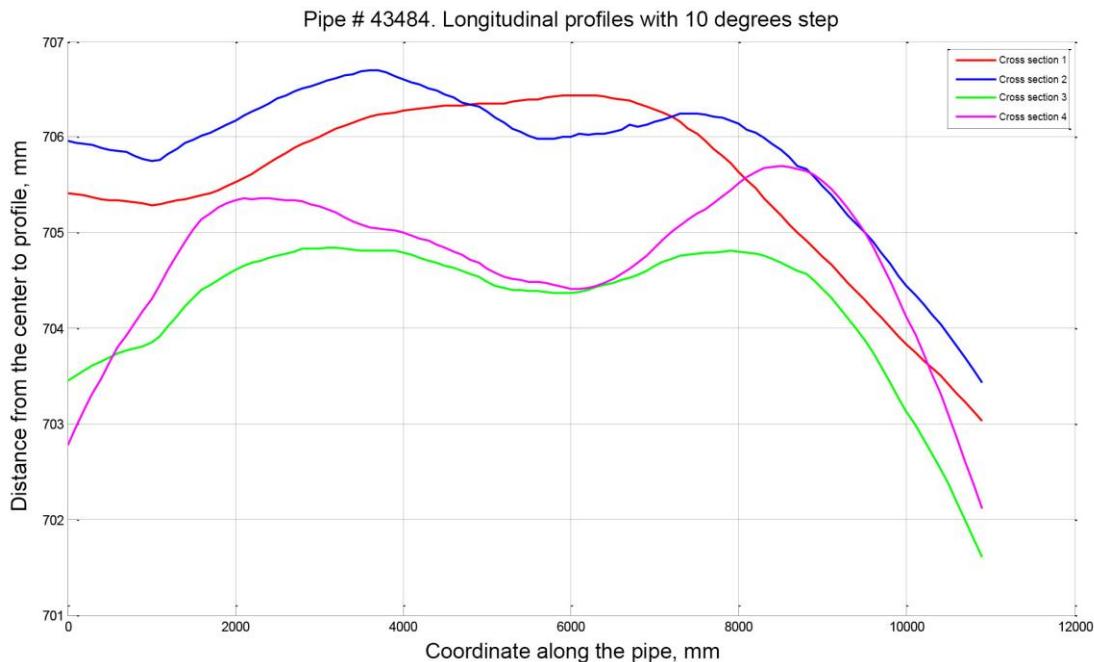


Figure 6.7. The trajectories of the surface points along the pipe, lying in the given planes of the section.

The technology for creation of a three-dimensional model of the pipe involves the calculation of the spatial position of the pipe axis. Thus, the warping of the pipe can be calculated both according to the generatrix and according to the pipe axis, which is not available to the manual and majority of automatic control methods. The data about the bowing of the pipe axis does not contain the component introduced by the irregular roundness of the pipe along the axis and can be used both for technological purposes and at the product test, in case of any changes in the measurement methods and evaluation criteria

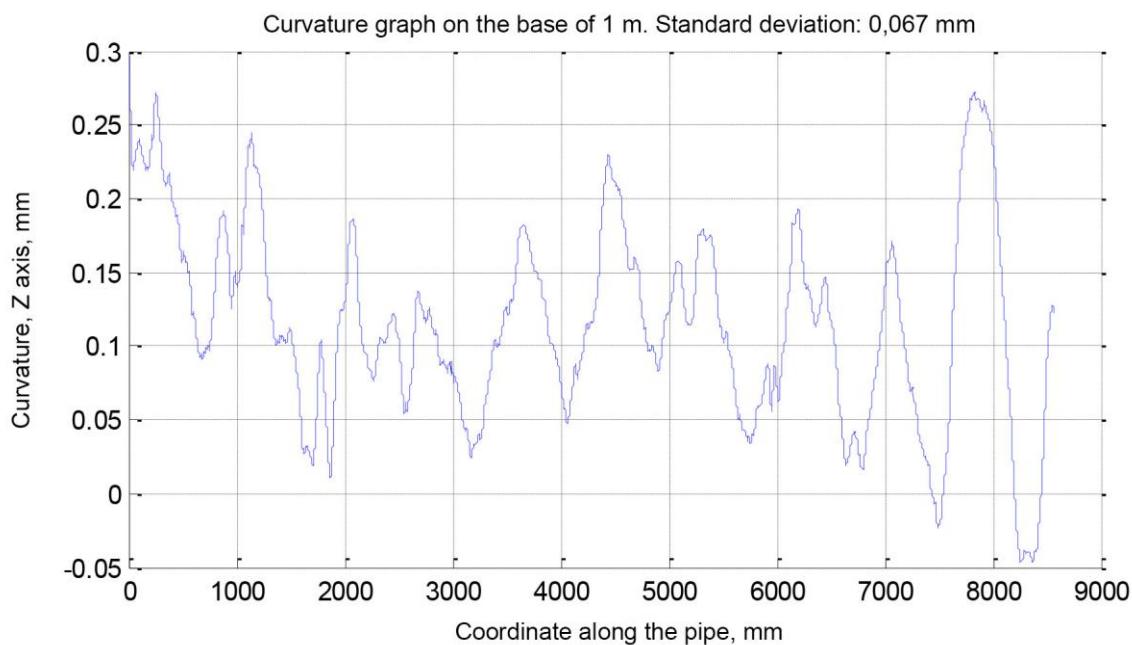


Figure 6.8. Bowing of the pipe axis on the basis of 1 meter.

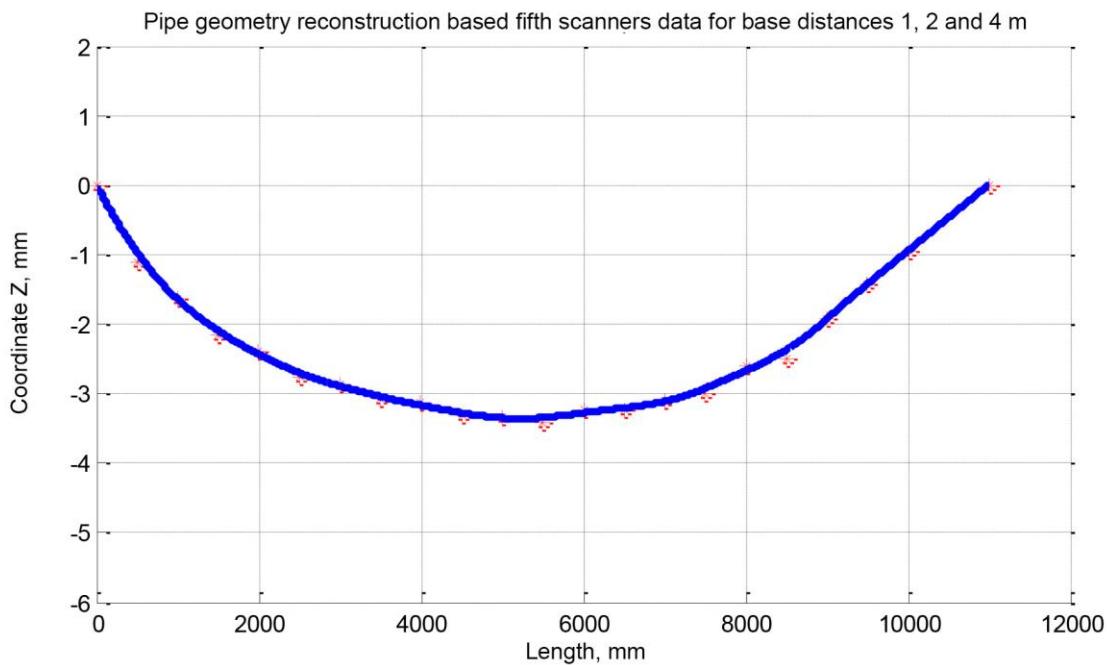


Figure 6.9. Projection of the spatial position of the pipe axis (total bowing of 3.5 mm).

## 7. Software and Interface

The software has an intuitive interface. Access to the system customization is divided into three levels: Developer, Engineer and Operator.

The control takes places in the automatic mode. During the control the operator has the possibility to manually enter the number of the controlled pipe, the nominal diameter, ND and others information, if for some reason it was not transmitted via network.

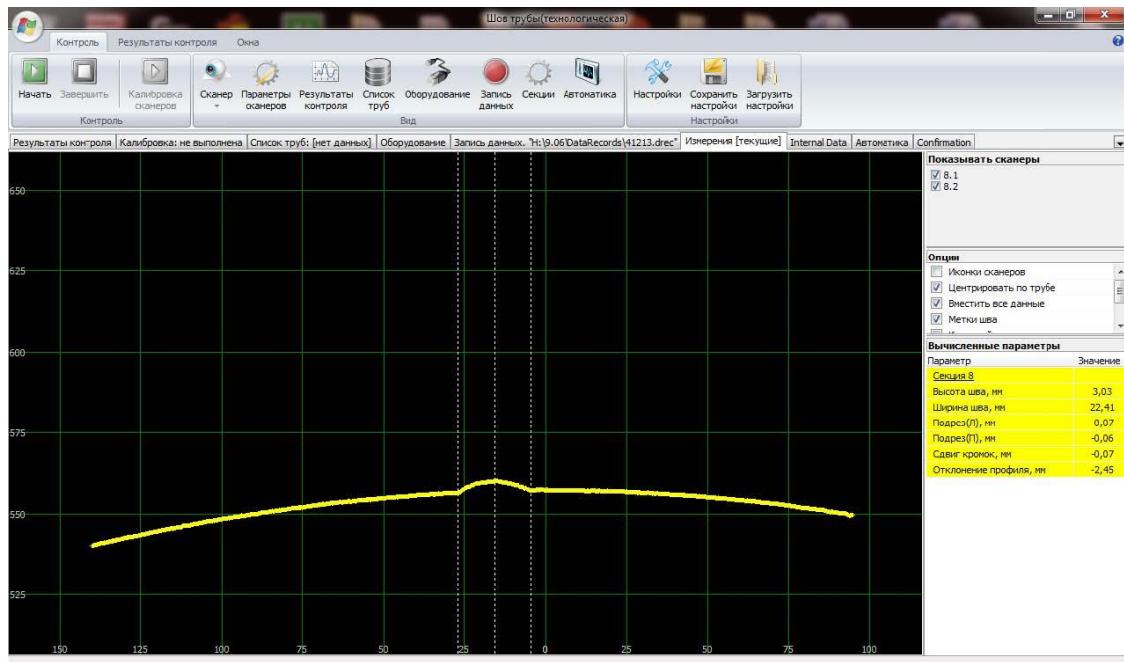


Figure 7.1. Profile of the weld and weld-affected zone.

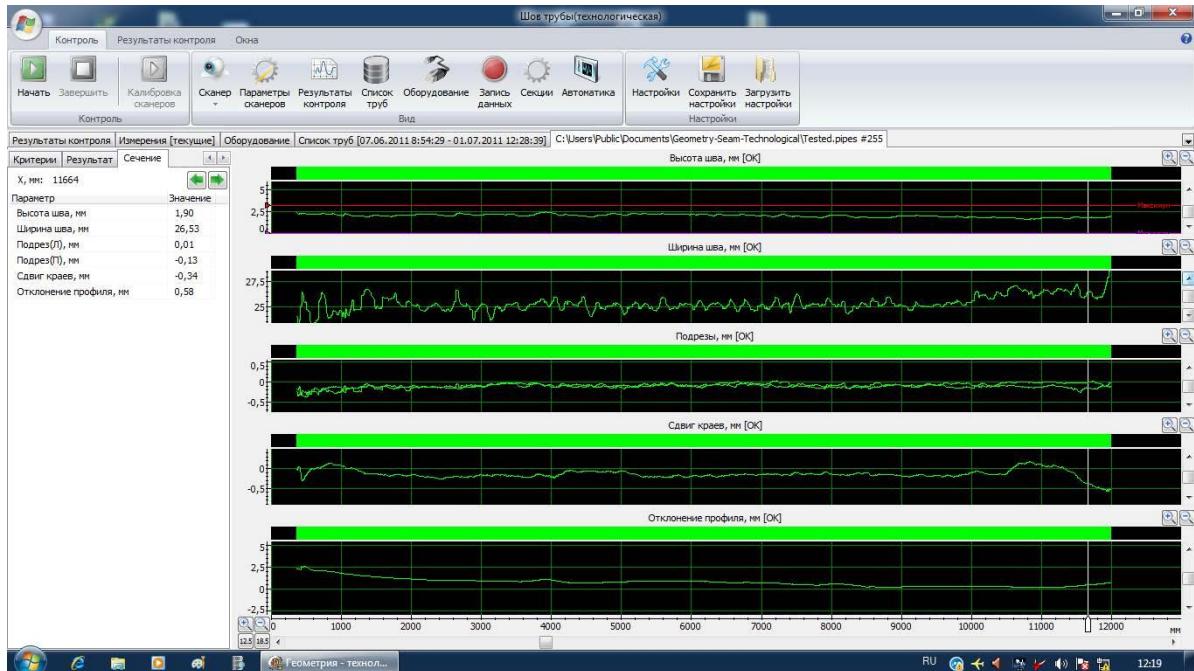
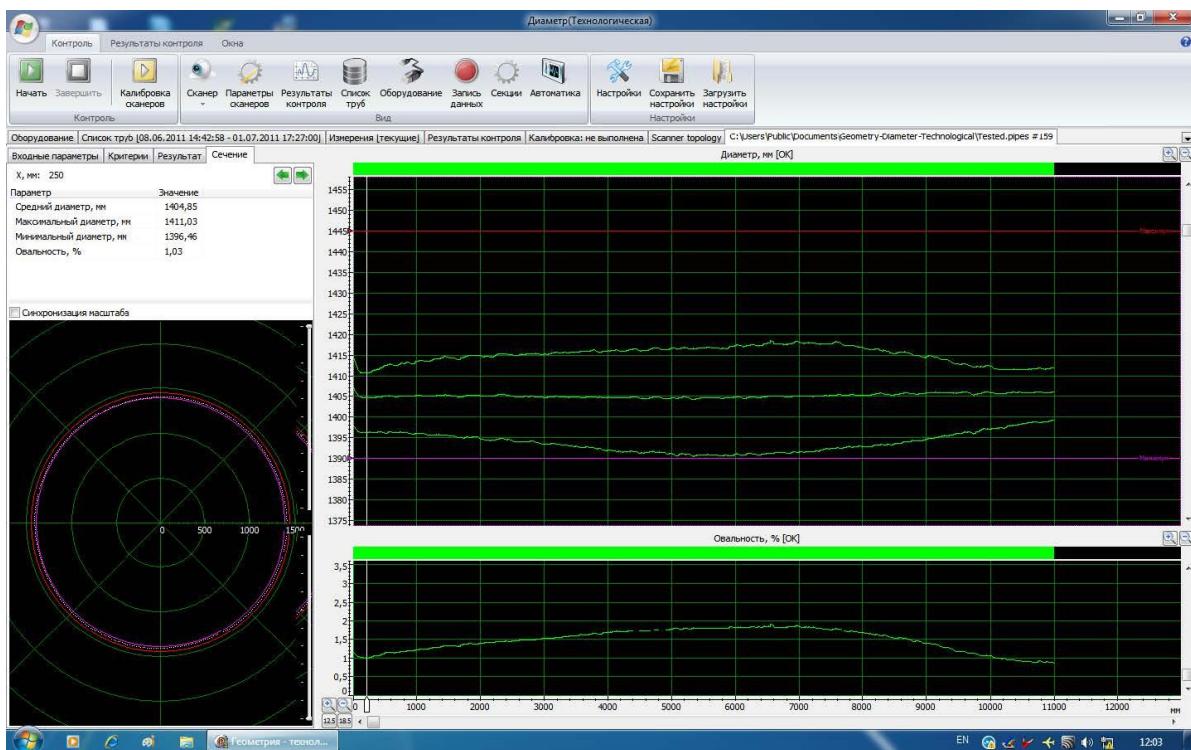


Figure 7.2. Diagrams showing the parameters of the weld and the weld-affected zone along the pipe.



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Figure 7.3. Diagrams of the maximum, average, minimum diameter and roundness along the pipe during the testing.

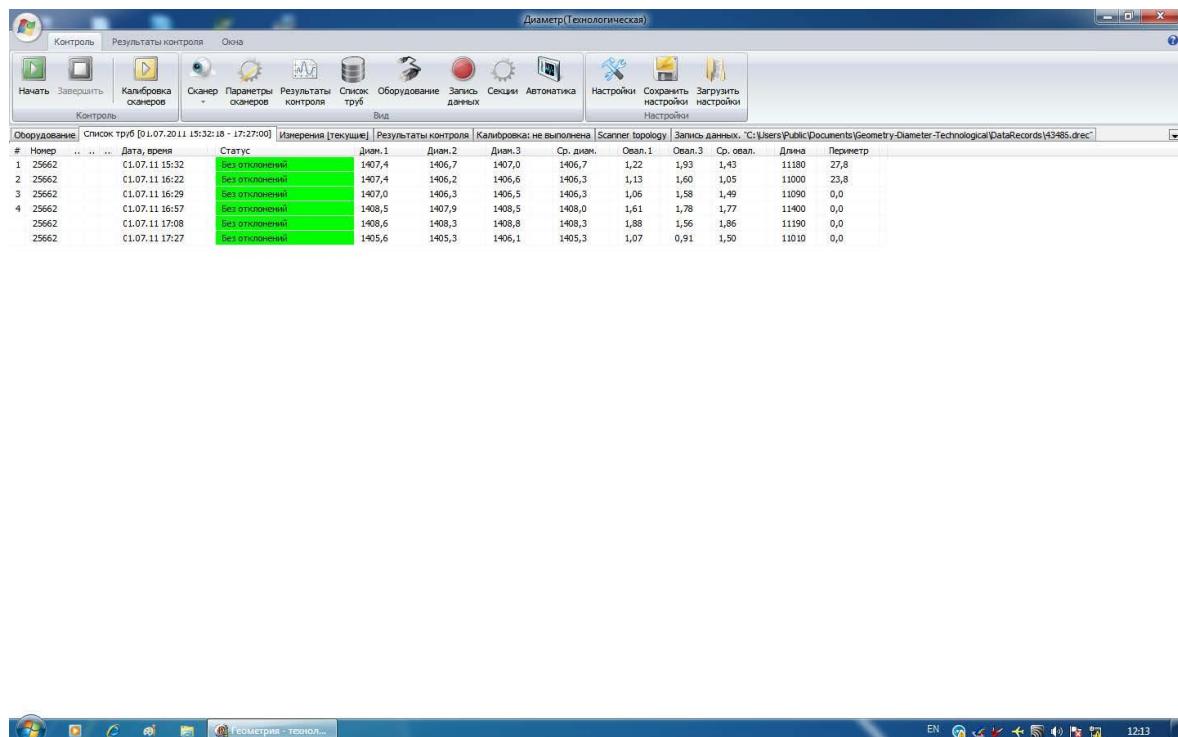
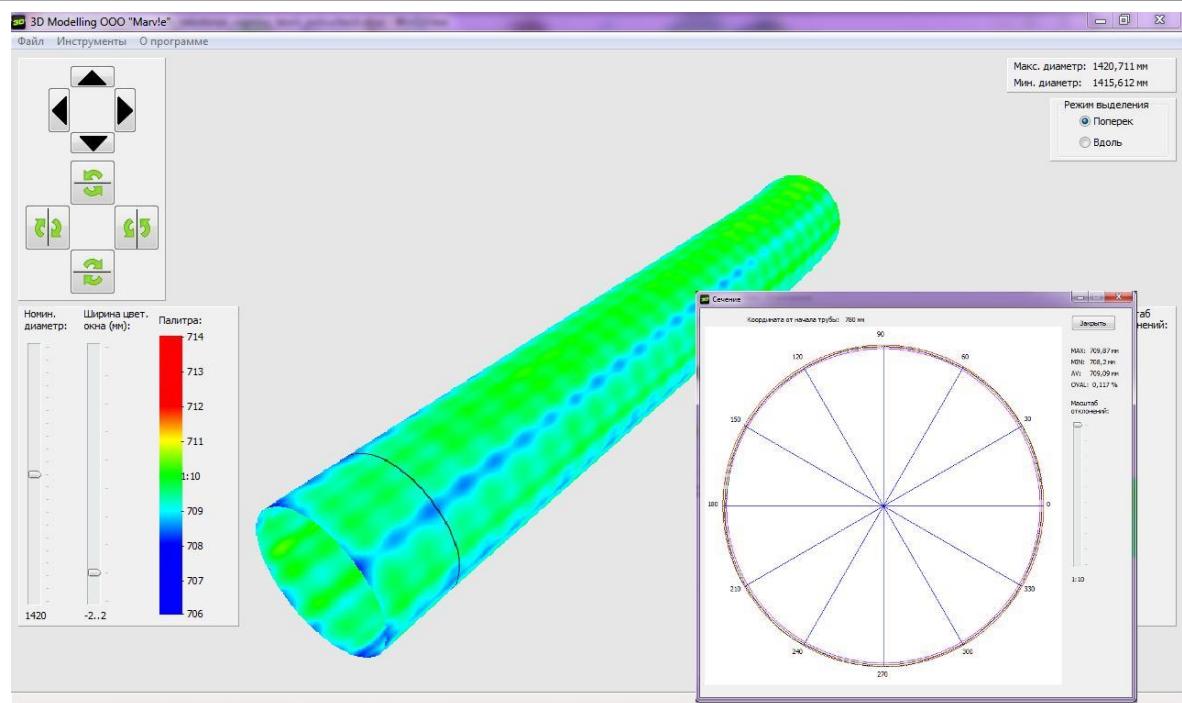


Figure 7.4. List of the tested pipes



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## 8. Equipment calibration

Calibration of the equipment in accordance with the requirements of the DNV standards must take place periodically and certify the characteristics of the control devices. At the proposed control devices the calibration takes place in the automatic mode and takes not more than 5-15 minutes. The calibration machine designed to store deliver SOP of the relevant dimension-type into the measurement zone, is shown in the Figure 8.1.

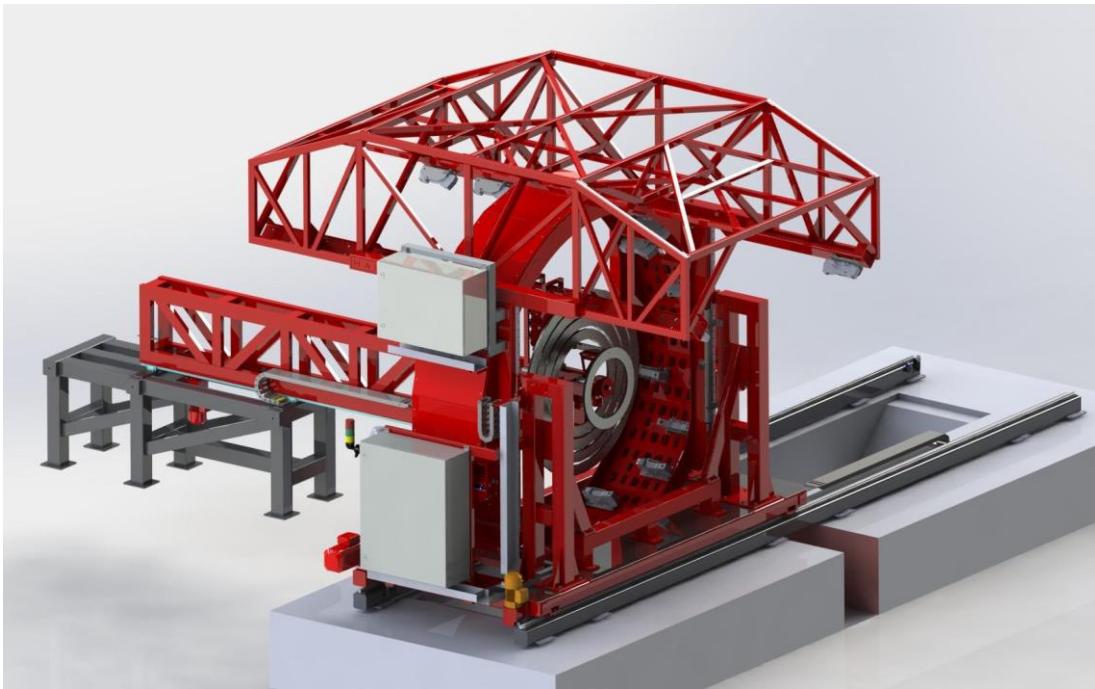


Figure 8.1. Calibration process of the device measuring the diameter, roundness and warping with the help of the automatic calibration machine.

In the Figure 8.2. is shown the device measuring the parameters of the bevel and the cutting edge during the calibration process according to the static SOP. The use of the static SOP fixed in the direct proximity to the devices or delivered to the control zone automatically, significantly simplifies the complex procedure of calibration and adjustment of the equipment and makes it possible to minimize the calibration time.

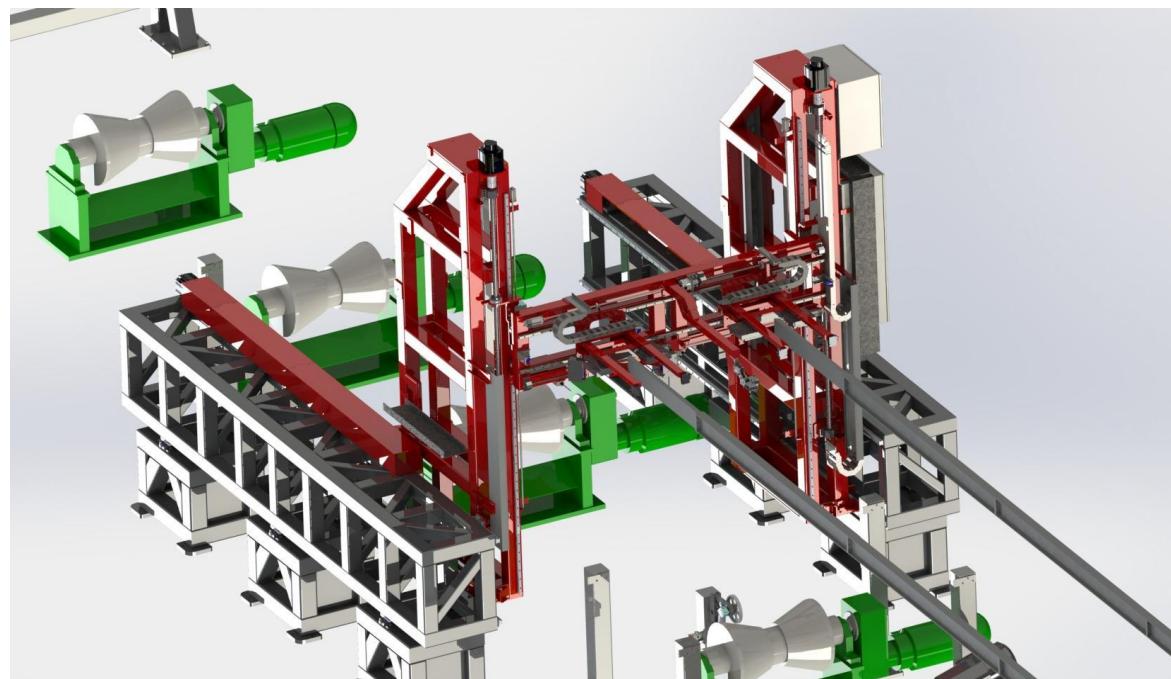


Figure 8.2. External appearance of the device measuring the parameters of the bevel and the cutting edge during the calibration process.

Reconfiguration of the equipment to a different dimension type of the pipe is made automatically according to the data entered by the operator or the ones received from the MES system.

There is no need in reconfiguration of the sensors from one dimension type to another.

## 9. Training

At the stage of acceptance of the equipment at the territory of the manufacturer is organized the training of the Customer's personnel under the approved plan of study. After the training the personnel is tested and only then authorized to work with the device.

The training is organized in agreement with the Customer:

- Machine operators are trained in frequency, service technology, lubrication, performance testing and repair of the machinery.
- Specialists in workshop automation devices are trained in configuration, diagnostics, sensors replacement, if necessary and organization of connection of the device with the workshop network.
- Operators and engineers are trained in operation, configuration, calibration of the device diagnostics and working with data.

## 10. Service maintenance

The delivered equipment is warranted by the manufacturer and, if agreed with the Customer, is provided with the service maintenance.

All the non-standard design elements of the device are designed by the engineers of "Marvie", LLC and manufactured by the Russian companies. "Marvie", LLC has all the necessary resources to provide service maintenance and, if necessary, can

quickly manufacture non-standard structural nodes and elements of the structure, and provide technical assistance for devices.

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Figure 1.10. Production plant for manufacture of non-standard equipment

List of manufacturers of the consumed constituent parts

No	Name of equipment	Manufacturer
1.	<b>Machinery</b>	
	Non-standard parts and assemblies	«Marvie», LLC (Russia)
	Linear and ring bearings, guides	Hiwin (Germany-Taiwan), GUDEI (Switzerland)
	Pneumatic equipment	SMC (Japan)
	Electric motors, gearboxes, linear drivers	SEW Eurodrive (Japan)
	Energy carriers track links	IGUS (Germany)
2.	<b>Computer controlled information complex equipment (CCIC)</b>	

	Cabinet and form factors, connectors	Rittal, Harting (Germany)
	Uninterruptible Power Supplies	APC Corp., PowerCom (USA)
	Industrial computer and its components, computer peripherals	Advantech, Intel, HP, NEC, Seagate, Logitech (USA)
	Network equipment	D-Link (USA)
	Synchronizers	«Marvie», LLC Based on the components of Analog Devices, ALTERA, Texas Instruments, Cristalonics (USA)
<b>3.</b>	<b>Automatic and electricity supply equipment</b>	
	Cabinets, control panels and other form factors	Rittal (Germany)
	Intelligent controllers and sensor terminals of the operator	SIEMENS (Germany)
	Low-voltage switching equipment, terminals, marking	Entrelec, Lovato, (Germany)
	Power switching equipment, frequency converters	SIEMENS (Germany), Omron, Yaskawa (Japan)
	Automation system sensors	Sick, Turk, Balluff, Pepper & Fuchs, Siemens (Germany), Omron (Japan)
<b>4.</b>	<b>2D-triangulation laser scanners, Optical micrometers and point triangulation laser sensors</b>	<b>RIFTEK</b>

## 11. Implementation of equipment delivery

**June 2010**

1. "Automated complex measuring geometrical pipe parameters technological"  
Basic measured parameters:

Diameter, roundness, deviation from the correct cylindrical shape.

Customer: Joint Stock Company "Chelyabinsk Pipe-Rolling Plant" (ChelPipe), OJSC Workshop «Vysota 239».

Quantity: 1 complex.

**October 2010**

1. «Automated complex measuring geometrical pipe parameters deliverable»  
Basic measured parameters:

Diameter, roundness, deviation from the correct cylindrical shape, bowing based on 1 m, Total bowing of the pipe.

Customer: Joint Stock Company "Chelyabinsk Pipe-Rolling Plant" (ChelPipe), OJSC Workshop «Vysota 239»

Quantity: 1 complex.

2. "Software and hardware complex controlling the parameters of the weld and weld-affected zone".

Basic tested parameters:

Height of weld reinforcement, width of weld reinforcement, displacement of the welded edges, deviation from the theoretical girth, undercuts, length of the pipe.

Customer: Joint Stock Company "Chelyabinsk Pipe-Rolling Plant" (ChePipe), OJSC  
Workshop «Vysota 239»  
Quantity: 3 control lines.

### **December 2010**

3. "Automated complex controlling the parameters of the bevel and the cutting edge".  
Basic measured parameters:

Angle of the bevel 1, angle of the bevel 2, dulling size, cutting edge, size of the cleared parts, misalignment of the inner and outer weld.

Customer: Joint Stock Company "Chelyabinsk Pipe-Rolling Plant" (ChePipe), OJSC

Workshop «Vysota 239»

Quantity: 1 complex.

### **August 2012**

4. "Software and hardware complex controlling the parameters of the weld and weld-affected zone, determination of weld center".

Basic tested parameters:

Height of weld reinforcement, width of weld reinforcement, displacement of the welded edges, deviation from the theoretical girth.

Customer: «Ultracraft», LLC

Quantity: 2 control lines.

### **September 2012**

5. "Automated complex measuring geometrical parameters of pipes deliverable "

Basic tested parameters:

Diameter, roundness, deviation from the correct cylindrical shape, bowing on the basis of 1 m, Total bowing of the pipe.

Customer: «VMZ», OJSC

Quantity: 1 complex.

### **February 2013**

6. «Automated complex controlling the bevel and the cutting edge».

Basic measured parameters:

Angle of the bevel 1, angle of the bevel 2, dulling size, cutting edge, wall width, inside diameter, parameters of the weld and the weld-affected zone.

Customer: «VMZ», OJSC

Quantity: 1 complex.

## 12. The set for measuring of pipes geometrical parameters "technological"

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## 13. The set for measuring of pipes geometrical parameters "deliverable"

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Automated complex for measuring of pipes geometrical parameters. Debugging software before shipment to the customer.

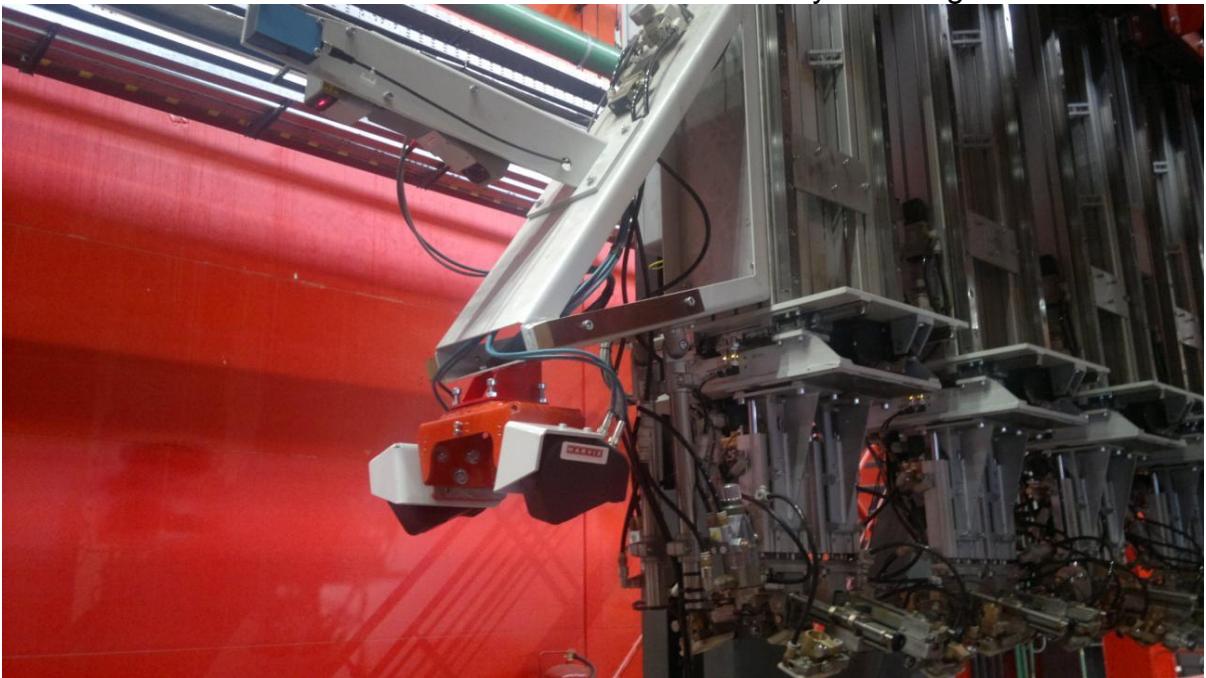
Automated complex controlling the parameters of the bevel and the cutting edge. Option equipment when an object is sequential control. The process of assembling and adjusting the equipment at the site of the manufacturer.

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The process of assembling and adjusting the equipment at the site of the manufacturer.



The software and hardware complex for geometric parameters measuring of the weld and weld-affected zone was mounted at the weld delayed coking unit.

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Equipment options with parallel transfer control object.



The process of qualifying plant and equipment to meet the requirements of the project "South Stream" representatives DNV.

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