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Installation for Calibration of Thin-Walled Precision Pipes

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Abstract: Installation for calibration by the mode "squeezing-expanding" of thin-walled precision pipes from deformable titanium alloys and corrosion-resistant steels with outside diameter from 40-160 mm and wall thickness from 0.5-1.5 mm was designed, made and experimentally tested. The developed installation represents the compact hydraulic machine with working equipment and the necessary quick-detachable tool, namely the multisector punches and matrixes, completed for each specified standard size. Calibration by multisector punches and matrixes allows avoiding the faceing in places of tool connector. At the calibrated tubular details the deflection of outside diameter under the subsequent automatic welding of annular joints doesn't exceed ±0.15 mm from the nominal size. Emergence of objectionable symptoms in the form of ovality and lengthwise loss of stability is excluded and it is provided increase of productivity and noiselessness of research.

Key words: Calibration, pipe shell, precision, thin-walled, expanding, cross squeezing, installation, multisector tool

INTRODUCTION

Now, pipeline mains of a number of mechanical engineering products incorporate thin-walled tubular elements from deformable titanium alloys and corrosion-resistant steels with the outside diameter D from 40-160 mm and thickness of a wall t from 0.5-1.5 mm. At assembly to the route of the pipeline elements with use of automatic welding it is necessary to prepare the joined edges for the purpose of irrelevance reduction of diameters and ovality. Thus, the deviation of outside diameter of the end of precision pipes under automatic welding of annular joints shouldn't exceed ±0.15 mm from the nominal size. Proceeding from it, it is required to apply calibration of the pipe ends of and tubular elements. There is a number of modes of pipe calibration (Chumadin, 2013; Demin, 2010; Kopylov *et al*., 2015; Li-Ming *et al*., 2009; Reshetnikov *et al*., 2015):

- Expanding by the internal pressure of the elastic or powder medium in a rigid matrix
- Heat setting of the thin-walled pipe ends
- Squeezing by pipe pushing in an integral annular matrix
- Squeezing of the pipe ends by the multisector matrix
- Cross squeezing and expanding of the pipe ends by the multisector tool

From the specified modes, the last has a number of advantages namely that in the calibration process there is a synchronous movement of sectors of matrixes to pipe axis or synchronous radial movement of sectors of a punch from a pipe axis. It is provided uniform deformation of metal, increase of stability of walls of a thin-walled pipe with receiving a qualitative external surface (Fig. 1). Besides use of cross squeezing and expanding by the

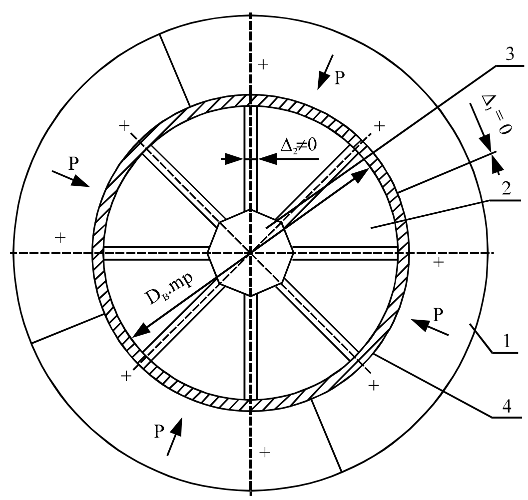

Fig. 1: Scheme of pipe calibration by cross squeezing and expanding of the multisector tool: 1: four-sector matrix; 2: eight-sector punch; 3: the octal mandrel; 4: pipe shell

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multisector tool allows to calibrate the ends of the thin-walled precision pipes having longitudinal welded seams. By means of one tool it is possible to vary the accuracy of the size of the calibrated pipe in the required range with the tolerance both in plus and in minus. However, there are also shortcomings of the mode such as:

- The imprints at big extent of circumferential deformation on an internal and external surface of pipe shell of punch sectors and a matrix caused by small quantity of these sectors
- Pipe contour faceting because of mismatching of tool radiuses and the calibrated surface
- Small productivity (the final size of the calibrated sector is reached for tens the press working strokes)
- Work noisiness of the used compression-type machines and their impressive gabarits

Therefore, calibration process of precision pipes by cross squeezing and expanding of the multisector tool demands creation of the new specialized equipment and improvement of an engineering design of the used tool.

Fig. 2: A thin-walled precision pipe with a diameter D = 80 mm with wall thickness t = 0.8 mm from PT-7M titanium alloy with calibrated end by the squeezing mode

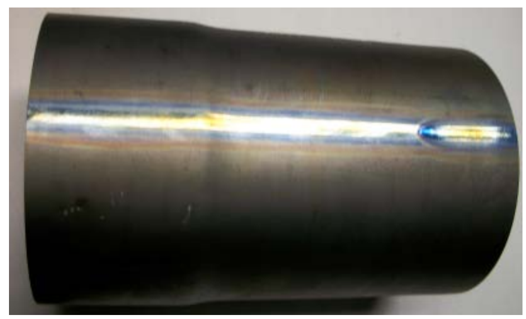

Fig. 3: A thin-walled precision pipe with a diameter D = 100 mm with wall thickness t = 0.8 mm from VT1-0 titanium alloy with calibrated end by the expanding mode

MATERIALS AND METHODS

Object of researches is creation of installation for calibration of the thin-walled precision pipeline from titanium alloys and corrosion-resistant steel.

Installation has to provide preparation of bearing faces of thin-walled precision pipes under automatic welding of annular joints with an outside diameter D from 40-160 mm with wall thickness t from 0.5-1.5 mm with diameter ratio to wall thickness $D/t \geq 100$ and with tolerance on diameter no >0.15 mm (Fig. 2-3). This tolerance is caused by conditions of introduction of automatic welding of annular joints at assembly of pipeline elements to the route. There is obligatory the matching of edges of the welded elements with formation of a step between them from 0.1-0.15 mm.

There must be realized the mode of calibration by cross squeezing and expanding with application of the created installation, consisting in initial squeezing of the end of the thin-walled pipeline element to the size $D_0 = (D-1) \pm 0.3$ mm with the subsequent expanding to the size of 5 mm. Squeezing with the subsequent expanding to the nominal size is made for the purpose of carrying out operation of calibration in the conditions of high stability of a wall of the thin-walled precision pipe end.

Research methods are computer modeling of kinematics of the created equipment, principled hydraulic and electric schemes, projecting of the datum nodes of installation with the hydraulic drive.

The general view of the projecting installation for calibration of thin-walled precision pipes is presented in Fig. 4 and its datum node a hydraulic calibration head is presented in Fig. 5.

Work at the installation is carried out in the following way. The calibrated part of a tubular detail (1) (Fig. 5) is inserted into a cavity between a punch (2) and a matrix (3) of the required calibrated diameters.

In case if it is necessary to make calibration by squeezing there is set up its size by blocker ring (6) with a limb at value of the graduation 0.05 mm (Fig. 5). Pushing of the button (9) “Squeezing forward” (Fig. 4), there is actuated the squeezing faucet (4) (Fig. 5), squeezing a basic matrix (3), making thereby process of squeezing of a thin-walled precision pipe. On reaching the squeezing

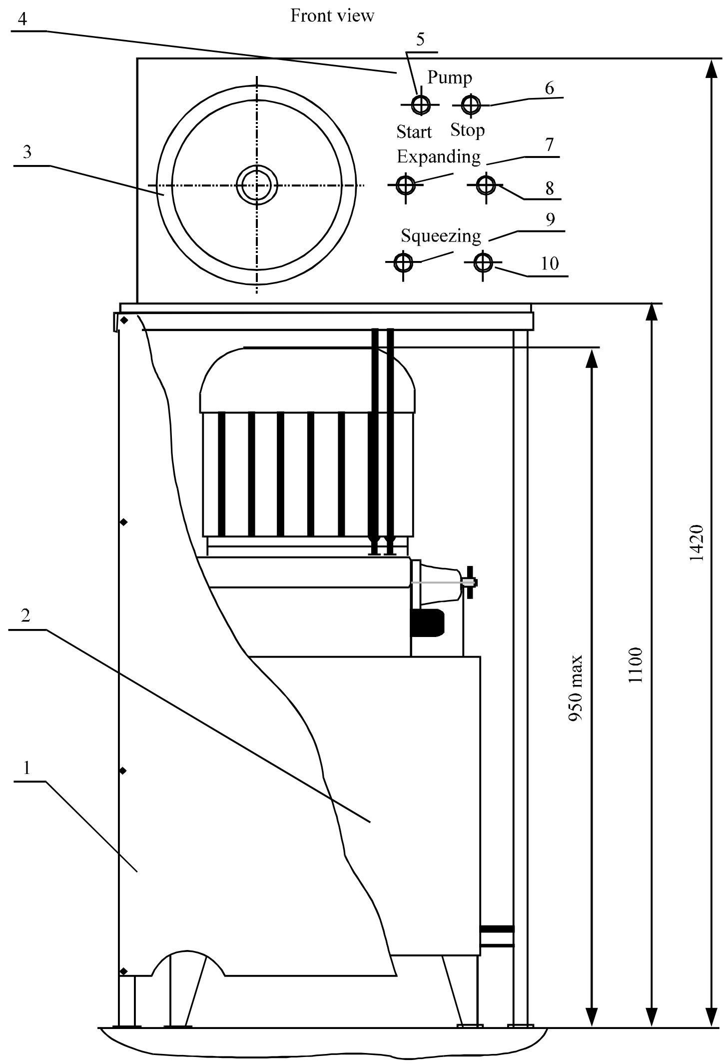

Fig. 4: The scheme of specialized hydraulic installation for calibration of the ends of thin-walled precision pipes: 1: a frame with the overhead fixed workbench; 2: pumping station G48-22N; 3: the hydraulic calibrating head; 4: control panel and hydraulic equipment; 5: "Start" button (it is carried out start of the pump of hydraulic aggregate); 6: "Stop" button (it is carried out stop of the pump of hydraulic aggregate); 7: "Expanding forward" button (it is carried out the operation of expanding); 8: "Expanding back" button (there is finished expanding operation); 9: "Squeezing forward" button (it is carried out the operation of squeezing); 10: "Squeezing back" button (there is finished squeezing operation)

faucet (4) of the position, corresponding to the outside diameter D there is activated the pressure relay, disconnecting supply of oil to the hydraulic system and activating the indication of the end of squeezing process. Operation of calibration is stopped. Pushing of the button(10) "Squeezing back" (Fig. 4) there is made a displacement of basic matrix (3) (Fig. 5) back, releasing thereby a tubular detail (1) from fixing and then taking it from a calibration cavity.

In case if it is necessary to make calibration by expanding there is set up its size by blocker ring (9) with a limb at value of the graduation 0.05 mm (Fig. 5). Pushing of the button (7) "Expanding forward" (Fig. 4), there is actuated the piston of cylinder of the drive of punch (11) (Fig. 5) and a basic punch (2), making thereby process of expanding. Diameter of the calibrated tubular detail is expanded to the outside diameter D then there is activated the pressure relay, disconnecting supply of oil to the hydraulic system and activating the indication of the end of expanding process after that the operation of calibration is stopped. Pushing of the button (8) "Expanding back" (Fig. 4), there is made a displacement

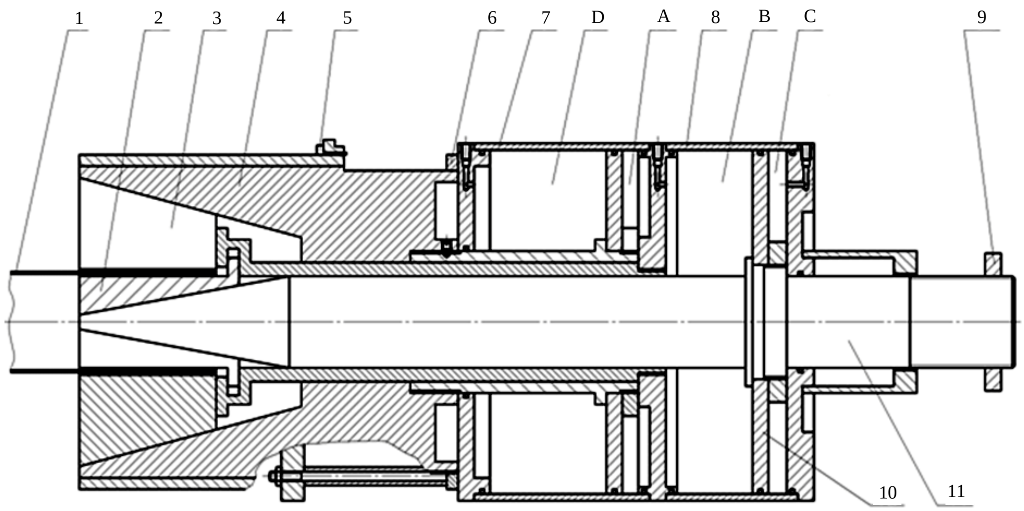

Fig. 5: The hydraulic calibrating head: 1: tubular detail; 2: punch; 3: basic matrix; 4: squeezing faucet; 5: pilot switch; 6: blocker ring; 7, 8: actuating cylinders; 9: blocker ring; 10: punch drive cylinder piston; 11: piston of cylinder of the drive of punch; A: a head end of the drive of matrix; B: a rod end of the drive of punch; C: a head end of the drive of punch; D: a rod end of the drive of matrix

of piston of cylinder of the drive of punch (11) (Fig. 5) back, releasing thereby a tubular detail (1) from fixing and then taking it from a calibration cavity.

RESULTS AND DISCUSSION

The experimental sample of installation was developed and made under the improved known way of pipe calibration by the mode "squeezing-expanding" for increase of sectors of the expanding tool with providing of active brace of a surface of the calibrated pipe that will allow increasing its quality and stability of a wall of pipe shell.

The developed installation for calibration of the ends of thin-walled precision pipes represents the compact hydraulic machine (Fig. 6) with working equipment (Fig. 7) and required quick-detachable tool-multisector punches (Fig. 8) and matrixes (Fig. 9), completed for each certain standard size. Calibration with multisector (20-60 sectors) punches and matrixes (40-60 sectors) allows avoiding the faceting in places of tool connector.

It was carried out an experimental calibration by squeezing and expanding mode of the ends of precision pipes with diameters 50, 63, 80, 90 100, 120, 140, 160 mm, having thickness t = 0.5, 0.8, 1.0, 1.2, 1.5 mm from titanium alloys PT-7M, VT1-0, OT4-0 and corrosion-resistant steels AISI 304 and AISI 321. The ends of pipe shells were squeezed and expanded on 0.8-1.2 mm on diameter at a feed pitch $\lambda = 10$ and $\lambda = 85$ mm. Thus, it was read out a pressure from hydraulic cylinder manometer of the

Fig. 6: Installation for calibration of the ends of thin-walled pipes

installation. There weren't the rejected details in the form of longitudinal corrugations and there wasn't a faceting. Results of experimental approbation of installation are presented in Table 1.

Table 1: Technical characteristics of an experimental sample of installation for squeezing and expanding of a thin-walled precision pipe

Name of parameters	Measurement unit	Values
Working pressure in a hydraulic system	MPa	4.0
The maximum pressure in a hydraulic system	MPa	6.0
Maximum throw of the piston		
At expanding	mm	
At squeezing	-	60
Outside diameter of the calibrated pipes		40
Minimum value	mm	40
Maximum value	-	160
Length of the calibrated pipe section	mm	from 10-85
Thickness of a wall of the calibrated pipe	mm	0.5-1.5
The maximum size of deformation at expanding	% from a pipe diameter	6.25
The maximum size of deformation at squeezing	% from a pipe diameter	5

(a)

(b)

Fig. 7: Working equipment: a) basic punch for pipe expanding and b) basic matrix for pipe squeezing

Fig. 8: Quick-detachable punches

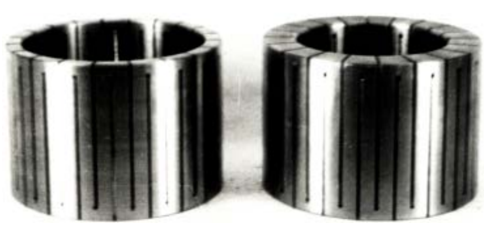

Fig. 9: Quick-detachable matrixes

CONCLUSION

The made experimental sample of installation for calibration by cross squeezing and expanding of the multisector tool of thin-walled precision pipes provides implementation of high requirements on the accuracy of outside diameter of the calibrated end of tubular elements under automatic welding of annular joints.

The created installation meets requirements to noise levels and vibration at workplaces as it has the hydraulic drive of the main executive devices in comparison with the available analogs.

Installation for calibration by cross squeezing and expanding of the thin-walled precision pipes possesses high efficiency due to opportunity to make operation of the technological cycle of calibration for one working stroke of the tool.

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