CALCULATION AND DESIGNING OF UNIVERSAL TRANSDUCERS FOR THE ULTRASONIC CONTROL OF WELDED JOINT CONNECTIONS OF POLYETHYLENE PIPES

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Application of the wide nomenclature of polyethylene pipes according to [1] for replacement old and linings of new pipelines, perfection of technology of welding for the purpose of maintenance of durability and tightness of welded connections of pipelines, and also absence of means of not destroying quality assurance of these connections has demanded working out of piezoelectric transducers (PT), providing the decision of a problem of reliability of pipelines.

The first workings out PT for quality assurance of welded butt joints of pipelines from polyethylene have been executed in VNIINK still in the early nineties last century. A series contact inclined separately-combined PT type "DUET" for one of the enterprises of c. Saratov has been at that time developed and made.

In the late nineties in a problem of quality assurance of welded butt connections of pipes was engaged НИИХИММАШ which has developed a technique of quality assurance of welded connections with use Ultrasonic Flaw Detectors EPOCH IIIB model 2400 firm PANAMETRICS (USA) and contact inclined combined PT on frequency 2,25 MHz type ABWM-4144T-60-NAB and ABWM-4144T-70-NAB, and also ABWM-60-4T and ABWM-70-4T, providing corners of input ultrasonic fluctuations(USF) in a body of a pipe 60 ° and 70 ° [2].

The analysis of work [2] has shown that quality assurance of welded connections with use contact inclined combined PT is possible basically "thin" (less than 10 mm) pipes. The control "thick" (more than 10 mm) is problematic. In this case all thickness of welded connection can be checked only two PT – the top part of seam PT with a corner of input 65 °-70 °, the bottom part of seam PT with a corner of input 50 °-60 °. Hence, technique НИИХИММАШ differs low productivity of the control. Besides, it is obvious that the combined scheme control welded connection does not provide the high value of the relation a signal/noise established [3].

Last years in problems of quality assurance of welded connections of polyethylene pipes a some of firms of Russia, including НПП «ПОЛИТЕСТ», Moscow, which has developed for these purposes ultrasonic equipment and a series «chord» PT [4] and МНТП «АЛТЕС», Joint-Stock Company " КОНСТРУКЦИЯ ", Moscow, which has developed series PT of type "DUET" and "TANDEM" [5].

The analysis of workings out PT of these firms show that the basic advantage «chord» PT is high efficiency of the control at the expense of possibility of the control of welded connection for one turn PT round a pipe without longitudinal, along an axis of a pipe, scanning. However to receive with the help «chord» PT high sensitivity of the control of welded connections of polyethylene pipes, "thick" and the big diameter which has been reached at the control of welded connections of steel pipes, it is impossible for feature of pipes because of the big attenuation ultrasonic fluctuations (USF) in a material of pipes – polyethylene. Even on frequency 1,25 MHz it is equal on the average for various marks of polyethylene 3 dB/cm [6]. Low sensitivity «chord» PT leads to low value of the relation a signal/noise that in some cases does not allow to reveal in welded connection defects in the size less than 2 mm.

Converters of type "DUET" and "TANDEM" differ from «хордовых» PT high sensitivity and high value of the relation a signal/noise – more than 16 dB. It is reached at the expense of smaller "run" USF from a radiating piezoelement to a seam and from a seam to accepting piezoelement PT.

On the basis of spent above the short review and the analysis of works on converters for quality assurance of welded connections of polyethylene pipes it is possible to draw a conclusion that the most suitable to these purposes are PT type "DUET" and "TANDEM".

For calculation of parametres contact inclined separately-combined PT type "DUET" scheme resulted in fig.1 has been used. It is easy to show that the corner of a turn of a “radiator” and “receiver” PT in the vertical plane, being in the defining parametre providing quality of the control of welded connection, is equal

$$\delta_1 = 2arcSin\frac{a+\frac{b}{2}Cos\frac{\delta}{2}+cSin\frac{\delta}{2}}{R} \qquad (1),$$

where

a – distance between the nearest tops of dihedral corners of prisms of a radiator and the receiver;

b – width of a prism of radiator and the receiver;

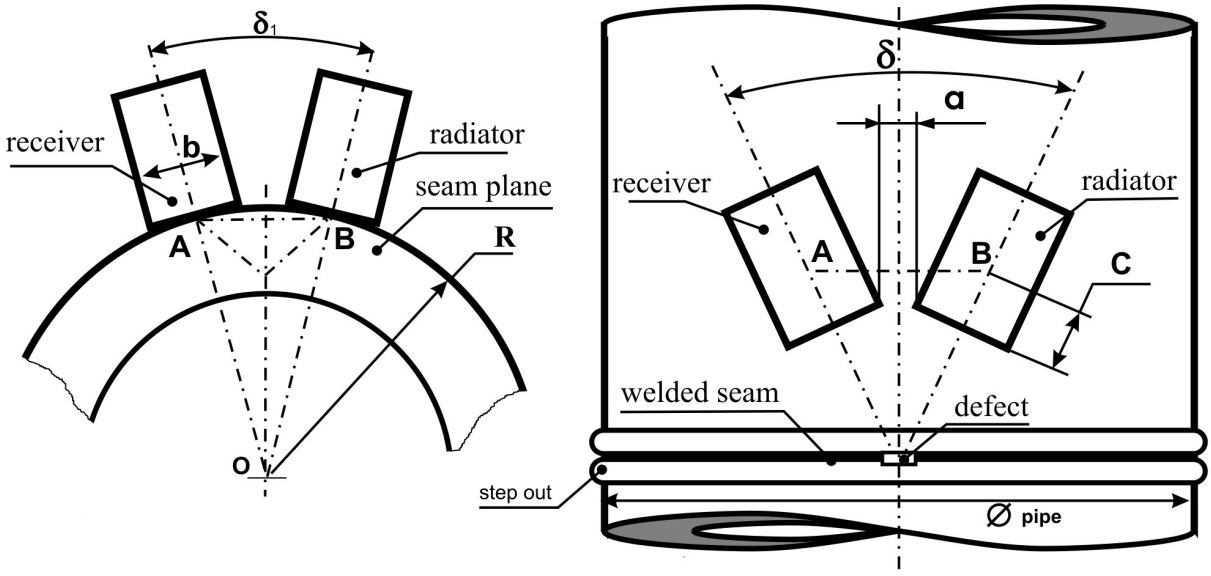
c – radiator and receiver arrow;

δ – corner of a turn of a radiator and the receiver in a horizontal plane;

R – pipe radius.

Following reasons have been put in a basis of a choice and calculation of other parametres PT:

- The material of prisms should provide input and receive USF in polyethylene speed of distribution longitudinal USF in which is equal 2300 m/c;
- The material of prisms should differ low value of factor of attenuation USF;
- Frequency of piezoelements should provide revealing in welded connection of defects in the size 0,8 mm and more;
- The radiator and receiver arrow should provide possibility of maximum approach PT to the platen of strengthening of a seam (step out) at the control.



Arrangement of a radiator and receiver PT in a horizontal plane.

Arrangement of a radiator and receiver PT in a vertical plane.

Fig. 1 Scheme of arrangement PT on a pipe.

The formula (1) and other reasons resulted above have laid down in a basis of calculation and design working out 19 types PT "DUET" "PRIZ-D8", welded butt connections of polyethylene pipes providing quality assurance in diameter from 50 mm to 325 mm and толщиною from 2,9 mm to 25,4 mm according to [1]. Key parametres and characteristics PT « PRIZ-D8 » are resulted in table 1 [7].

Table 1.

Symbol transducer	Pulse factor of transformation K_{uu}^{II}, not less, dB	Focal length, F, mm	Effective frequency of an echo-impulse, $f_Э$, MHz	Diameter of revealed defects, Ø, mm
1	2	3	4	5
Ï122-1,8-∅50× (2,9÷5,6)-D-001	-39	107	1,8	0,8
П122-1,8-∅63× (3,6÷7,1)-D-001	-38	119	1,8	1,0
П122-1,8-∅75× (4,3÷8,4)-D-001	-38	123	1,8	1,2
П122-1,8-∅90× (5,2÷10,1)-D-001	-38	130	1,8	1,5
П122-1,8-∅110× (6,3÷12,3)-D-001	-37	135	1,8	1,8
П122-1,8-∅125× (7,1÷14,0)-D-001	-37	142	1,8	2,1
П122-1,8-∅140× (8,0÷12,7)-D-001	-37	144	1,8	2,1
П122-1,8-∅160× (9,1÷11,8)-D-001	-37	148	1,8	2,1
П122-1,8-∅180× (10,3÷13,3)-D-001	-37	154	1,8	2,4
П122-1,8-∅200× (11,4÷11,9)-D-001	-37	155	1,8	2,6
П122-1,8-∅225× (12,8÷13,4)-D-001	-36	162	1,8	2,9
П122-1,25-∅140×15,7-D-001	-40	144	1,25	2,1
Ï122-1,25-∅160× (14,6÷17,9)-D-001	-40	148	1,25	2,6
П122-1,25-∅180× (16,4÷20,1)-D-001	-40	154	1,25	3,0
П122-1,25-∅200× (14,7÷22,4)-D-001	-40	155	1,25	3,3
П122-1,25-∅225× (16,6÷25,2)-D-001	-40	162	1,25	2,9
П122-1,25-∅250× (14,2÷22,7)-D-001	-40	163	1,25	3,7
П122-1,25-∅280× (15,9÷25,4)-D-001	-38	168	1,25	4,6
П122-1,25-∅315× (17,9÷23,2)-D-001	-38	170	1,25	4,1

Decoding of symbol PT:
П - ultrasonic transducer;
122 - contact inclined separately-combined;
1,8 - effective frequency;
∅50× (2,9÷5,6) - diameter and a range of thickness of a wall of a controllable pipe;
D - "DUET";
001 - updating PT.

Distinctive feature PT «PRIZ-D8» in comparison with PT other firms is that they have not a cylindrical working surface of a pipe, and flat surfaces of a radiator and the receiver in the form of a dihedral corner. It has allowed to exclude influence on quality of the control of non-uniform curvature of a cylindrical surface of polyethylene pipes as with a pipe surface flat working surfaces контачат on the lines parallel forming pipe, and USF are entered into a pipe body under a necessary corner and are accepted from a pipe only on a narrow strip along these lines, thanks to presence of contact greasing. Same most occurs and in case of cylindrical working surface PT as any others USF, radiated by transferring piezoelement PT and pipes falling on a cylindrical surface, refract in a pipe body under corners distinct from defects necessary for revealing in welded connection and, hence, are not informative.

The state metrological tests PT «PRIZ-D8» for the statement of type of measuring apparatuses, certification PT and their entering into the State registry have confirmed a correctness of the formula (1) and other reasons stated above, at work such PT and have shown that PT «PRIZ-D8» provide revealing of defects in welded connections of the polyethylene pipes equivalent to the area

of a flat-bottomed aperture in diameter 0,8 mm and more depending on thickness and diameter of pipes. Now PT “PRIZ-D8” are produced in lots at JSC "INTROSCOP” factory.

For the decision of some methodical questions of quality assurance of welded connections of polyethylene pipes, diameters and which thickness are specified in table 1, have been removed dependences of amplitude of the echo-impulse reflected from a flat-bottomed aperture (defect) in СОП of working out МНТП «АЛТЕС», Joint-Stock Company " КОНСТРУКЦИЯ ", on moving PT along a forming pipe concerning near A = f (L near) and distant A = f (L distant) defect. For diameter and a thickness of a pipe ∅200x22,4 mm these dependences are resulted in drawing 2. The amplitude of an echo-impulse was thus measured with use дефектоскопа УД2-12 at a strengthening reserve equal 10 dB.

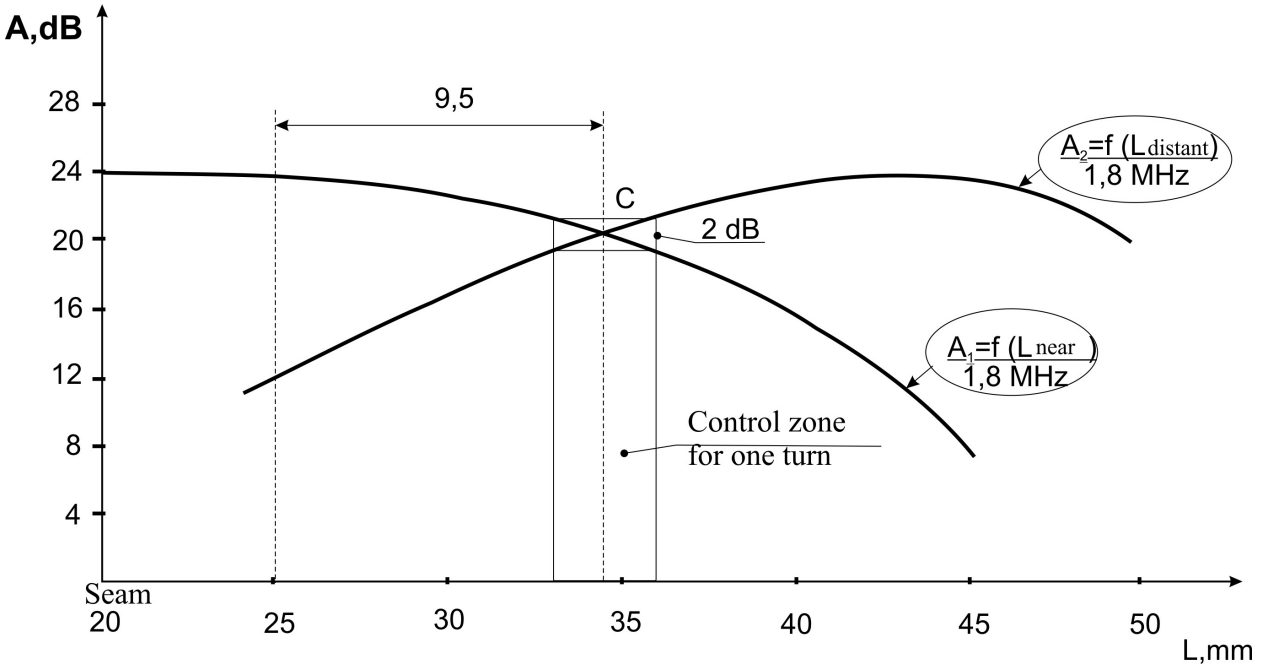


Fig. 2. Dependence of amplitude of an echo-impulse on moving ПЭП along a forming pipe ∅200× 22,4 mm

Apparently from fig. 2 dependences A=f (L near) and A=f (L distant) are crossed on distance 9,5 mm from step out in the general point With and have identical amplitude of the echo-impulse reflected from defect. It allows to draw a conclusion that PT type "DUET" also. As well as «хордовые» PT, provide quality assurance of welded connections of polyethylene pipes over one turn PT round a pipe. On a pipe in diameter ∅200x22,4 mm PT are recommended to establish for this purpose from грата on distance 9,5 ± 3 mm, thus the amplitude of an echo-impulse in a range ± 3 mm changes all on 2 dB that at the control at level of the reflected echo-impulses equal 24 dB is insignificant. Similar conclusions and recommendations are received for all other standard sizes of the pipes specified in table 1.

Operating experience of a considerable quantity of standard sizes PT «PRIZ-D8» has led to necessity of working out universal PT one - two types solving all problems under the control of polyethylene pipes serial PT «PRIZ-D8». By working out such PT all positions resulted in the present work have been considered, the formula (1) has been used, and also that for revealing of defects in welded connection those are used only USF which are entered into a pipe body under a necessary corner and are accepted from a pipe only on narrow strips along contact lines.

Schematically universal PT it is shown in fig. 3. The modified prisms of the receiver and the generator are executed essentially smaller thickness in comparison with prisms PT «PRIZ-D8» and connected structurally between itself the hinge. It has allowed to provide reliable contact of surfaces of prisms to a surface of pipes of all range of diameters and, hence, to provide quality of the control of welded connections of pipes one (two) universal PT.

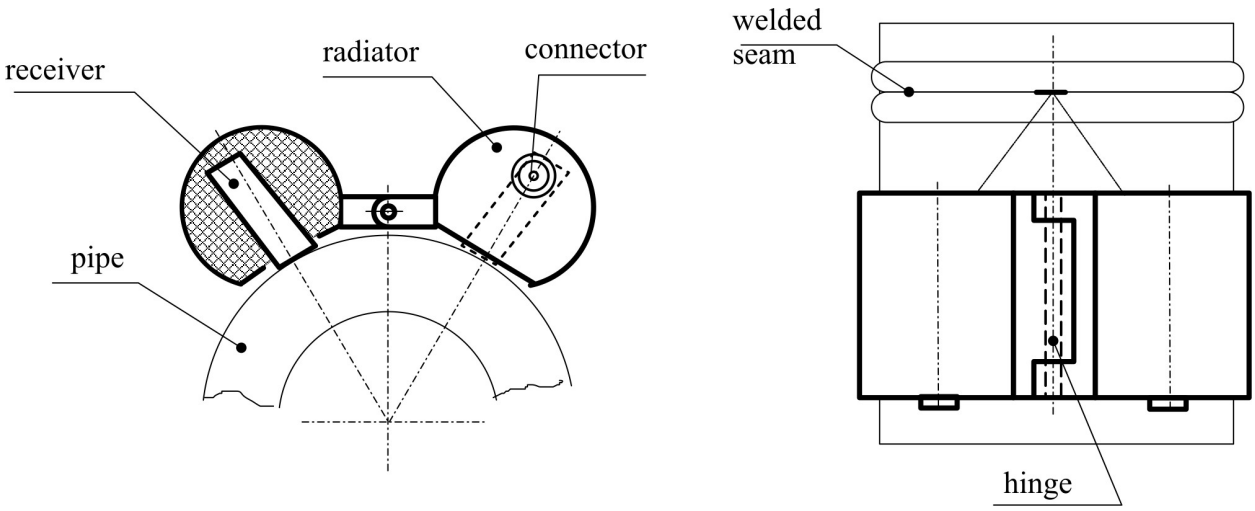


Fig.3. The scheme universal PT.

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