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COMPUTERIZED ULTRASONIC QUALITY CONTROL SYSTEM IN THE PRODUCTION OF HELICAL WELDED TUBES

SYSTÈME DU CONTRÔLE DE QUALITÉ PAR ORDINATEUR ET PAR ULTRA SONS DANS LA PRODUCTION DE TUBES SOUDÉS HÉLICOIDAUX

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SUMMARY: Inspection of helical welded steel tubes by means of an ultrasonic automate, which interfaced with a computer is capable to recognize the defects of the weld, to identify them and to continuously report back the informations necessary for their elimination.

RESUME : Examination de tubes en acier soudés hélicoidaux par moyen d'un équipment automatique ultrasonique capable d'indiquer et d'identifier les défauts de soudure et de signaliser continuellement les informations nécessaires a leur élimination.

I. INTRODUCTION

A satisfactorily functioning three-step inspection system has been developed in the last decade for the quality control of the helical welded steel tubes produced in the Dunai Vasmü. The ultrasonic and X-ray image intensifier weld inspection equipments are organic parts of the production process. Weld inspection is completed by ultrasonic defect control of the tube material. The automatic weld inspection equipment of the fist step guarantees a 100 % weld control. Types and size of the weld defects demonstrated by the ultrasonic method are determined by an X-ray image intensifier equipment in the second step. In case of the presence of flat defects /e.g. hot cracks/ also the third step of the inspection system is to be put into functioning, as it often happens in this case that the defect signal of the first step is not corroborated in the second. X-ray image intensifier inspection cannot demonstrate equivocally the crack-type defects and thus it is undecided whether the sector of the weld found defectuous by the automatic weld inspection equipment does contain such a defect or was the indication the consequence of disturbing factors. In the third step of the inspection system we preferably use manual ultrasonic testing but also fracture tests are carried out if necessary for the precise identification of the defect.

By means of our complex inspection system we can verify reliably those qualities of the tubes produced in Dunai Vasmü which are claimed by our customers. E.g. very high quality conditions have been fulfilled in the tubes of the oil-pipe-line "Friendship II", or in the tubes of the recently inaugurated Soviet-Hungarian gas-line "Brotherhood".

Another important aim of the development of a production process with intensified inspection is the quality control. The equipments for testing during the production are furnishing those quality data which serve as a basis for the quality control. The knowledge about type and size of the defect is indispensable for eliminating the defects in welding. The disadvantage of the otherwise very reliable three-step inspection system is that this data is obtained generally more than 60 minutes after the occurence of the defect. This long period influences the effectivity of quality control rather more disadvantageously if the production is shifted towards the larger tube diamaters.

II. CONCEPT OF A QUALITY CONTROL SYSTEM WITH INCREASED EFFICIENCY

The demand for eliminating the disadvantages of the three step testing system originates largely in the increased economy of the pipe line tubes. In the concept for a more efficient quality control system the most probable notion will be the further development of the first step to a level where the second and third steps of the system are no more needed for the determination of the defect type and size. Thus the basic control information will be obtained ten times quicker, i.e. within about 6 minutes.

Informations obtained by the probe movements usual in manual ultrasonic testing and the welding technology data are principally sufficient for identifying the type of the welding defect. The solution proposed by de Sterke [1] being the basis of the automatic systems [2-6] for the inspection of the welds on thin-wall tubes /5-25 mm/, simplifies considerably the displacement of the probe. It is characterized by two probes being conducted on both sides of the weld at a constant distance from same. The distance of the weld probe will be selected adequately so that the sound beam progressing along the zig-zag line and getting continuously larger will comprise the entire weld volumen. This technically justified simplification however leads to the loss of several informations which are indispensable for the identification of the defect type. Its further disadvantage consists in the fact that by enlarging the wall thickness greater and greater sound pressure differences can be measured between the different parts of the weld thus the homogeneous flaw detection sensitivity can be guaranteed in a decreasing degree.

A further development of the de Sterke solution is technically feasible by employing 3 x 2 probes. Fig. 1. shows the disposition of the probe pairs. The first probe pair /A1, B1/ has a radiation degree of 45° and is disposed on both sides of the weld in a way that the sound beam radiates the <u>upper</u> part of the weld. The second probe pair /A2, B2/ of 70° comprises the <u>middle</u> part of the weld. The third probe pair /A3, B3/ is again of 45° and tests the <u>lower</u> part of the weld. The 45° probes are employed also because of the favourable geometry of the sound field, but we prefer them mostly because they are much more apt to detect the weld defects being near to the surface, mainly the cracks, as those of 70° [7].

By the disposition of 3 x 2 probes we can obtain sufficient information for identification of the defect type.

a/ Information on the situation of the defect permits to discern threecharacteristical defects /Fig.2./ of the double-sided powder-shielded arc weldings, because

- the longitudinal external crack is situated in the upper part of the weld /Fig. 2/a/
- the lack of penetration is situated in the middle part of the weld /Fig. 2/b/
- and the longitudinal internal crack is situated in the lower part of the weld /Fig. 2/c/.

b/ The analysis of the echo amplitude enables to differentiate the defects of different types situated however in the same part of the weld. E.g. a spheroidal slag inclusion situated in the middle part of the weld provokes generally an echo of considerably smaller amplitude as the lack of penetration.

c/ The employing of the transmission technique enables a further differentiation if the defects of different type are situated in the same weld volumen. E.g. in case of a longitudinal crack in the upper part of the weld, a considerable acoustical shadow appears, whilst in the case of gas pore or tubular porosity the acoustical shadow is of immaterial degree.

d/ Measuring the longitudinal extension of the weld defect does not only help in recognizing the type of the defects but it also supplies important data for the assessment of the repairability of the defect.

III. COMPUTERIZED ULTRASONIC QUALITY CONTROL SYSTEM

The main technical conditions of realizing a quality control system of increased efficiency are the following:

a/ In the disposition of 3 x 2 probes the test cycle consisting of 9 operations according to the echo and transmission techniques has to be repeated with such a frequency, that a continuous scanning can be practically saveguarded even at a maximum testing velocity. The equipment system KS 3000 consisting of several dozens of building elements corresponds to these requirements in the highest degree, it even performs the evaluation of the signals presented by the probes. The YES - NO informations appear at the output of the equipment in a shape apt for processing in a computer.

b/ Considering that the weld - and with it its defectuous section - are moving at different times along the line of the probe pairs, the informations supplied by the three pairs of probes have to be stored for a certain period. The weld to be tested must be divided into conveniently short testing sections /of 1 cm/ and the stored informations for the appropriate sections have to be ordinated. This task is performed by an interface of special design.

c/ A computer performs, on the basis of the data supplied by the interface, the identification of the weld defects, the reporting to the chief welder by means of an alpha-numerical display, and the printing-out of the weld defect protocole for the further assessments.

The defect identification principle of the computerized quality control system can be followed on the 3rd Fig. In case of a longitudinal internal crack, we obtain on the outputs 1. - 10. of the equipment KS 3000 during the first six operations exclusively NO informations, because the sound beams of the 1st and 2nd probe pairs avoid the defect in the lower part of the weld. In the 7th, 8th and 9th operation YES informations appear as a rule, because the 3rd pair of probes supplies in the echo functioning mode echos of a amplitude higher than the response levels "a" and "b". In transmission mode an acoustical shadow of such degree will appear, that the amplitude of the transmission signal drops below the anti-coincidence level "c". The summarizing table presents the identification signal combinations of three characteristic defects. The number of practically found signal combinations is of course considerably higher.

Fig.4. presents the scheme of a weld defect protocole printed by the computer. Each line of the protocole represents a 0,5 m long weld section. Each character corresponds to a 1 cm long weld section. The weld co-ordinates can be read out in meters on the left side of the protocole. Dashes represent defectless weld sections, and the ciphers those of defectuous sections. On this sample of a protocole we can read out, that the tested tube has shown an external crack of 5 cm in the 2nd meter, a lack of penetration of 11 cm in the 5 th meter and an internal crack of 3 cm in the 11th meter.

IV. REFERENCES

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[7] WÜSTENBERG H., MUNDRY E., Nuten und Kanten als Bezugsreflektoren in der Materialprüfung mit Ultraschall, Materialprüfung 14 /1972/ 2, 58-61.

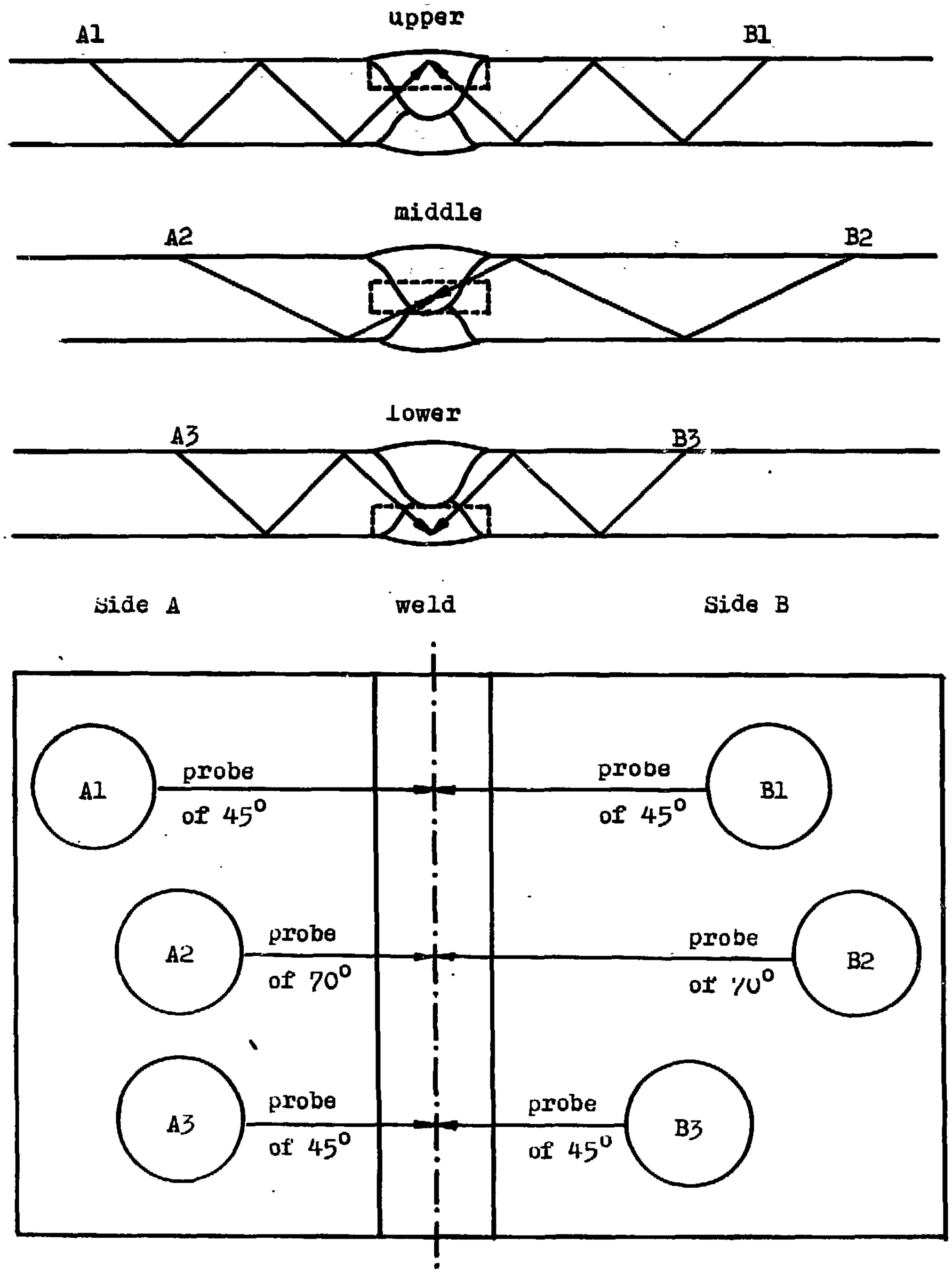

upper
A1
B1
middle
A2
B2
lower
A3
B3
Side A
weld
Side B
A1
probe
of 45°
probe
of 45°
B1
A2
probe
of 70°
probe
of 70°
B2
A3
probe
of 45°
probe
of 45°
B3

Fig.1.

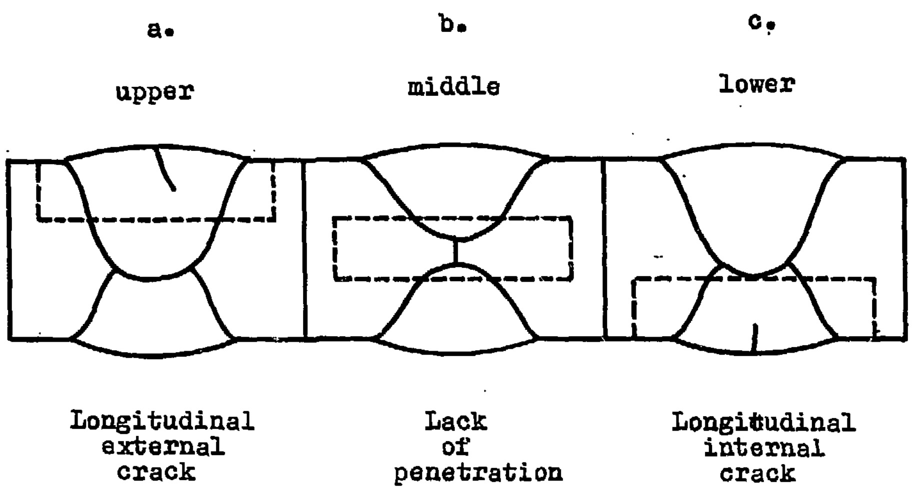

a.
upper
b.
middle
c.
lower
Longitudinal external crack
Lack of penetration
Longitudinal internal crack

Fig.2.

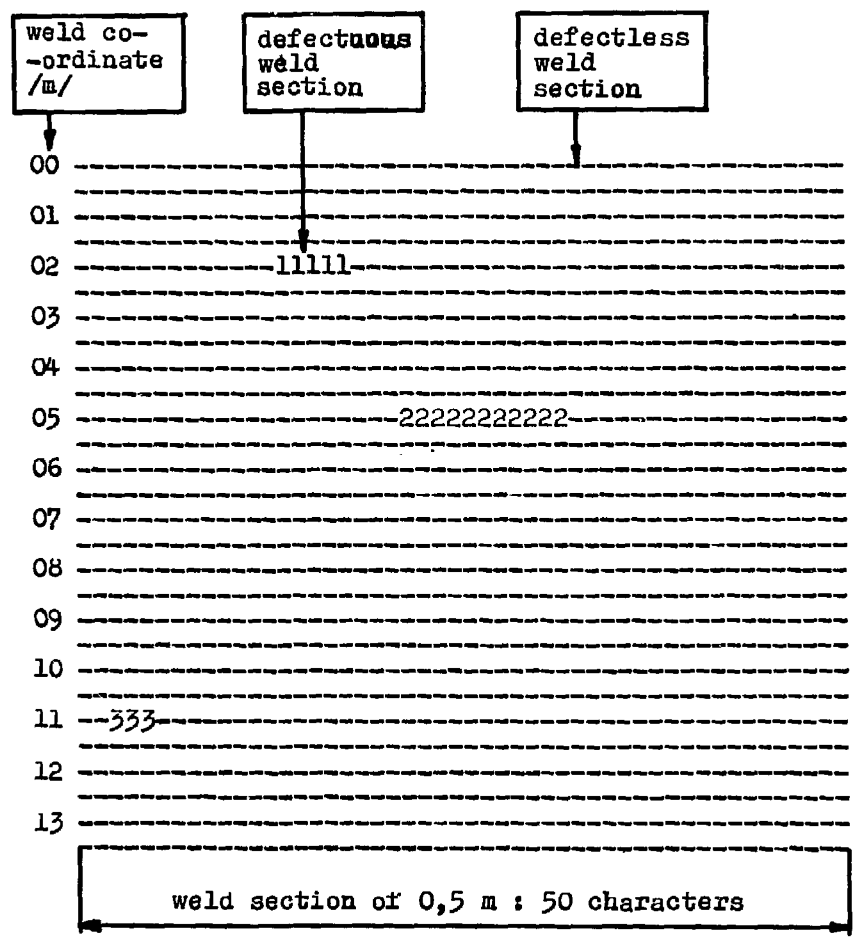

weld co--ordinate /m/
defectuous weld section
defectless weld section
00
01
02
11111
03
04
05
22222222222
06
07
08
09
10
11
333
12
13
weld section of 0,5 m : 50 characters

Fig.4.

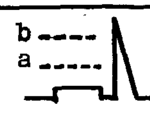
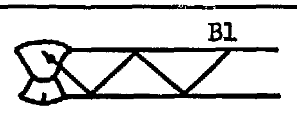
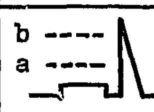
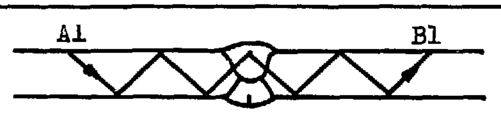
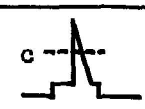
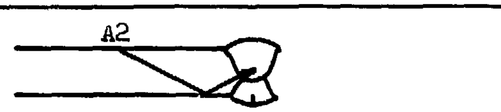
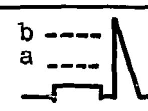
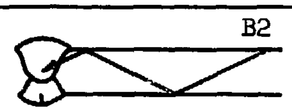
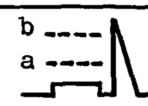
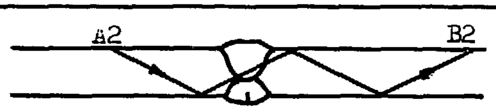
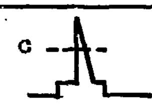
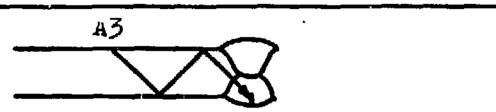
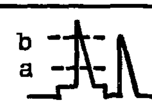
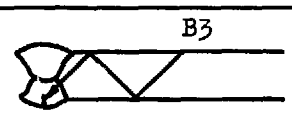
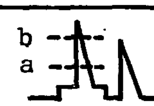
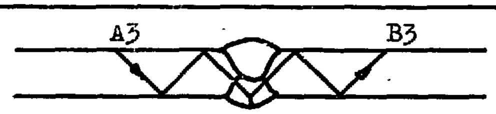
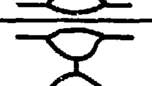
Operat-ions	Sound paths in the welded joint	Reflect-ograms	KS 3000 outputs	YES-NO inform-ations
1.			1. a 2. b	0 0
2.			3. a 4. b	0 0
3.			5. c	0
4.			6. a 7. b	0 0
5.			8. a 9. b	0 0
6.			10. c	0
7.			11. a 12. b	1 1
8.			13. a 14. b	1 1
9.			15. c	1

Fig.3.

Type of defect	Identif-ication signal	Signal combinations for defect identification														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1