METHOD OF TESTING THIN-WALLED PIPES IN COMPLEX STRESSED STATE

V.A. GLOUSCHENKOV and S.G. SIMAGINA
Samara Aviation Institute,
443086 Samara, Moskovskoye Shosse 34

ABSTRACT

A method to determine maximum plasticity of thin-walled pipe billets in complex stressed state has been developed. The method makes it possible to change the scheme of the stressed state within a wide range by changing stress parameters of the process or by changing design factors and technological factors.

KEYWORDS

Thin-walled pipe, complex stressed state, plasticity, plasticity diagram, test equipment.

Quite a few technological operations are used in the production of the parts made of the empty tubular billets. The billets are in complex stressed state during these operations and the degree of deformation is maximum. The examples of such operations are pipe cutting by twist with active back-pressure (Simagina et al., I99Ia), pulsed magnetic forming (Bely et al., I977), pipe forming with the help of elastic medium (Isachenkov, I967) and others.

These technological processes require the knowledge of destruction criteria. Theoretical and experimental methods to study destruction mechanics, based on phenomenological approach described in a number of works published earlier (Smirnov-Alayev, I968; Kolmogorov, I970; Bogatov et al., I984) is widely used today. The authors propose to use the destruction criterion, related to the metal maximum plasticity Λ, which depends on the characteristics of the stressed state K . The function $\Lambda = \Lambda(K)$ is referred to as plasticity diagram and is plotted in accordance with the results of special tests. There are various ways of plotting plasticity diagram, but they don't involve thin-walled pipes testing. Since tubular billets to be cut or formed have already lost part of their plasticity, further tests of the billets are required. Cylinder samples test results can't be relied on, as they may lead to spoilage. Neither have the authors of this paper found any method to test thin-walled pipes in complex stressed state.

This paper is about the method of thin-walled pipes testing developed by the authors (Aryshenski et al., 199I). The principle of this method consists in applying radial inside and outside pressures to the surfaces of the sample tested with the future addition of torque.

Test Procedure. Three longitudinal marks are made on the outer surface of the tubular billet every I20° (Fig.I).

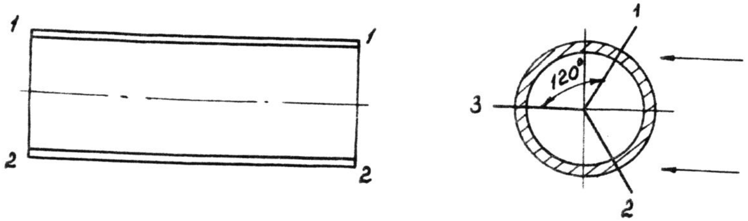


Fig.I. Longitudinal marks made on the sample tested.

Sample I with marks is fixed in two semimatrixes (2 and 3) featuring vertical parting line. Semimatrix (2) is immovable and semimatrix (3) can revolve. Elastic medium (4) (e.g., polyurethane) is introduced into the sample and compressed by axial force. The sample is thus pressed against the semimatrixes. With the sample still pressed against it, semimatrix (3) begins to revolve. The torque which results from it causes the pipe deformation and cutting along the parting line of the semimatrix.

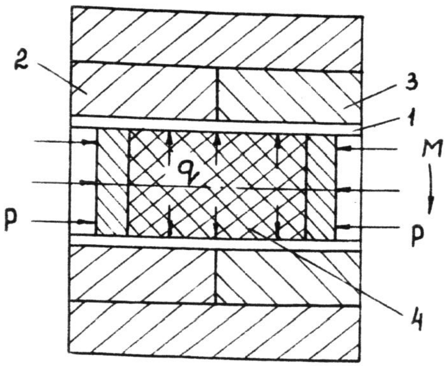


Fig.2. Scheme of pipe testing.

The test is performed on the multipurpose test machine (e.g. ЦШМУ-30) which can produce axial force and torque at a time. During the test torqual (M) and semimatrix turning angle (α) are plotted on diagram of torque (Fig.3), diagram of axial force (Fig.4) is made simultaneously.

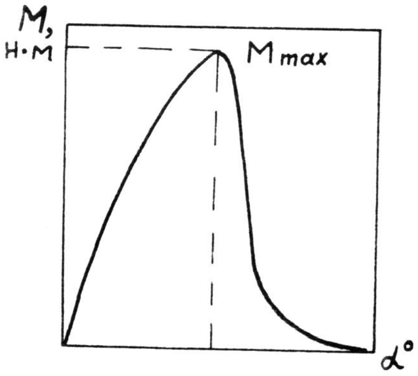


Fig.3. Torque diagram.

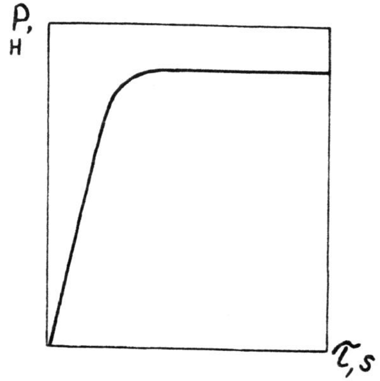


Fig.4. Axial force diagram.

As soon as a crack appears on the surface of the sample.the test is stopped. The appearance of the crack is followed by a sharp decrease of the torque, which is shown in the diagram (Simagina, 199Ib). On finishing the test, the sample is taken out of semimatrixes.

Analysis of Test Results. Longitudinal marks twist angle measurement precise to I second was taken with the help of measuring microscope (Fig.5). The sample was fixed on the measuring prism (Ц-I48 ГОСТ 564I-66), which was put on the stage of the measuring microscope. The cross-hairs horizontal line of the microscope was set against the ultimate mark (its non-deformed part), the angular scale of the microscope showing "0". After that the cross-hairs horizontal line moved parallel towards the point of the longitudinal mark, featuring the maximum deformation of the sample (billet butt-end) and matched the tangent and longitudinal mark in this point (Fig.5). At that moment the angular scale of the microscope pointed the value, corresponding to the longitudinal mark twist angle with respect to its initial position. The maximum shear deformation (plasticity) is in this case $\Lambda = tg\,\varphi$. Stressed state characteristics are calculated on the basis of the values of the q and tangent stresses τ, which are formed in the billet. Experiments with the use of foil detector show that may be taken as equal to axial pressure and may be thought equally spread along the generating line. The maximum error in this case would not exceed I0 per cent.

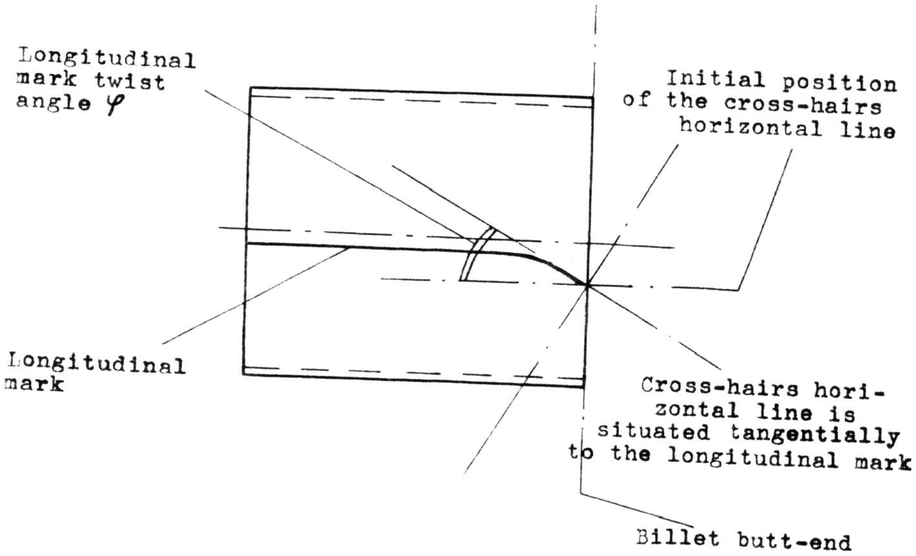


Fig.5. Twist angle measuring scheme.

Example of Testing. Tubular samples ø 55xI made of the alloy AMr3M were tested according to the method developed. Shore hardness number 87 polyurethane was used as elastic medium. During the test the inner surface of the sample was oiled. Test results with different values of q are listed in table I.

Table I. Test results.

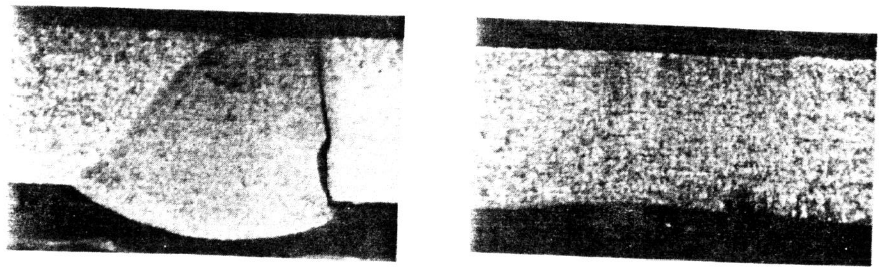
q, MPa	$\Lambda_{exp} = tg\varphi$	$K_{exp} = \frac{\sigma}{\tau}$	Stressed state scheme
73.9	2.3I	+0.99	Close to uniaxial tension
22I.9	0.55	+0.30	Close to simple shear

Thus changing the value of pressure q one can generate different schemes of stresssed state in a tubular billet. Friction between the elastic medium and the sample can also be used for the purpose of changing the scheme (Fig.2). Friction causes more compressing stresses in the focal point of deformation. These stresses are oriented along its axis. The stresses may be so great that they cause a certain increase of

thickness in the focal point of deformation (Fig.6a). Lubrication of the inner surface of the sample helps to avoid the above mentioned friction and changes the stressed state scheme as well as the deformation focal point configuration (Fig.6b). The destruction zone features insignificant (up to I3 per cent) decrease of thickness.

Stressed state scheme changes can also be attained with the help of clearance between the semimatrixes (Glouschenkov et al., 199I).

Conclusions. A method to determine maximum plasticity of thin-walled tubular billets in complex-stressed state has been developed. The method makes it possible to change the scheme of the stressed state within a wide range by changing stress parametres of the process or by changing design factors and technological factors (friction, clearance ...). The method is tested on thin-walled tubular samples made of aluminium alloys



a) б)

Fig.6. Deformation focal point configuration.

and steels. Test results are used in calculating main parametres of the processes of cutting pipes by twist.

REFERENCE

I. Aryshenski U.M., Glouschenkov V.A., Simagina S.G., Polushin A.G. (199I) Method of testing tubular samples, a.s. N I645880.
2. Bely I.V., Fertic S.M., Khimenko L.G. (1977) Reference book on pulsed-magnetic treatment of metals. Vyschaya shkola. Kharkov.
3. Bogatov A.A., Mizhiritsky O.I., Smirnov S.V. (1984) Limit of plasticity under metal forming. Metallurgia. Moscow.

4. Glouschenkov V.A., Isarovich G.Z., Burmistrov A.E., Simagina S.G. (I99I) Analysis of methods of thin-walled pipe cutting in specified length. Metal forming ( ), 2I8-224, Győr, Miskolg.
5. Isachenkov E.I. (I967) Stamping by rubber and liquid. Mashinostroenie. Moscow.
6. Simagina,S.G., Glouschenkov V.A. (I99Ia) Thin-walled pipes wasteless cutting and calibration into billets of specified length. Sheet Forging and Hot Forging (Isachenkov E.I.), 34-37. MDNTP, Moscow.
7. Simagina S.G. (I99Ib) Method to determine the maximum shear deformation, a.s. N I64925I.