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Testing of resistance welded small parts in electrical and precision engineering – Destructive and non-destructive testing

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Contents:

1 Scope

This technical bulletin is valid for destructive and non-destructive testing of resistance welded small parts in electro-technique and precision mechanics.

2 Introduction

Resistance-welding in the production of small parts where different materials and surfaces are generally welded together is usually carried out in the solid state without forming a molten nugget. In the production of large parts, for example, in the sheet metal work for vehicle production in which welding machine settings are set according to tables of standardized values and quality assurance, testing is carried out by adherence to prescribed diameters of the nugget or weld spot. In the production of small parts however, drawing inferences on the load-bearing behavior of a weld from a measurable weld spot diameter is seldom possible. Instead, they are usually tested for their breaking strength.

Goal of this bulletin is a collection of empirical data from destructive and non-destructive testing of welds in resistance-welded small parts with a description of the test procedures which are generally used. This is intended to serve as a basis for further investigations and may also be used to establish a quality assurance system with reference to the relevant quality assurance norms.

Welders and welding supervisors get hints for the evaluation of test results on test pieces. This can ensure that the quality is a consistent as possible before and during the production.

It is not goal of the bulletin to prescribe standardized types of test pieces for destructive tests. Because of the large variety of pieces such tests are usually tests of components.

No specifications are given concerning the behavior of welded constructions and the forces which arise in them under normal operating conditions. Material properties are specified insofar as they are relevant to evaluating the results of destructive testing.

Extensive information concerning quality assurance in resistance-welding can be found in the DVS Book No. 393: Schweißtechnik 11 – Normen, DVS-Merkblätter und Richtlinien im Bereich Widerstandsschweißen – Prüfen und Qualitätssicherung [N1] as well as in the DIN-DVS Book No. 312: Schweißtechnik 9, Normen, DVS-Merkblätter und -Richtlinien im Bereich Widerstandsschweißen – Grundlagen, Verfahren und Geräte [N2].

Manufacturers and customers should agree on the applied quality assurance measures for resistance-welding of small parts on an individual basis unless specific details are given in the valid guidelines for the various areas of application.

3 Overview, Test Characteristics, Test Procedures

3.1 General Information

In order to calculate the behavior of a work piece with respect to its strength, rigidity, fatigue strength, weight, volume, etc and to be able to dimension it accordingly, the parameters of the forces (magnitude, direction, distribution, and temporal characteristics) which arise under normal operating conditions must be known. This especially applies to the load-bearing behavior of the welds in the work piece.

In the field of resistance-welding small parts, for example, in the electronics industry and in precision engineering, the materials to be bonded are usually non-ferrous metals, noble metals, conducting and contact materials, etc.; bonds are usually between dissimilar materials. To date,,only limited data exists concerning

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the characteristics of such materials at welding temperatures, including their suitability for welding, the formation of alloys, the strength characteristics of welds, etc.

The values for the rigidity and strength of welds in large parts can generally be established in normed destructive tests. For resistance-welded joints, such as sheet steel of widths of up to approximately 3 mm, the following test procedures are available:

– tensile shear testing,
– cross tension testing,
– peel testing,
– torsion testing,
– impact shear testing,
– fatigue testing.

The evaluation criteria which can be recorded are, for example, the minimum breaking forces, the surface of the fracture, and the type of fracture.

Transferring such testing procedures to resistance-welded small parts is problematic due to the lack of authoritative data concerning the following:

– the geometry of test pieces,
– testing apparatus, testing procedures, test loads,
– performance of tests,
– data recording and evaluation of measurement results.

For these reasons, data from such tests for a specific application can only be compared or transferred to other types of applications in rare cases. Manufacturers of welded components or component groups are therefore obliged to work out individual production and test procedures for their product.

Among non-destructive test procedures for welded joints the visual inspection is more informative, more comprehensive, and more important for small parts than it is for large parts, due to the large number of visible quality criteria. Further non-destructive test procedures are more complex, time-consuming and uncertain, and therefore only seldom used.

Hardly any test procedure can be used process related as a 100% test ("online"). Quality assurance by means of regulating the welding process is all the more important in the production of small parts Parts are often welded at only one single point so a short welding process determines the later usability of the produc

3.2 Test Characteristics

Evaluation characteristics for resistance-welded joints include:

1. External features:
   Dimensional accuracy, deformations, depth of electrode impacts, space between the welded pieces, absence of internal and external spattering, tarnishing, damage to metallic coatings or non-metallic coatings
2. Stability features:
   – under static load-bearing conditions: for example, shear force, cross tension force, peel force, torsional moment, angle of torsion, size of weld spot
   – under dynamic load-bearing conditions: for example, tensile fatigue strength, fatigue strength under bending/ reversed bending, impact shear strength
3. Weld characteristics:
   Size of the weld nugget, regularity of the nugget shape, grain size: coarse/fine, hardness characteristics, area of heating, solid/molten phase, formation of alloys; internal irregularities such as cracks, pores, inclusions
4. Corrosion performance
5. Conductivity:
   Electrical conductivity, magnetic conductivity; thermal conductivity
6. Impermeability:
   Bursting pressure test, coarse leakage rates; fine leakage rates

3.3 Test procedures

The usual test procedures for welded joints in small parts are summarized in table 1.

Table 1. Usual test procedures for resistance-welded joints in small parts.

Test Procedure	Implementation	NOn-Destructive	Destructive	Extent of Testing
Visual inspection	Magnifying glass	x		Up to 100%
	Microscope	x		Up to 100%
	Measured values	x		Up to 100%
	Image processing	x		Up to 100%
Mechanical-static	Peel test		x	Samples
	Shear test		x	Samples
	Tensile test		x	Samples
	Torsion test		x	Samples
Mechanical-dynamic	Vibration test		x	Samples
	Impact test		x	Samples
Thermal	Temperature cycling		x	Samples
	Temperature shock		x	Samples
	Temperature simulation at higher or lower temperature		x	Samples
Electrical	Conductivity	x		Up to 100%
	Function	x		Up to 100%
	Surge voltage test	x		Up to 100%
Chemical/ physical	Climatic simulation		x	Samples
	Corrosion testing		x	Samples
Irradiation	Ultrasound	x		Up to 100%
	X-ray	x		Up to 100%
Thermography	Spectral pyrometer	x		Up to 100%
	Thermovision	x		Up to 100%
Impermeability	Bursting pressure		x	Samples
	Dye penetration test		x	Samples
	Bubble test		x	Samples
	Helium leak test	x		Up to 100%

4 Destructive Testing Procedures

4.1 Workshop Test Procedures

Testing procedures used to assess welded joints on-site in the welding production include peel and chisel testing, fig. 1. In these procedures individual welds or series of spot welds are tested to breaking point directly on the component using simple testing equipment without measuring particular mechanical strength properties.

Criteria for testing the load-bearing behavior of welded joints can include:

– type of fracture, for example, unbuttoning or shearing off [N5],
– surface of fracture, for example, size of the formed button or the sheared surface,
– fracture behavior,
– fracture appearance, for example, dendritic, fibrous, coarse-grained,
– irregularities in the weld seam, for example, internal spattering, cavities, cracks.

Workshop testing on welded joints in small parts is generally carried out manually. It can serve to determine the correct settings for welding equipment and to test samples during on-going production. Examples of workshop test procedures used especially to test small parts are shown in fig. 2.