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Metallic materials — Sheet and strip — Method for springback evaluation in stretch bending

Matériaux métalliques — Tôles et bandes — Méthode d'évaluation du retour élastique lors d'un cintrage sous traction

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*.

This second edition cancels and replaces the first edition (ISO 24213:2008), which has been technically revised.

The main changes compared to the previous edition are:

— the Normative references has been updated;

— Clause 7 c) and Clause 9 a) have been revised to specify the test piece more clearly;

— In Figure 2 b), a label to the test piece has been added;

— Clause 8 d) has been revised because the use of dial gauge is one of the methods for determining the radius of curvature;

— the Bibliography has been updated.

Introduction

This document has been established to evaluate the amount of springback occurring in metallic sheets deformed by stretch bending. It may be used for specifying a material, directly controlling a forming operation, designing dies, or calibrating finite element programs.

In metallic sheet forming processes, the geometry of the formed parts may deviate from the design geometry after the parts are removed from the dies due to elastic recovery. This phenomenon is referred to as springback.

Metallic materials — Sheet and strip — Method for springback evaluation in stretch bending

1 Scope

This document specifies a method for evaluating the amount of springback of sheets of metallic materials known to exhibit large amounts of springback subjected to plane-strain stretch bending, which is a typical deformation mode generated in press-formed panels. By using this method, the amount of springback under stretch bending is evaluated accurately and quantitatively[1][2].

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 80000-1, *Quantities and units — Part 1: General*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

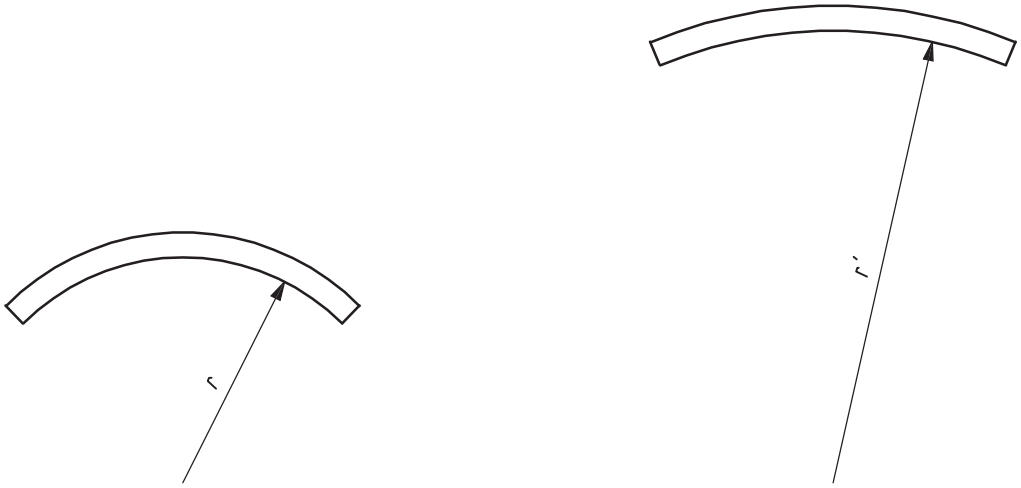
— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
curvature
κ
reciprocal of the radius of curvature, r, determined at the centre of a stretch-bent specimen on the inner surface in the longitudinal direction

$$\kappa = \frac{1}{r}$$

3.2
amount of springback
η
relative change in curvature of a test piece under force and after removal of the force shown in Figure 1

$$\eta = \frac{|\kappa' - \kappa|}{\kappa} = \frac{r' - r}{r'}$$



a) Under force b) After removal of the force

Figure 1 — Radius of curvature of a test piece under force and after removal of the force

3.3
stretch bending
method of bending a test piece under tension

3.4
blank holding pressure
force applied on the test piece in the direction of its thickness, divided by the surface area of the test piece contacting the die

3.5
nominal tensile stress
tensile force per unit cross-sectional area of the test piece

4 Symbols and designations

The symbols used in this document and the corresponding designations are given in Table 1.

Table 1 — Symbols and corresponding designations

Symbol	Designation	Unit
a	Thickness of test piece	mm
b	Width of test piece	mm
F_h	Blank holding force	N
h	Amount of punch penetration	mm
F_p	Punch force	N
p	Blank holding pressure	MPa
R_p	Punch radius	mm
r	Radius of curvature of the inner surface of the test piece under force	mm
r'	Radius of curvature of the inner surface of the test piece after removal of the force	mm
r_d	Die profile radius	mm
S	Total surface area of test piece in contact with dies	mm^2
T	Nominal tensile stress applied to test piece	MPa
W	Distance between dies	mm
w	Width of the base of a dial gauge for measuring the curvature of the test piece after removal of the force (see Annex C).	mm
x	Measured value by a dial gauge for measuring the curvature of the test piece after removal of the force (length of AD in Figure C.1)	mm
κ	Curvature of the inner surface of the test piece under force ($= r^{-1}$)	mm^{-1}
κ'	Curvature of the inner surface of the test piece after removal of the force [$= (r')^{-1}$]	mm^{-1}
η	Amount of springback	
2θ	Spread angle of test piece around punch	rad

5 Principle

This test is a method for evaluating the springback of a metal sheet using a stretch-bending method. The amount of springback is determined as the change in curvatures of a test piece under force and after removal of the force (see formulae in 3.1 and 3.2). The nominal tensile stress applied to the test piece is determined using the measured value of punch penetration and punch force (see Annex B).

6 Test apparatus

The test apparatus is described below.

6.1 Stretch-bending testing device for springback evaluation. An example of the stretch-bending device used in the test is shown in Figure 2. The radius of the semi-cylindrical punch shall be (100 ± 1) mm. However, the radius of the punch tip and its tolerance may be determined by agreement between the parties involved.

6.2 Device for determining the radius of curvature of a test piece. The principle for determining the radius of curvature with a dial gauge is shown in Annex C, in which a dial gauge with an accuracy of 0,001 mm shall be employed. The use of optical micrometers or other non-contacting length probes is also recommended.