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Elektromagnetno utripno varjenje - 1. del: Znanje o varjenju, terminologija in slovar

Electromagnetic pulse welding - Part 1: Welding knowledge, terminology and vocabulary

Schweißen und verwandte Verfahren - Elektromagnetisches Pulsschweißen - Teil 1: Schweißwissen, Terminologie und Begriffe

Soudage par impulsion électromagnétique - Partie 1 : Connaissance, terminologie et vocabulaire du soudage

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Electromagnetic pulse welding - Part 1: Welding knowledge, terminology and vocabulary

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 18007-1:2023) has been prepared by Technical Committee CEN/TC 121 “Welding and allied processes”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

The EN 18007 series of standards consists of the following parts:

— *Part 1: Welding knowledge, terminology and vocabulary*,

— *Part 2: Design of welded joints*,

— *Part 3: Qualification of welding operators and weld setters*,

— *Part 4: Specification and qualification of welding procedures*,

— *Part 5: Quality and inspection requirements*.

Introduction

Electromagnetic pulse welding is an innovative solid-state welding technology, that belongs to the group of pressure welding processes, and is based on the use of electromagnetic forces to deform, accelerate and weld workpieces. No external heat source is used, the connection is only created by a high-velocity impact.

The increasing use of the electromagnetic pulse welding process has created the need for a standard, to ensure that the welding operations are carried out in the most effective manner and that appropriate controls are performed on all aspects of the implementation.

To be effective, welded products need to be free from problems in production and in service. To achieve this goal, it is necessary to provide controls from the design phase through material selection, choice of parameters, the fabrication itself, and inspection. For example, poor design can create serious and costly difficulties in the workshop or in service. Incorrect process parameters and/or material selection can result in welding defects. Welding procedures need to be correctly formulated and approved to avoid weld discontinuities. To ensure the manufacture of a quality product, management needs to understand the causes of potential problems and implement appropriate inspection procedures and subsequent quality measures. Supervision should be implemented to ensure that the specified quality is achieved.

1 Scope

This document defines terms and definitions related to the electromagnetic pulse welding process. In this document, the term "aluminium" refers to aluminium and its alloys.

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/TR 25901 (all parts), *Welding and allied processes — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the ISO/TR 25901 series and the following apply.

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

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

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

3.1
electromagnetic pulse welding
creation of a welded joint by impact using a pulsed electromagnetic field

3.2
electromagnetic pulse sheet welding
creation of a welded joint of sheets by impact using a pulsed electromagnetic field

3.3
electromagnetic pulse tube welding
creation of a welded joint of tubes by impact using a pulsed electromagnetic field

3.4
electromagnetic pulse crimping
creation of a crimp connection (mechanical joint) using electromagnetic forming

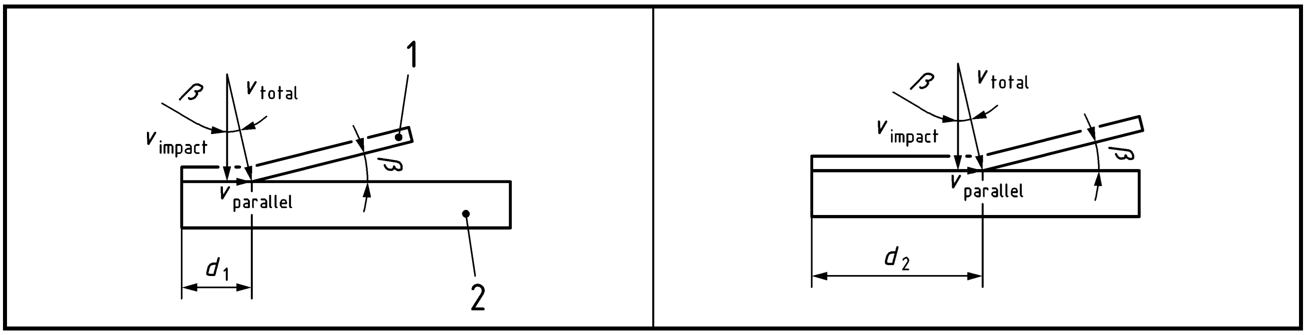
3.5
flyer sheet
flyer tube
sheet or tube that is accelerated by electromagnetic forces during the process (see Figure 1)

3.6
target sheet
target tube
sheet or tube that is stationary during the process (see Figure 1)

3.7
driver
auxiliary workpiece used for efficient acceleration of workpieces with low electrical conductivity

3.8
impact velocity
normal component (according to target sheet/tube surface) of the velocity of the flyer sheet/tube velocity when it impacts with the target workpiece (see Figure 1)

3.9
collision point velocity
mean velocity parallel to the target workpiece at which the weld is created (see Figure 1)



Key

1 flyer

2 target

Mean collision point velocity $v_{collision,mean} = \frac{d2 - d1}{\Delta t}$.

Figure 1 — Definition of characteristic velocities (Source: Fraunhofer IWU)

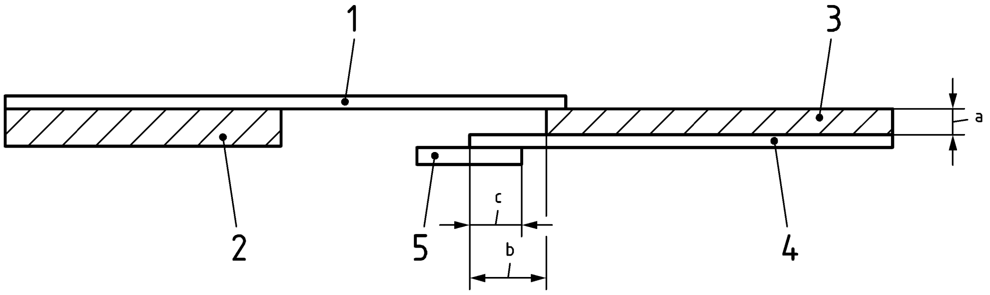
3.10
impact angle
angle between flyer's and target's impact surface during the complete duration of the impact event (see Figure 1)

3.11
jetting critical angle
angle at which a jet is created at the collision front

3.12
stand-off distance
gap
initial gap between the joining partners; the distance by which the metals to be welded are separated from each other prior to the welding process (see Figure 2)

3.13
free length
length between the flyer tube/sheet and the internal workpiece; part of the flyer (tube or sheet) that can freely move under the effect of the magnetic forces (not obstructed by the support or a part of the target workpiece) (see Figure 2)

3.14
overlap of flyer and tool coil
work length [4]
length of work zone
distance that the flyer workpiece overlaps with the coil or field shaper (see Figure 2)



Key

1 Cu 1 mm

2 spacer 2

3 spacer 1

4 Al 1 mm

5 flat coil

a stand-off

b overlap

c free-length

Figure 2 — Schematic representation of the geometrical parameters of the electromagnetic pulse welding process (sheet applications)

3.15
discharge energy
energy discharged into the coil as a result of the discharge of the capacitors, characterized as follows:

$$E = \frac{1}{2} C V^2$$

where

E is the discharge energy (J)

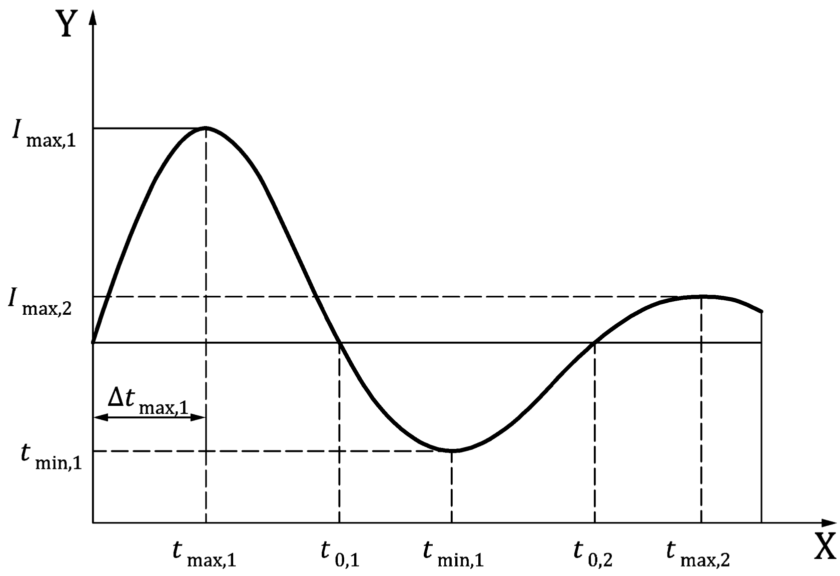
C is the capacitance (F)

V is the charging voltage (V)

3.16
discharge current
current discharged into the coil as a result of the discharge of the capacitors

3.17
discharge current frequency
significant frequency of the current induced in the coil from t_0 until $t_{max,1}$; the duration $t_{max,1}$ corresponds to the quarter of the period (noted T/4)

Note 1 to entry: Figure 3 illustrates this concept and presents the current discharge frequency equation.



Key

X time

Y current

Significant frequency $f_{significant} = \frac{1}{4 \times \Delta t_{max,l}}$

Figure 3 — Pulsed current parameters (Source: Fraunhofer IWU)

3.18
pulse repetition rate
number of pulses per unit of time

3.19
current rise time
time taken by the electromagnetic pulse to change from a specified low value to a specified maximum value ($\Delta t_{max,l}$ in Figure 3)

3.20
skin effect
alternating current tends to distribute itself inside a conductor in such a way that the current density is highest near the surface of the conductor; this is called the skin effect

3.21
skin depth
how deep eddy currents penetrate a material is defined as the depth at which their intensity decreases to 1/e (about 37 %) of their maximum intensity

3.22
bitter coil
coil formed by stacking alternating conductors and insulating discs, each foreseen with a radial cut

3.23
single turn coil
one turn coil
coil consisting of one turn

3.24
helix coil
coil with the turns arranged in a helical shape

3.25
flat coil
coil with the turns arranged in a single plane, either single or multi-turn

3.26
Rogowski coil
toroidal coil without a ferromagnetic core to measure the discharge current in an electrical circuit

3.27
pitch of the coil
number of turns per unit of length, parallel to the flyer direction

3.28
high pulsed power generator
device that charges capacitors, stores electrical energy, and discharges it in the forming or welding coil in a very short time interval; machine supplying the discharge energy needed for the electromagnetic pulse welding process

3.29
field shaper
field concentrator
component that concentrates the magnetic field onto the welding zone; it essentially increases the amplitude of the magnetic field, onto a smaller region (axially)

4 Welding knowledge

4.1 Process principles

The electromagnetic pulse technology (also known as electromagnetic pulse forming, crimping and welding) is an automatic production technique that uses electromagnetic forces to deform and join similar or dissimilar materials. Electromagnetic pulse forming is a high-speed deformation process that uses a pulsed electromagnetic field for contactless forming of metals. The energy stored in a capacitor bank is discharged rapidly through a tool coil. The alternating electromagnetic field produced by the coil generates eddy currents in the adjacent workpiece made of a metallic material with good electrical conductivity. The varying currents cause a varying magnetic field that generates the eddy currents. These currents, in turn, produce their own magnetic field. The forces generated by the two magnetic fields oppose each other. Consequently, a repelling force (Lorentz force) between coil and workpiece is created.

The forces generated can for example be used to plastically deform a flyer tube or sheet with high velocity onto an internal or external workpiece (target sheet/tube), to form, cut or perforate a sheet using a special-shaped die. Under precisely controlled conditions and process parameters, a solid-state weld can be realized (electromagnetic pulse welding) after plastic deformation of materials. The configuration for joining tubular products is shown in Figure 5. Depending on the arrangement of the tool coil and workpiece, tubular profiles can be expanded or compressed, or sheet metals can be formed (see Figure 4). A principle sketch of the welding process is shown in Figure 6.

Due to the solid-state nature, this process can be used for joints of similar and dissimilar materials (with very different melting temperatures).