VEREIN DEUTSCHER INGENIEURE

Electrical Discharge Machining (EDM)

Definitions, processes, application

VDI 3400

Translation of the German issue 1975-06

The German version of this guideline shall be taken as authoritative. No guarantee can be given with respect to the English translation.

Contents Page

VDI Society for Production Engineering
(VDI-Gesellschaft Produktionstechnik – ADB)

VDI manual Production Management, Part 2: Manufactoring Processes
(VDI-Handbuch Betriebstechnik, Teil 2: Fertigungsverfahren)

Introduction

This guideline deals with the removal operations based on electro-discharge machining which are found in the bold-bordered boxes in Table 1. The guideline is the revision of the September 1970 issue of the guideline VDI 3400 and takes into account technical innovations and further developments in this field after that date.

1 Definitions[1]

Electrical Discharge Machining (EDM[2], electro-erosion, electro-eroding) comprises machining methods for electrically conductive workpiece materials using electrical discharges (sparks, arcs) and a dielectric (dielectric fluid) for material removal.

1.1 Spark erosion (spark eroding, spark machining)

This method is characterised by the material being *removed* using recurrent non-stationary or quasi-stationary electrical discharges which are discrete in time (sparks); these discharges are primarily produced by spark voltages in excess of 20 V in a dielectric fluid.

Electro-discharge machines (spark-eroding machines) are systems or devices whose working principle is based on spark erosion.

1.2 Arc erosion (arc eroding, arc machining)

In this process, the material is *removed* by recurrent stationary electrical discharges which are discrete in time (arcs); in most cases, these discharges are initiated by mechanical contact of the electrodes, and periodically interrupted by axial movement of the "tool electrode". Discharges primarily occur at voltages below 20 V.

Arc-erosion machines (arc-eroding machines) are systems or devices whose working principle is based on arc erosion.

The definitions referring to spark erosion apply by analogy also to the less commonly used arc erosion process.

1.3 Machining methods based on spark erosion

1.3.1 Sinking EDM

Comprises all removal operations in accordance with Section 1.1, in which the tool electrode and/or the workpiece (workpiece electrode) is/are adjusted in a controlled manner in the machining direction, without the workpiece and/or the tool electrode performing a rotating main movement about their own axes. A rotatory or translatory, uniform or oscillating additional movement can be superimposed to the controlled adjustment movement of the electrodes (Figure 1).

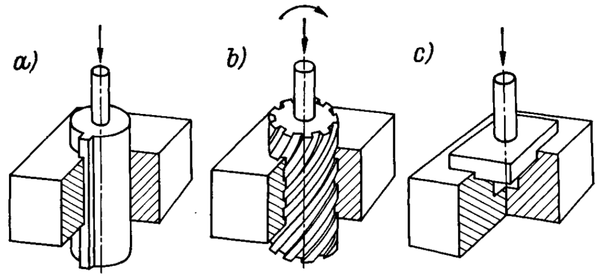


Figure 1. . Sinking EDM
a), b) ED-drilling
c) Spark-erosion engraving

1.3.1.1 ED-drilling

Comprises the removal operations in accordance with Section 1.3.1 for making breakthroughs of constant or varying cross-section (Figure 1a, Figure 1b).

1.3.1.2 Spark-erosion engraving

Comprises the removal operations in accordance with Section 1.3.1 for producing three-dimensional shapes (Figure 1c).

This also includes spark-erosion die spotting where tool surfaces are mutually removed.

1.3.2 ED cutting

Comprises all removal operations in accordance with Section 1.1, allowing workpieces to be cut off, cut in, or cut out (Figure 2):

1.3.2.1 ED blade-cutting, Figure 2a

1.3.2.2 ED wire- or band-cutting, Figure 2b

1.3.2.3 ED cutting using a rotating disk, Figure 2c

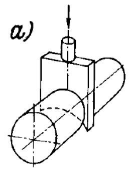
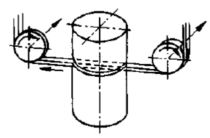
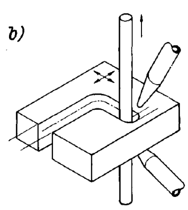
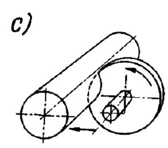


Figure 2. Spark-erosion cutting
a) using *blade*
b) using *wire* or *band*
c) using *rotating disk*







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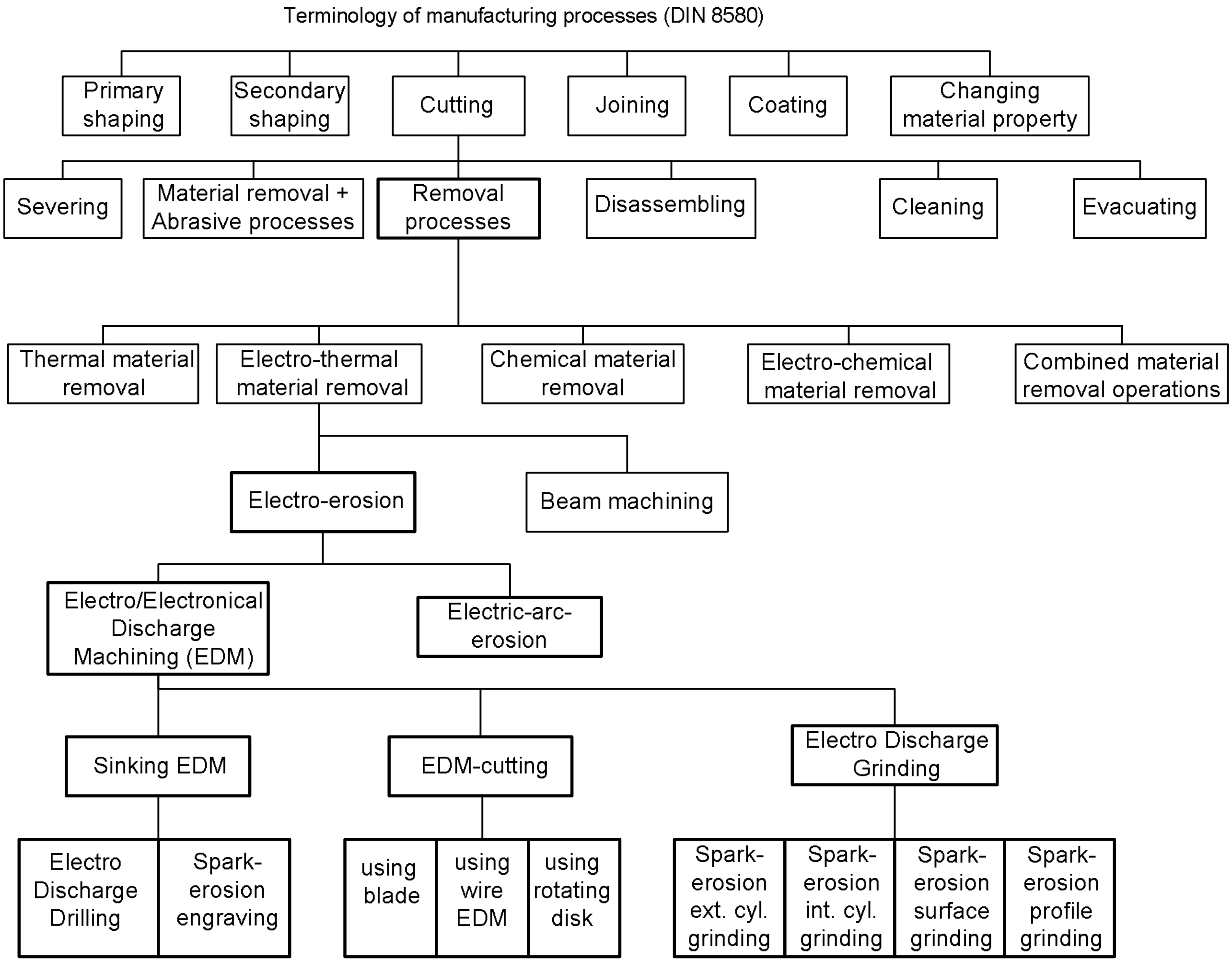
[1] Terms and characteristics given in brackets can be used alternatively.

[2] This footnote applies to the German version only.

Table 1. Classification of electrical discharge machining



1.3.3 ED grinding

comprises all removal operations in accordance with Section 1.1, in which the tool electrode and/or the workpiece (workpiece electrode) is/are adjusted in a controlled manner in the machining direction, with the workpiece and/or the tool electrode performing a rotating main movement about their own axes. A rotatory or translatory, uniform or oscillating ancillary movement can be superimposed to the controlled adjustment movement of the electrodes (Figure 3):

1.3.3.1 Spark-erosion external cylindrical grinding, Figure 3a

1.3.3.2 Spark-erosion internal cylindrical grinding, Figure 3b

1.3.3.3 Spark-erosion surface grinding, Figure 3c

1.3.3.4 Spark-erosion profile grinding, Figure 3d

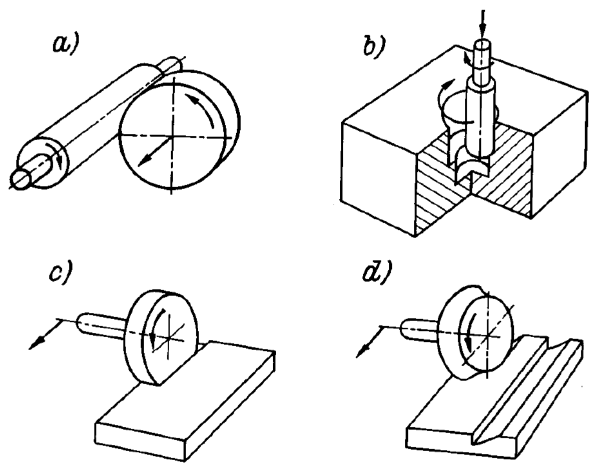


Figure 3. Spark-erosion grinding

a) Spark-erosion external cylindrical grinding
b) Spark-erosion internal cylindrical grinding
c) Spark-erosion surface grinding
d) Spark-erosion profile grinding

1.4 Characteristic quantities

The symbols used and the denotation of the characteristic quantities are compiled on page 27; furthermore, terms and characteristics are listed in the "Glossary".

1.4.1 Technological characteristics

The following characteristics can be used for evaluating the machining result:

1.4.1.1 Material removal

The *material removal rate (MRR)*, V_W, (formerly: removal performance) is the volume of material removed from the workpiece per *unit of time*;

the *material removal per discharge*, V_{Wf}, is the volume of material removed from the workpiece per *discharge*.

1.4.1.2 (Electrode) Wear

The *(electrode) wear rate*, V_E, (formerly: tool electrode wear) is the volume of material removed from the tool electrode per *unit of time*;

the *electrode wear per discharge*, V_{Ef}, is the volume of material removed from the tool electrode per *discharge*:

the *relative electrode wear*, ϑ, (formerly: relative tool electrode wear) is the ratio of electrode wear rate to material removal rate, in terms of percent

$$\vartheta = \frac{V_E}{V_W} 100$$

Further quantities characteristic of the wear (such as edge wear, longitudinal wear, etc.) require in each case a description of the measuring procedure.

1.4.1.3 Surface

The *surface quality* of the machined workpiece is determined by the shape and depth of the discharge craters. All common roughness values can be used for a numerical assessment.

In the workshops, there is often a lack of appropriate instrumentation and measuring experience in accordance with relevant standards. To allow roughness comparison, it is therefore recommended to use a surface comparator [21; 22] featuring the following grades:

Class :	0	1	20	21	22	23…40
R_a in µm :	0,1	0,112	1,0	1,12	1,25	1,40…10,0

For practical application, the following classes have been selected for an agreed surface comparator:

Class K :	12	15	18	21	24	27	30
R_a in µm :	0,4	0,56	0,8	1,12	1,6	2,24	3,15

Class K :	33	36	39	42	45
R_a in µm :	4,5	6,3	9,0	12,5	18,0

Figure 4 shows commercially available surface comparators which comply with this recommended selection of classes.

In practice, it is mainly the material removal rate, V_W, the relative electrode wear, ϑ, and the surface quality that are evaluated.

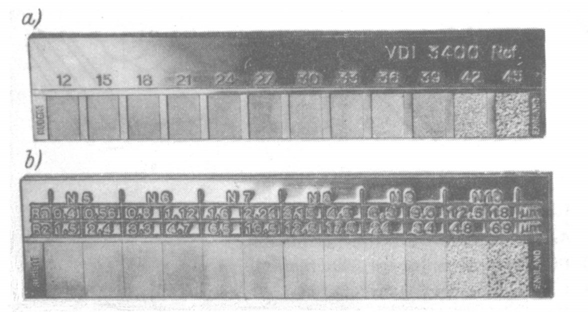


Figure 4. Surface comparators

a) featuring the classes as recommended in this guideline

Photo courtesy of Nassovia-Krupp

b) featuring the same classes as a), but with class designations according to the standard proposals drafted by ISO/TC 57/SC 1, Working Group 2

Photo courtesy of Rubert

1.4.1.4 Working gap

During stationary eroding operations, the working (spark gap) lies between the tool electrode and the workpiece. A distinction is made between the frontal gap, s_{90}, (measured along the feed direction) and the side gap, s_0 (measured normal to the feed direction).

1.4.2 Electrical characteristics[3]

In the case of static pulse generators producing rectangular voltage pulses, the characteristic curves of voltage and current are as shown in Figure 5.

The *pulse duration*, t_i, is the time interval during which one voltage pulse is applied to the gap.

The *pulse interval*, t_o, is the time interval between two voltage pulses.

[3] Symbols for the various characteristics can be further identified by means of time or state indices; where required, location indices are additionally used (see Overview "Denotation of characteristic quantities, p. 27).