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1 Scope of application

The technical code describes machines, devices and tools for the joining of films and mouldings made of plastics using high frequency (HF), including the process engineering.

2 Functional principle**2.1 Definition of terms**

According to DIN 8593, the high-frequency welding procedure belongs to Main Group 4 of the "fabrication procedures for joining". In spite of the clear conceptual delimitation, this is almost always called welding. In practice, the welding machine designation has also become established although joining operations which do not correspond to the "welding" definition are often carried out with the machines.

Both terms, joining and welding, are used in this technical code.

2.2 Heating operation

The alternating high-frequency electrical field acting between the electrodes causes an accelerated movement of the molecules in the plastic located in it. The molecules of the material must be electrically polar, i.e. electrically non-neutral. Such a molecule then constitutes a dipole which, in the presence of an alternating electrical field, endeavours to turn in the field direction.

At the frequency of 27.12 MHz applied most often within the framework of the HF joining technique, the molecules are oriented 27.12 million times per second. This results in internal friction which generates heat.

In the case of a homogeneous material and a uniform field distribution, the high frequency leads to a uniform heating throughout the material cross-section. In the layers close to the surface, a temperature drop occurs due to the heat dissipation to the surroundings situated in the lower temperature range and to the cold electrodes. Figure 1 shows the principle of HF welding.

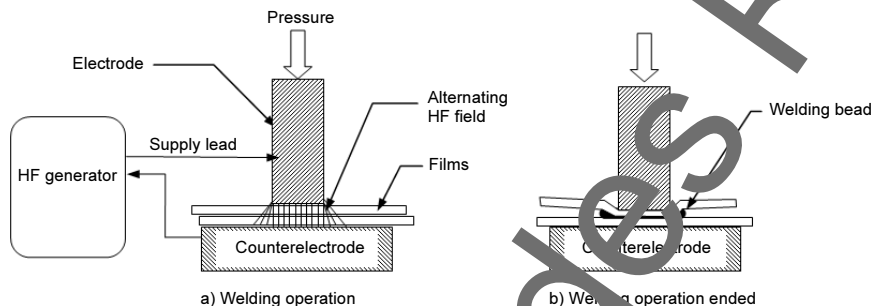


Figure 1. Principle of high-frequency welding.

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DVS, Technical Committee Working Group "Joining of Plastics"

3 Machines, devices and tools

3.1 Structure and operating mode of a high-frequency welding machine

An HF welding machine, Figure 2, consists of the generator, the HF leads with filters, the adjustment device, the working jig, the controller and the electrodes.

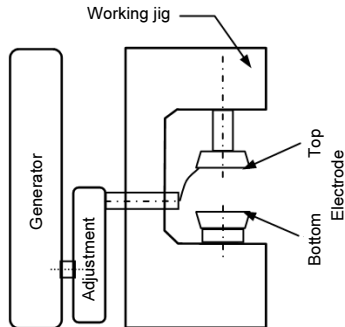


Figure 2. High-frequency welding machine.

3.1.1 High-frequency generator

The HF generator transforms the low-frequency electrical energy of the alternating current mains into high-frequency electrical energy. The International Telecommunications Treaty from 1959 and the relevant Enforcement Ordinance dated May 1, 1961 stipulate the permissible frequency ranges. As from this point in time, the following frequency ranges have been applicable as working frequencies for industry, medicine and science:

- 13.56 MHz \pm 0.05%
- 27.12 MHz \pm 0.6%
- 40.68 MHz \pm 0.05%
- 433.92 MHz \pm 0.2%
- 2,450 MHz \pm 50 MHz
- 5,800 MHz \pm 75 MHz
- 22,125 MHz \pm 125 MHz

Due to practical requirements (permissible frequency bandwidth, level of the HF voltage applied to the electrodes and voltage distribution across the welding face), the frequency of 27.12 MHz \pm 0.6% is mainly utilised for joining and welding with high frequency. In general, the output powers of the HF generators are between 0.6 kW and 120 kW. The efficiency of generators with stable frequencies (the ratio of the power input from the mains to the HF power output to the electrodes) is approx. 50%. The following is regarded as a reference point for determining the HF power during the welding of PVC-P films in a thickness of 2 x 0.5 mm:

Approx. 1 kW of HF power (first welding parameter) is needed for a weld length of 1 m and a weld width of 2 mm. The required HF power deviates from this with other materials and total material thicknesses.

The welding times are dependent on the material and on the material thickness. An HF power of approx. 35 W/cm² is needed for PVC-P film with a total thickness of 0.6 mm and a welding time of 1.5 - 2 s. With lower film thicknesses, a higher power is required due to the heat dissipation into the cold electrodes.

A higher HF power is also necessary with higher film thicknesses, because of the larger volume to be heated. Lower HF power is needed with longer welding times of, for example, 6 - 8 s.

The overwhelming proportion of the customary welding time (second welding parameter) is between 1 and 6 s. The film thicknesses are between 0.2 mm and 2 mm for most applications. The welding time is followed by the after-effect or cooling time.

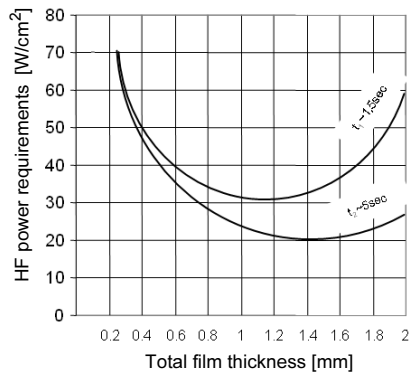


Figure 3. HF power requirements in W per cm² of welding area; welding time t₁: approx. 1.5 - 2 s, welding time t₂: approx. 5 - 6 s.

3.1.2 HF leads

The HF leads transport the high-frequency electrical energy via the adjustment device to the electrodes which are located in the working jig. The HF leads also include filters in order to restrict the emission of harmonic waves in the case of HF generation with stable frequencies and without any interference radiation.

3.1.3 Adjustment device

It serves to adjust the working jig to the HF generator and regulate the desired welding power.

3.1.4 Working jig

This transmits the joining pressure required for the welding operation. Furthermore, it has the tasks of guiding the electrodes with parallel faces and of keeping the joining pressure exact during the preselected time. During the joining operation, it must be possible to reset the working jig precisely around the required and preselected penetration depth. The working jigs are fabricated in a C or gassy construction. The drive is provided hydraulically or pneumatically, in some cases also via a motor. Pedal-operated machines are also utilised for simple terms of reference and for small-series series. The required specific pressure on the electrode sole (third welding parameter) is 1 MPa for PVC-P.

3.1.5 Electrodes

These are necessary for the joining and welding operations. The most important functions are:

- to transmit high-frequency energy to the material which is to be welded and is located between the top and bottom electrodes
- to clamp and shape the joining parts during the joining, stamping, non-forming or welding operation
- to dissipate the heat created in the joining material when the high frequency has been switched off

3.1.6 Electrode protection jigs

High voltages are applied to the HF electrodes when the high frequency has been switched on, provision must be made for protection jigs. These switch off the HF power supply immediately when flashovers arise. This avoids any damage to the electrodes or to the joining parts.

3.1.7 Task-related additional facilities

According to the terms of reference in each case, the HF welding machines are equipped with a single, double or multi-level sliding table, a turntable or feed installations as the charging facilities.