14.
Mechanisation
and Welding Fixtures
As the production costs of the metal-working industry are nowadays mainly determined by the costs of labour, many factories are compelled to rationalise their manufacturing methods by partially and fully mechanised production processes. In the field of welding engineering where a consistently good quality with a maximum productivity is a must, automation aspects are consequently taken into account.

The **levels of mechanisation** in welding are stipulated in DIN 1910, part 1. Distinctions are made with regard to the type of torch control and to filler addition and to the type of process sequence, as, e.g., the transport of parts to the welding point. Figure 14.1 explains the four levels of mechanisation.

Figure 14.2. shows **manual welding**, in this case: manual electrode welding. The control of the electrode and/or the arc is carried out manually. The filler metal (the consumable electrode) is also fed manually to the welding point.
In **partially mechanised welding**, e.g. gas-shielded metal-arc welding, the arc manipulation is carried out manually, the **filler metal addition**, however, is executed **mechanically** by means of a wire feed motor, Figure 14.3.

In **fully mechanised welding**, Figure 14.4, an automatic equipment mechanism carries out the **welding advance** and thus the torch control. **Wire feeding** is realised by means of wire feed units. The work-pieces must be positioned manually in accordance with the direction of the moving machine support.

In **automatic welding**, besides the process sequences described above, the work-pieces are **mechanically positioned at the welding point** and, after welding, automatically trans-ported to the next working station. Figure 14.5 shows an example of automatic welding (assembly line in the car industry).
Apart from the actual welding device, that is, the welding power source, the filler metal feeding unit and the simple torch control units, there is a variety of auxiliary devices available which facilitate or make the welding process at all possible. Figure 14.6 shows a survey of the most important assisting devices.

Before welding, the parts are normally aligned and then tack-welded. Figure 14.7 depicts a simple tack-welding jig for pipe clamping. The lower part of the device has the shape of a prism. This allows to clamp pipes with different diameters.

Devices, however, may be significantly more complex. Figure 14.8 shows an example of an assembly equipment used in car body manufacturing. This type of device allows to fix complex parts at several points. Thus a defined position of any weld seam is reproducible.
In apparatus engineering and tank construction it is often necessary to rotate the components, e.g., when welding circumferential seams. The equipment should be as versatile as possible and suit several tank diameters. Figure 14.9 shows three types of turning rolls which fulfil the demands. Figure top: the rollers are adjustable; Figure middle: the rollers automatically adapt to the tank diameter; Figure bottom: the roller spacing may be varied by a scissor-like arrangement.

In general, dollies are motor-driven. This provides also an effortless movement of heavy components, Figure 14.10.
A work piece positioner, e.g. a turn-tilt-table, is part of the standard equipment of a robot working station. Figure 14.11 shows a diagrammatic representation of a turn-tilt-table. Rotations around the tilting axis of approx. 135° are possible while the turn-table can be turned by 365°. Those types of turn-tables are designed for working parts with weights of just a few kilograms right up to several hundred tons.
A turn-tilt table with hydraulic adjustment of the tilting and vertical motion as well as chucking grooves for the part fixture is depicted in Figure 14.12.

In robot technology the types of turn-tilt-tables - as shown in Figure 14.13 - are gaining importance. **Positioners with orbital design** have a decisive advantage because the component, when turning around the tilting axis, remains approx. equally distant to the welding robot.
Other types of workpiece positioners are shown in Figure 14.14 – the **double column turn-tilt-table** and the **spindle and sliding holder turn-tilt-table**. Those types of positioners are used for special component geometries and allow welding of any seam in the flat and in the horizontal position.

![Double-Column Turn-Tilt-Table](image1.png)

**Figure 14.14**

![Spindle / Sliding Holder Turntable](image2.png)

**Figure 14.15**

In the field of welding, special units are designed for special tasks. Figure 14.16 shows a **pipe-flange-welding machine**. This machine allows the welding of flanges to a pipe. The weld head has to be guided to follow the seam contour.
Plain plates or rounded tanks are clamped by means of longitudinal jigs for the welding of a longitudinal seam, Figure 14.17. The design and the gripping power are very dependent of the thickness of the plates to be welded.

A simple example of a special welding machine is the tractor travelling carriage for submerged-arc welding, Figure 14.18. This device is designed for the application
on-site and provides, besides the supply of the filler metal, also the welding speed as well as the feeding and suction of the welding flux.

For the guidance of a welding head and/or welding device, **machine supports** may be used. Figure 14.19 shows different types of machine supports for welding and cutting. Apart from the translatory and rotary principal axes they are often also equipped with additional axes to allow precise positioning.

To increase levels of mechanisation of welding processes robots are frequently applied. Robots are handling devices which are equipped with more than three user-programmable axes. Figure 14.20 describes **kinematic chains** which can be realised by different combinations of translatory and rotary axes.
The most common design of a track-mounted welding robot is shown in Figure 14.21. The robot depicted here is a hinged-arm robot with six axes. The axes are divided into three principal and three additional axes or hand axes. The wire feed unit and the spool carriers for the wire electrodes are often fixed on the robot. This allows a compact welding design.
Varying lever lengths permit the design of robots with different operating ranges. Figure 14.22 shows the **operating range** of a robot. In the **unrestricted operating range** the component may be reached with the torch in any position. The **restricted operating range** allows the torch to reach the component only certain positions. In the case of a suspended arrangement the robot fixing device is shortened thus allowing a compact design.

For the completion of a robot welding station workpiece positioners are necessary. Figure 14.23 shows positioner devices where also several axes may be combined. These axes may either turn to certain defined positions or be guided by the robot control and moved synchronically with the internal axes. The complexity and versatility of the axis positions increases with the number of axes which participate in the movement.
Movement by means of a **linear travelling mechanism** increases the operating range of the robot, Figure 14.24. This may be done in ease of stationary as well as suspended arrangement, where there is a possibility to move to fixed end positions or to stay in a synchronised motion with the other movement axes.

Figure 14.24