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PROCESSES THAT OCCUR WHEN FORMING WELDED JOINTS

Abdullayev Jo'ra Khudoyorovich

Uzbekistan, Termiz

Email : joraabdullayev 67@gmail.com

Termez State University of engineering and agrotechnologies, assistant

ABSTRACT Welding is the process of joining two or more metals or other materials using heat, pressure, or a combination of both. The chemical, physical, and mechanical processes that occur during this process determine the quality of the weld, its durability, and the properties of the material. The processes of forming welded joints are complex and involve atomic and molecular changes between the materials. This article analyzes the main processes that occur during welding.

Key words: oxide, dilatometric effect, mass transfer, overheated region, residual stresses.

Introduction Surface coatings (oxide layers) of weld metals or alloys are usually relatively hard and soluble (except for iron oxides). Their presence at the final stage of the process generally prevents the formation of metallic bonds, since they are washed away during welding and are lost from the surface of the joint of two parts. [1]

In conditions of spot, back and seam welding, erosion and redistribution of surface layers is achieved by melting the metal at the point of contact of two sheets.

1. Main types of welding process . In the welding process, chemical bonds are formed between two or more materials. In such processes, materials are mainly heated at high temperatures. Welding processes are divided into:

- **High-temperature welding** : By bringing the metals to their melting point, they are melted and joined together. This type of process is used in autoclave and electric arc welding.
- **Low temperature welding** : Joining materials in an unmelted state, such as gas welding (with oxygen).
- **Ultrasonic welding** : Materials are joined together using rough mechanical action.

2. High temperatures and energy changes . During welding, metal materials are heated to high temperatures, melted or softened, and joined together. The specifics of this process are as follows:

- **Melting and solidification** : When welding, the melting point of the materials must be reached. When metals are heated, they melt, and thus the molecules join together in the molten part. In this process, the hardness and strength of the metal decreases, but new chemical bonds are formed in the molten part.
- **Joining** : When the molten metal pieces begin to cool, they join together to form a new joint or weld. Many new materials are created through these processes, such as nickel, iron, or aluminum compounds.

Energy exchange plays a very important role in these processes. During welding, under the influence of thermal energy, changes occur in the structure of materials, i.e. the welded materials come closer to each other and new bonds are formed between them.

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4. Mechanical processes and stresses Mechanical processes that occur during welding change the physical properties of the material. During welding, changes occur quickly, especially between heated materials:

Formation of stresses : During the welding process, internal stresses arise due to rapid heating and cooling of materials. These stresses can cause deformation and destruction of the material. This especially affects the strength of the materials being welded.

- **Critical cooling** : During the cooling process, the material begins to crystallize. If cooling occurs too quickly, this can change the internal structure of the material and reduce its subsequent properties.

5. Factors affecting welding quality. The quality of chemical, physical and mechanical processes occurring during welding is affected by various factors:

- **Welding Temperature** : The optimum temperature helps the materials to melt properly and the joints to be strong. Too high or too low a temperature reduces the quality of the materials.
- **Material properties** : Different materials react differently. For example, changes in iron sulphide and strong aluminum alloys are different.
- **Influence of the gas environment** : During the welding process, gases present in the environment (e.g. oxygen, nitrogen) can affect the quality of the weld.

6. Spatial and microscopic changes occurring during welding . During the welding process, changes also occur in the structure of the material at the microscopic level. These changes often manifest themselves in the following situations:

- **Formation of new phases** . When welding, new chemical phases (or alloys) are formed between materials. These new phases change the mechanical properties of the material.
- **Crystallization process** : During welding, the crystalline structure of the material changes, which affects the mechanical and physical properties of the weld.

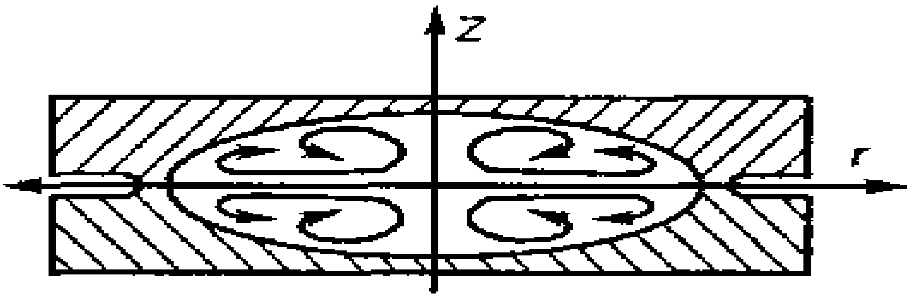

Figure 1. Direction of rotation of the liquid metal core during mixing.

It is this current that causes the liquid metal to mix with the welding current.

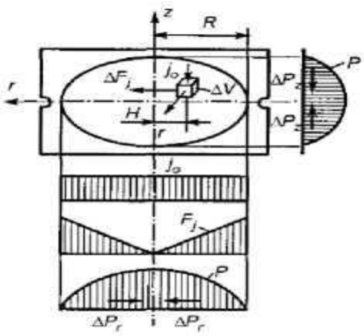

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Figure 2. Scheme for determining electrodynamic forces and scheme for distributing current density jo , forces Fj and pressures P in liquid metal along z and roks .

If we assume that the current density is uniformly distributed over the cross-section of the core, then the force A Fj , acting on the elemental volume *AV of the metal at a distance r from the core, is equal to:*

$$\Delta F_j = \mu_m j_0^2 \Delta V_r / 2 ,$$

where: / $_{lt}$ – absolute magnetic absorption of the substance.

all volumes of the core A V, create a pressure in the liquid core similar to the pressure caused by gravity in the liquid. These forces also affect the volumes of the metal in the solid state, where they are balanced by the resistance forces of the crystal lattice.

Volumetric forces A Fj have the greatest value at the edges of the core and decrease to zero at its center. The pressure at the point of contact of the sheets is expressed by the parabolic equation:

$$p = \mu_m j_0^2 (R^2 - r^2) / 4$$

and reaches its maximum value at its center *(R* is the radius of the core).

As a rule, the casting core has an ellipsoid shape, so pressure gradients in the molten metal arise not only in the horizontal direction (AP_g), but also in the vertical direction (AP $_z$). Under the influence of these gradients, layers of liquid circulate.

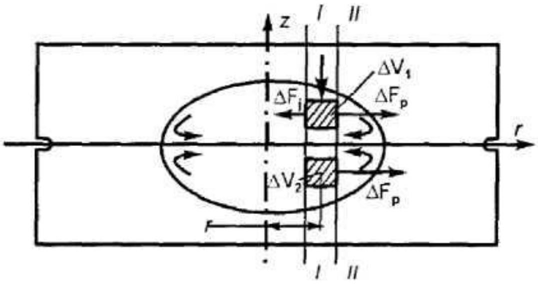

Figure 3. Distribution of forces acting on particles suspended in a solution

Suspended solid in solution (conductive AV 1 or, in most cases, electrically conductive impenetrable AV 2) the curtain particles are subject to forces AF_p caused by the pressure difference in sections II and II - II :

$$\Delta F_p = \Delta P_r \Delta V$$

Non-conducting particles move and collect at the edges of the cast core. If the current density j 1 in the conductive particle AV 1 greater than current density j 0 in molten metal , then the particle

$$\Delta F = \Delta F_p - \Delta F_j = \mu_m (j_0^2 - j_1^2) r^2 / 4$$

as a result of the difference in forces, the particle moves towards the center of the nucleus.

In butt welding, the ends of the parts are open to interaction with the atmosphere. In contact welding, oxidation accelerates the process most actively. Fusion butt welding is characterized by continuous renewal of metal at the ends of the parts; when connectors connecting oxygen and other gases explode, a large number of metal droplets and vapors are formed (for example, carbon monoxide CO when welding steel). into the crack, which greatly slows down the rate of interaction of the metal with the atmosphere. However, when joining chemically active metals (titanium,

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molybdenum, etc.), such protection may not be effective enough, and therefore, in some cases, welding is carried out in an atmosphere of inert gases. The conditions for the destruction and loss of oxides in butt welding depend on the temperature of the ends of the parts, the temperature gradient, and the properties of oxides and metals. The difficulty of removing oxides in contact welding increases as their hardness increases. For example, when welding steels, it is difficult to remove the oxide Fe 2 O 3, the hardness of which is comparable to the hardness of the base metal. But FeO , which has a melting point and hardness lower than steel, is easily lost. In butt fusion welding, when the oxides are predominantly liquid, their hardness does not significantly affect their loss while they are on the substrate. Since plastic deformation during contact welding is relatively small, the oxides are partially eroded and lost. In this case, the surface renewal (loss of oxides from the ends of the parts) does not exceed 60 - 70%, which generally indicates that the plasticity of the joints will be relatively low.

In fusion welding, the loss of oxides occurs much more easily and occurs together with the particles of molten metal ejected from the joint and mainly during the precipitation of oxides by squeezing them into the lattice with liquid and solid metal. In the optimal mode, the deformation of the surface is comparatively small, and the renewal of the surface approaches 100%.

Thermal expansion of metal during welding

As a result of heating metal bodies, their linear dimensions and volume increase (dilatometric effect). In particular, at temperature T of a solid body, its length lt and volume W are equal to:

$l_T = l_0(1+\alpha_l T)$ And $V_T = V_0(1+\beta_v T)$,

where: lo and Vo are the length and volume of the body at temperature T=0°C; *and* $_{\{}$ and D , are the thermal coefficients of linear and volumetric sudden expansion.

During melting, the volume of the body increases sharply and reaches 8-10% Vo.

In spot and weld conditions, the thickness and dimensions of the parts increase predominantly in *the z-axis direction* , since the coldness of the adjacent metal parts stops the increase in dimensions in the *r-axis direction*. During welding, the thermal expansion of the metal leads to the movement (gap) of the machine electrodes, primarily the upper movable electrode.

A significant displacement of the upper electrode is observed from the moment of metal melting (the appearance of the core) and now occurs with an increase in the temperature field and the size of the core.

CONCLUSIONS AND SUGGESTIONS In conclusion, it can be said that welding processes are one of the most important areas of metallurgy and materials science. During welding, changes between chemical, physical and mechanical processes determine the quality of connections and the strength of materials. In order to properly control the welding process and create high-quality connections, it is necessary to take into account the required temperature, gas environment and specific properties of materials. These processes are important for ensuring the strength of materials in industry, construction, transport and other areas.

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