July 14, 2021

Ways to weld metal without using electricity

If you were raised in the 1980s or 1990s, you probably know the word carbide. Or more precisely, the phrase calcium carbide. Children and teenagers almost always got their hands on pieces of this stone-like product after a welder came to make repairs in their courtyard or at a nearby facility. Even today, calcium carbide continues to be used in welding processes that have not changed for more than 100 years.

The 19th century was a period of experimentation and technical innovation. It is also the century that saw ground-breaking developments in welding – the process of connecting metals at the molecular level. This was the beginning of the practical application of arc welding, which since then has been used even in space. However, work has been under way to develop methods for welding metals without using electricity. Obviously, this research was not in vain. Today, there are several dozen types of welding, which are divided into three major categories:

- fusion welding
- pressure welding
- thermomechanical welding

In every category, there are welding processes that do not use an electrical arc. The most famous among them are probably gas welding, cold welding and explosion welding. Each of them has its own history and practical application.

Gas welding

The development of gas welding using calcium carbide is a history with bizarre twists and turns. The first experiments to research the properties of a mixture of gases that produced high temperatures when burning began in the late 18th century. The term “gas welding” appeared in the 1840s. It was used by the French inventor Eugène Panon Desbassayns de Richemont in a scientific article about welding lead.

This way of connecting metals was actively studied by another French inventor, Henri Louis Le Chatelier. In 1895, he generated a high-temperature flame of 3000°C by burning a mixture of acetylene and oxygen. Despite these results, the process was not widely used for a long time.

Acetylene gas was discovered back in the early 19th century. It was even artificially synthesised in 1863, albeit in laboratory experiments. They did not yield large enough amounts for mass application at a low cost. It was not until the 1890s that, at almost the same time in France and the US, an industrial method for producing calcium carbide from limestone and coal was found. That product became a source of acetylene, which was formed by mixing water and calcium carbide in special tanks.

However, this too was insufficient. There was still a need for special burners that could mix acetylene with oxygen to produce a flame at a high enough temperature to be applicable in metal welding technology. In 1903, the engineers Edmond Fouché and Charles Picard developed and patented such a device.

Only after that did gas welding begin to be used widely. It was not easy, because by then, arc welding had been in widespread use for more than 10 years. Around the mid-1930s, gas welding became the main way to join metal. It was relatively cheap, simple and reliable. In addition, the oxygen and acetylene equipment was more compact and mobile compared with the existing generators used to maintain an electrical arc.

Then, in the 1930s, a technological breakthrough in electric welding took place. As the size of electrical generators decreased, they became more portable and the process began to be automated. As a result, gas welding lost its main advantages. For a while, it seemed that it could disappear like many other technological anachronisms or be relegated for use in very narrow fields.

However, that did not happen. Scientific research in the field led to a crucial change in the process. Oxygen burners began to be used to cut metal, rather than to weld. A new phase of technological development began. This gave birth to new research institutes and massive plants that produced special equipment: autogenous machines that are used to cut, weld and replate metals by burning gas.

Explosion welding

Explosion welding is a relatively new way to join metal. It is used to weld metals with different properties. Combining them creates unique materials: bimetal and clad metal. One side of such plates can successfully resist corrosion, while the other is hard and wearproof. The potential of metal welding technology using this method was discovered during World War II. Pieces of shell cases were found that were firmly welded with other metal objects after an explosion. That caught the attention of researchers. In the early 1960s, a practical method for explosion welding was developed and patented in the US by the DuPont company.

The technology developed quickly and entered widespread use. Today, it is used to obtain bimetals, which are used in many economic fields. Sometimes, this process uses three or even four types of metal, rather than two, to form a kind of sandwich. When one of the layers is much thinner than the others, the process is called cladding.

Broadly speaking, the explosion welding process can be described as follows. Two or more layers of metal are placed at a short distance from one another, either at an angle or in parallel. An explosive is spread evenly on the upper cladding layer. A controlled explosion is then carried out to join the layers and form a material that possesses the properties of each metal.

In practise, though, it is not as simple as in theory. A tremendous number of complex technological requirements must be met: from the angle and detonation speed to ensuring explosion safety in the facility where the welding is

taking place.

There are currently up to 300 combinations of various metals that can be joined this way. Bimetals produced by explosion welding increase equipment reliability and decrease product costs. This is because of the reduction in the use of expensive metals by layering them over a less costly base material.

Cold welding

Cold welding is probably the most ancient way to connect metals. It is believed to have been used as early as the 8th-9th centuries BC to manufacture products from nuggets of precious metals. In the late Bronze Age, people worked malleable metals like gold, silver and copper with stone hammers. That process taught our ancestors that pieces of these metals could be easily joined even without using an external heat source. Those were basically the earliest attempts at cold welding. It was used to first increase the size of metal products, then to produce decorations. Modern researchers adopted cold welding as an integral part of materials science in the 1940s.

However, the application of this method is limited to malleable metals that can be firmly joined through friction, compression or impact. Silver, aluminium, lead, copper, zinc, nickel and some other materials can be joined by cold welding. For this purpose, it is necessary to have two clean, smooth surfaces of the same metal.

The main advantage of cold welding is the absence of impurities in the weld, which are practically inevitable when electric or gas welding is used. For this reason, it is widely applied in electronics and electrical engineering, where it is important to use pure metals such as copper and aluminium to conduct current. Nanotechnology is one of the most promising modern methods for welding metals without heat. It has already been proven that micro particles and nanoparticles of metals can be joined without even applying pressure through just a few seconds of contact.

The term “cold welding” also has another meaning that can appear misleading. Today, adhesives can be found in many shops under the same name. Generally, this is a two-component compound based on an epoxy resin. It can be used to perform emergency repairs, such as sealing a hole or crack, or connecting a broken metal part, to solve a problem until a welder arrives. And if it is a gas welder, you can ask for a piece of calcium carbide to remind you of childhood.