Welding through the Ages

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History

Welding can trace its historic development back to ancient times. The earliest examples come from the Bronze Age. Small gold circular boxes were made by pressure welding lap joints together. It is estimated that these boxes were made more than 2000 years ago. During the Iron Age the Egyptians and people in the eastern Mediterranean area learned to weld pieces of iron together. Many tools were found which were made approximately 1000 B.C.. During the Middle Ages, the art of blacksmithing was developed and many items of iron were produced which were welded by hammering.

The modern welding processes have been developed during the last 150 years. Gas welding and cutting stared around 1850.
During the first half of the 1900's electrical power companies started to generate and distribute power. With the emergence of electrical power, inventor started to experiment with electrical current for the purpose of welding metals together. The most creative and distinguished inventors were probably the Russian Nickolas de Benardos (1842 – 1905) and the American, Elihu Thomson (1853 – 1937). Within a relatively short period of time, they introduced two entirely different methods of electric welding, arc welding and resistance welding. Electric arc welding is the transformation of electrical energy into heat through the arc to melt and fuse metals together. Beside N. de Benardos, Olszewski, C. L. Coffin, De Méritens, Slawianoff and Zerener had also fundamental inventions for arc welding at that time. For shielded metal arc welding the Swede Oscar Kjellberg (1870 – 1931) invented a suitable coated electrode.

Elihu Thomson, a Professor at Franklin Institute in Philadelphia, was the first to demonstrate the possibility of joining metals by resistance welding. His experiments which were completed in 1886, led to the very extensive, complex methods which are useful in the assembly of many of our modern structures.

Additional to these, today joining technologies with other physical principles are available on the market, such as laser beam welding, diffusion welding, ultrasonic welding or friction welding processes.

Applications

The range of the welded zone of welded components includes: welding of thin wires (welded area: 0.08 mm^2) or micro contacts (0.5 mm^2), the well known spot welds in car body manufacturing (20 mm^2) as well as welded rails (approximately 8000 mm^2) or big components. At the present time, welding practice is divided into about 70% arc welding with the balance divided between resistance welding and gas-shielded metal arc welding.

Quality assurance

The quality of welds depends on a lot of different quantities which are dependent on each other e.g. kinematics, continuums mechanics, fluid dynamics, thermodynamics, electrodynamics and thermoelectric effects.
The correlation between welding process, design (component, electrode, welding tool) and the material aspect of weldability have ever been part of the discussion about quality assurance.

In 1929 Felix Goldmann, Technical Academy Munich/Germany, showed in his work the benefit of using metallography to look inside the welded specimens. Measuring the hardness and the possibility to describe the microstructure in the joined area and heat affected zone lead to a general understanding of the metallurgy in welding. In the following years methods for destructive and non-destructive testing have been developed. Today component testing under static and fatigue load combined with environmental simulation (corrosion tests combined with thermal or electrical load) are now part of the daily work. Modern examination methods like scanning electron microscopy (SEM) and technologies for ultrasonic testing, thermography and X-ray computer tomography support the work in research and development.

Numerical Simulation

During welding process in industrial production the temporal and spatial formation processes of the temperature field cannot be shown by measuring technique. Therefore, complex parameter studies for the presentation of ”Welding parameter diagrams” with accompanying strength tests (static, dynamic) and metallographic investigations are necessary.

For a better understanding of the process meanwhile special solutions for welding have been developed using the multi-physics capabilities of finite element (FE) software tools. Some examples are discussed in this presentation. Using the methods of numerical analysis one can optimize and define the process relevant parameters of the welding machine. FE-Simulation can be used by quality assurance as well as design engineers. Also coupled models which allow a linked simulation of welding process combined with models for component testing and product life simulation are the challenge of actual software-engineering projects.

Conclusion

Today welding technology is used in a wide field of industrial applications in a world which asks for best quality of welded components. Applications in the field of alternative energy require new innovative solutions. Modern welding technologies with process control systems are the key for realizing such complex welding tasks. An efficient welding technology combined with best trained welders will open the door for going green in future.