Newly-developed consumable makes thin-plate welding more effective

by Lars-Erik Stridh, ESAB AB, Göteborg

As a result of increasingly fierce competition from low-cost countries, rapid changes are taking place within the welding industry in Europe. A large part of the heavy welding industry is moving its production eastwards, to countries with low labour costs, leaving behind it industries with skilled and mechanised welding. Europe has a number of major automotive producers with many suppliers, most of whom have introduced robotic welding into their production process.

The consumables these robots use for welding are generally solid wire with a diameter of 1.0mm. The shielding gas is often a mixed gas with a third component to minimise spatter. Continuous developments are taking place within automotive production when it comes to systems for joining sheet metal. These systems include bonding, resistance welding, MIG soldering, laser welding and closing-head rivets. Arc welding still maintains a powerful position in present-day automotive production and, depending on the brand, there are between one and two kilograms of weld metal in every vehicle.

Robotic welding increases at a relatively constant rate every year. The number of arc welding robots rises by around 10% every year in Europe. In the automotive industry, these robots are usually included in advanced cells containing several robots that work together in a production chain. In the fiercely competitive situation that currently exists, it is vital for the automotive industry and its suppliers to make this production process as efficient as it can possibly be.

Interior from the robot cell in Göteborg where a front suspension part is test welded with OK Tubrod 14.11 Ø 1.4 mm.

Background

The requirements that are set for welding for different components for the automotive industry are naturally rigorous. After all, the vehicles that are involved are going to transport people and attempts are constantly being made to find lighter materials to reduce the weight. This is done to economise on natural resources and cut fuel consumption, but, at the same time, the safety standards for passengers are being constantly stepped up. The plate thicknesses are small and homogeneous wire is generally used. One of the problem areas is penetration. The measurement precision of the sheet-metal components which are going to be welded together varies. This means that the joints are slightly different and their position varies somewhat. This is a problem, as the arc from a ∅ 1mm homogeneous wire has a small diameter, making the penetration profile narrow and thereby sensitive to joint tolerances. In practice, this means that welding defects such as incomplete penetration or perforation easily occur.

It is also important that the transition between the parent metal and the weld run is uniform and smooth. In other words, the fatigue strength must be high. This characteristic is becoming increasingly important as more and more high strength steel is being used in structures to save weight by reducing plate thickness

Productivity and cycle times in the robot cell are very important when it comes to keeping costs down. As a result, attempts are made to increase the welding speed whenever possible. This leads to another important factor – the hardness of the weld metal and the HAZ (heat affected zone). The heat that develops in the arc from a homogeneous wire is relatively low and this results in rapid cooling and the risk that the hardness will be too high and the weld joint will therefore be brittle.

Example of the very good penetration also at high welding speeds, in this case 27 mm/sec.

New approach

ESAB's process know-how and collaboration with different suppliers to the automotive industry and with the automotive industry directly, in combination with these customers' production expertise, has resulted in a new concept for welding thin plate, which can now be used successfully within the automotive industry.

When it comes to welding thin plate, most people assume that they should use solid wire with a small diameter. Few of them consider using a metal-cored wire with a larger diameter. However, this is exactly where developments have led – namely to robot welding using a metal-cored wire with a diameter of 1.4mm.

The product is called OK Tubrod 14.11. It is a welding wire that has been developed to suit robot welding. It is therefore easy to feed, as it must not cause feed disruptions. The arc is stable and produces a minimum of spatter and one very important characteristic is that it is possible to weld with high currents and relatively low arc voltage with no reduction in arc stability. This has been made possible by target-oriented development work.

A very common joint; overlap. Plate thickness is 1.5mm and welding speed in this case 32 mm/sec.

Customer applications

The following example illustrates the advantages. A supplier to the automotive industry welds many different small components. The company uses ∅ 1.0mm solid wire and, to obtain the widest possible penetration, it uses pure carbon dioxide as the shielding gas. Six robots work together in a robot cell. A centrally-located welding table is filled with six identical components and it then rotates one-sixth of a revolution after each welding operation. The six robots weld different parts of the component simultaneously, which means that the welding times are different and some robots have to wait a few seconds while the others finish welding. The waiting times are not that long – anything from four to ten seconds – but, in view of the fact that there are six welding operations in the total cycle, the total waiting time can be a minute or two. The refilling time in the cell is short and the cell welds continuously, so there can be as much as an hour of non-productive time during the course of a day. Over a month, this makes 20 hours. The production cost in an uncomplicated robot cell with one robot, one positioner and one operator is around SEK 1,000 an hour. The production cost in a complicated robot cell with six robots is naturally much higher. So the cost of this "waiting time" is very high.

As this company is currently operating at maximum capacity when it comes to what solid wire can achieve while maintaining approved quality levels, tests were conducted using OK Tubrod 14.11, ∅ 1.4mm. In the tests that were conducted using a robot at the ESAB Welding Centre in Göteborg, it was found that the welding speed could be increased from 18 mm/sec for solid wire to 30 mm/sec for flux-cored wire. This means that the whole of the waiting time described above could be eliminated for some robots and that the total cycle time could also be reduced by synchronising the welding speed of the robots.

The photographs show examples of the surface appearance and penetration during these welding tests.

Another example from another supplier who also welds components for the automotive industry is shown

Part from car industry
Weld length: 31 cm.

	Solid wire	OK 14.11	Difference
Cycle time (s)	58.6	40	–31%
Welding speed (m/min)	0.6	1.5	+150%
Welding time (s)	31	12.4	–60%
Robot motion time (s)	27.6	27.6	
Cycle time/unit (s)	58.6	40	–31%
Reloading time (s)	10	10	
Number of units/h	52	72	+38%
	OK 14.11	**Solid wire**	
Wire consumed/unit (kg/unit)	0.014	0.014	
Wire price (£/kg)	4:36	0:77	
Wire cost (£/unit)	0:0612	0:0106	
Shielding gas consumed (m^3/unit)	0.014	0.018	
Shielding gas price (£/m^3)	2:83	2:47	
Shielding gas cost (£/unit)	0:0400	0:0400	
Energy cost (£/unit)	0:0047	0:0047	
Robot + operator cost (£/h)	103:06	103:06	
Robot + operatos cost (£/unit)	1:43	1:68	
Total cost (£/unit)	1:55	1:73	

in the table. In this table, the cost is presented for the previous method of welding with 1.0mm solid wire and is compared with the results for the same component using OK Tubrod 14.11, Ø1.4mm cored wire.

Advantages

The reason why the use of this relatively thick, metal-cored wire, OK Tubrod 14.11, has been given such a good reception is quite naturally largely due to the opportunity to reduce the total cost by cutting the cycle times as a result of the improvement in productivity. In addition, the welding quality is also enhanced. The run geometry produces a smooth, fine transition to the parent metal. As penetration is wider and more reliable, welding is now also more tolerant as far as gap variations are concerned, thereby reducing the number of welding defects and the number of rejects. This represents savings that directly affect the profit margin. What is more, the amount of spatter from the wire is also lower, thereby reducing the number of stoppages to clean fixtures. Furthermore, the cleaning of gas hoods which the robot performs at the cleaning station is reduced by 50%, with the result that the cycle time is even further reduced.

Summary

There is excellent potential for streamlining the robot welding of thin plate This applies particularly to the automotive industry and its suppliers who demand high productivity and high and reproducible quality. It is, however, important, when introducing a new consumable for welding which can cut cycle times, that the whole production chain is taken into account, in order to avoid creating a bottleneck further down the chain and thereby losing the savings that are made in the welding cell. By planning the welding operation carefully and adapting the remainder of the production chain, a great deal of money can be saved and the automotive industry in Europe can maintain its competitive edge and keep jobs in Europe.

About the authors

Lars-Erik Stridh, EWE, graduated from Bergsskolan in 1982. He worked three years as a welding engineer at a repair and maintenance company in Göteborg and after that 13 years as product manager for flux cored wires at a competitive company. Lars-Erik Stridh joined ESAB in 1999, is based in Göteborg but works on ESAB's total market.