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USE OF WELDING SHIELDING GAS MIXTURES IN AUTOMOTIVE WELDING PROCESSES

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Abstract: *The paper will present a review of the use of shielding gases used for welding in the automotive industry and the main problems caused by the effect of shielding gases. The welding technologies in which some mixtures of shielding gases are used allows the improvement the fatigue and corrosion resistance characteristics required in welded joints of automotive body parts, as well as an efficiency booster in the production process. Shielded arc welding with low* CO_2 *concentration shielding gases, Plasma-Arc Hybrid*^{TM} *welding and hybrid laser arc welding will be highlighted in this paper and some methods to improve welding parameters by different shielding gas mixtures will be presented.*

Key words: *automotive industry, welding parameters, shielding gases, resistance characteristics*

1. INTRODUCTION

Welding is the main means of fabrication and repair of metal products and is used in every industry. Among major application areas, welding is extensively used in the automotive related industries [1]. The most frequent welding processes for automotive applications include resistance spot welding (RSW), resistance seam welding (RSEW), shielded gas welding with consumable electrode (MIG/MAG, GMAW), tungsten inert gas welding with tungsten electrode (TIG/WIG), laser beam welding (LBW), friction stir welding (FSW) and plasma arc welding (PAW).

Advanced welding processes for automotive applications have been developed for the new high strength steels and aluminium alloys to reduce the body weight and increase fuel efficiency. In conventional welding methods, a filler material (consumable electrode) is always added to the weld joint to flow into the joining gap to produce an extremely strong bond. The filler metal added to each weld increases the weight of the vehicle, which in turn decreases fuel economy.

Two material families are the focus in industry: high strength steels and aluminum alloys.
Both materials are becoming challenging from welding perspective as mechanical and welding performance increases [2].

2. WELDING APPLICATIONS IN AUTOMOTIVE INDUSTRY

A wide variety of car body components are joined together using welding techniques. The demand to develop new welding processes for automotive applications or extend the limits of the actuals are increasing to meet new material combinations for automotive body parts. The need for innovative welding processes has been strongly felt in recent years, with automotive manufacturers focusing on lighter, yet stronger and fuel-efficient vehicles using lightweight alternative materials.

2.1 Laser beam welding

The use of laser technology for welding high-volume automotive components has gained popularity due to its distinct advantages. Key benefits include good flexibility, improved productivity with substantial savings in maintenance and energy costs, while producing a strong weld with low deformations.

Some advantages of laser beam welding (LBW) are considered to be the following:

- High productivity (nearly 10 times faster than TIG).
- Low heat input and low distortions.

➢Ease of automation for repeatability.
➢No filler material needed (reducing costs).
➢Similar and dissimilar metals can be welded.
➢Clean welding.
➢Deep and narrow welds can be done.
➢Minimal heat affected.
➢Excellent metallurgical quality in welds.
➢Ability to weld smaller, thinner components.
➢Increased travel speeds.

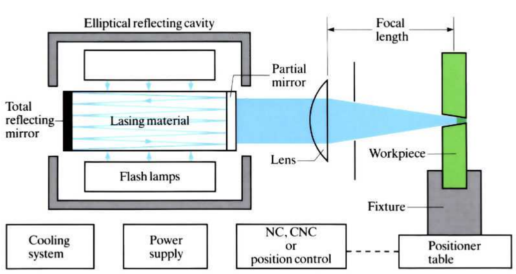
Some disadvantages of Laser Welding

➢Rapid cooling rate can cause problems as cracking in high carbon steels.
➢High cost of equipment
➢High reflectivity of a laser beam at the metal surface – special surface treatment needed.
➢Require precise joint preparation and laser beam alignment.

Applications of Laser Welding

➢electronics industry for applications as connecting wire leads to small electronic components;
➢ transmission components in automotive field (gear wheels).
➢ welding power electronics casings etc.,
➢ medical equipment,
➢ cladding process [4-7].

The LBW process uses the heat generated when a focused laser beam hits the surface of the joint. Metal sheets between 0.2 and 6 mm thick can be easily laser welded.



a – schematic of LBW [3]

b detail from work space in LBW of carbon steel
Fig. 1. Laser welding

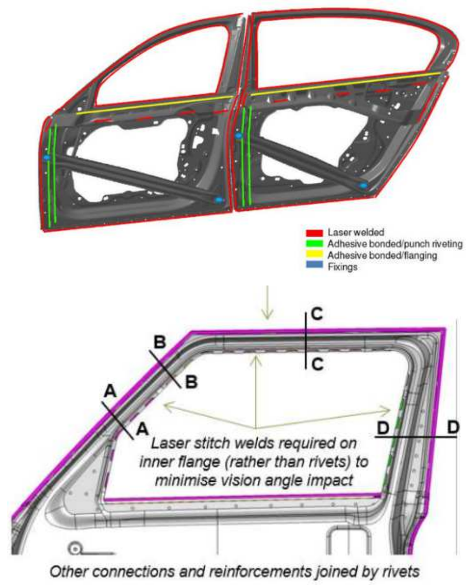


Fig. 2. Car side door welding
a) joining techniques contours; b) laser welding. [4]

Most automotive industries use crossflow CO_2 laser systems and fiber lasers in the 2 to 6 kW power range. The laser beam directed at the workstation is focused on the parts to be welded using copper mirrors or fiber optics, depending on laser source technology. It is a non-contact process and suitable mainly for automated applications. Process parameters as laser power, speed and the size of the focused spot, beam scanning frequency and width determines the depth and width of the weld. A beam from one laser source can be easily switched to multiple workstations, allowing optimal use of the laser for different welding functions.

This inherent flexibility of LBW meets the requirements of high-volume automotive production for different geometries without extensive setup. Figure 2 shows the laser welding in case of car door for BMW 7 series.

2.2 Arc welding of automotive steel sheets

Arc welding is widely used for chassis parts due to advantages as ease of continuous joining to provide high joint strength and stiffness, and a large variety of joint geometries to allow easy joining of sheets, pipes, supports or other fittings. Because chassis parts are composed of many welded components, it is essential that welded joints are highly resistant to fatigue and corrosion. In addition to reducing spatter, welding processes and consumables must be able to cope with the voids (missalignments) often found in cold press-formed shapes.

To reduce CO_2 emissions, lowering vehicle weight is an urgent requirement in the automotive industry, and in this respect the need to use thinner, higher strength steel sheets is growing. While high-strength 440 and 590 MPa class steel sheets have been used mainly for chassis (vehicle frame) parts, the use of 780 MPa class steel is being sought in response to the need for reduced car weight. On the other hand, for body parts, the use of higher strength steel plates of the 1,470 MPa class has already started.

Weld joints are generally designed to outperform the base metal, i.e. to have a higher strength than the base material, and for this reason high strength filler materials are frequently used for welding high strength steel sheets. However, in the manufacture of automotive parts, welded seams of a 490-MPa class are often used for general applications, regardless of the strength of the base metal, because the use of different welding joints for different parts is costly and, in addition, when welding thin elements, sheets, the weld metal tends to harden due to dilution with the base metal [6, 8, 10].

2.3 GMA welding - problems solved by low concentrations of CO_2 in shielding gas

There is a great need to improve fatigue strength and corrosion resistance of joints for shielded gas welding of chassis parts. Since stress concentration at the welding tip is the dominant factor for fatigue characteristics of welded joints, it is difficult to achieve a fatigue strength improvement effect of joints by adopting high tensile strength steels.

Furthermore, since corrosion reduces the thickness of the steel plate regardless of the strength of the steel plate, an increase in steel strength cannot contribute to a decrease in plate thickness. The slag adhering to the weld bead and/or weld tip causes paint film defects.

Corrosion starts from these defects and passes into the steel. Although joint fatigue strength is reduced by concentrating stress at the weld tip, a further decrease in fatigue strength by reducing sheet thickness through corrosion is a concern in the real exploitation environment of the vehicle.

To address these issues, FKE Steel has studied and developed the application of a low CO_2 concentration shielding gas welding method, which is a shielding gas welding method with a low active gas (CO_2) mixing ratio.

2.4 Changing the shape of the weld bead by shielding gas composition

Decreased CO_2 concentration modifies several process characteristics influencing arc stability, weld behaviour and seam geometry. Mixtures usually used are either 8 – 10% CO_2 or 90-02% Ar or three component 4-5% CO_2 + 2-4% O_2, rest Ar mixtures, mainly aiming decreased spatter and lower heat input. Generally, any decrease in concentration of high conductive CO_2 is decreasing heat transfer to weld metal, leading to a narrower weld seam penetration. That increases the risk of lack of fusion, especially in high-speed welding using GMA process. This is accompanied by a slight decrease of heat input (approx. 10%) given by decreased CO_2 concentration [4, 5, 9].

3. CASE STUDY - ROBOTIC TIG WELDING OF 1 MM SHEETS SUITABLE FOR THE AUTOMOTIVE SECTOR

In the automotive field, sheet thicknesses are relatively thin (0.6 – 3 mm) and welding processes must be chosen very carefully. The following study involves the joining of 1mm thick stainless-steel sheets, which can be applied to certain areas of a vehicle body. The joining was carried out robotic with the TIG process in argon as shielding gas. The application was performed in 3 variants with two different welding technologies, in standard and pulsed current.

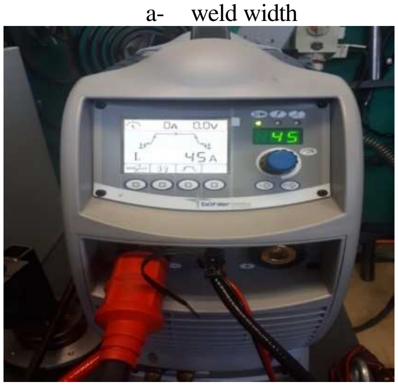
TIG as a shielded gas welding process that uses tungsten electrode attached to the end of the welding torch. The electric arc ignites between the electrode and base material that melts the metallic parts together but the tungsten rod itself does not melt. The benefit there is no need to add any filler material during the welding process making it a technique that loved by welders. The tungsten electrode is also referred to as non-consumable electrode as it is not melted during the welding process.

Because TIG welding does not use slag or fluxes, the process produces very clean welds. The process is excellent for joining components that are press fit without need for any filler materials. If a gap must be filled, filler wire can always be used. Due to its super clean welds, it is an ideal welding technique for motorcycle repairs and those into custom car builds. For the same reasons, the TIG process can be used for welding various exotic non-ferrous metals such as copper, aluminium, nickel, magnesium, and titanium. For motorcycle repairs you can use it for some exotic metals and alloys.

3.1 Case 1 – steady current DC

- welding speed = 40 cm/min
- weld current = 45 A
- arc voltage = 8,8 V
- shielding gas flowrate = 8 l/min
- shielding gas: argon

a- weld width



b -welding parameters

Fig. 3. Welding parameters recorded – case 1

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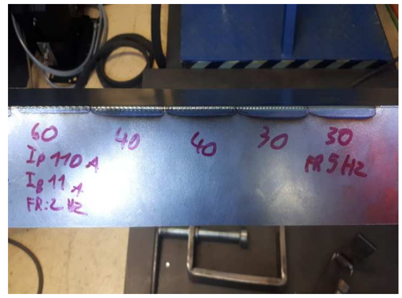
3.2 Case 2 – Alternating current AC

- welding speed = 30 cm/min
- Pulse current = 110 A
- Base current = 11 A
- Pulse frequency = 5 Hz
- Average current = 40 A
- Arc voltage = 9, 0 V
- Shielding gas flowrate = 8 l/min
- - shielding gas: argon



a- weld

b -welding parameters

Fig 4. Welding parameters recorded – case 2

Welding of the samples was carried out in three clamping variants and two technology variants as follows:

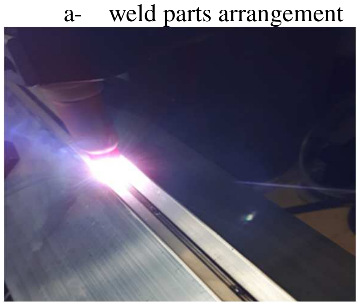
- a free piece (Fig. 5);
- a stiffened piece (Fig. 6);
- a stiffened and cooled piece (Fig.7).

Fig. 5. Welding the free part

Fig.6. Welding of the stiffened part

Fig.7. Welding of the stiffened and cooled part

a- weld parts arrangement



b -welding process

Fig.8. a) Robot positioning; b) Image during welding

Two aluminium plates were used to cool the workpiece, which were fixed by means of flange clamps on the outer surface of the workpiece. The table on which the piece is fixed is adjustable, which allows you to fix the angle of 45 degrees (Fig.8).

The shielding gas is sufficiently powerful in sustaining the welding speed in the tested range, while for higher welding speed, to avoid product coloration, trailing nozzles should be used.

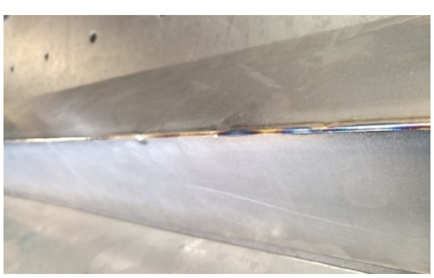


Fig. 9. Visual inspection after welding with the second variant of welding technology

Fig. 10. Visual examination - comparison between the three selected sample cases

For the case of thin plate welding with higher speed then tested here – up to 1 m/min or more, a small addition of hydrogen is possible.

This will improve the heat transfer, further increasing welding speed and decreasing deformations [11].

4. CONCLUSION

As conclusion regarding the tested case studies for this paper, the shielding gas is sufficiently powerful in sustaining the welding speed in the tested range, while for higher welding speed, in provider to avoid product coloration, trailing nozzles should be used.

For the cases studies of thin plate welding with higher speed tested here – up to 1 m/min or more, a possible improvement could be a small addition of hydrogen (approximate 5%). This will improve the heat transfer, further increasing welding speed and decreasing deformations.

Arc welding using low CO_2 in case of Laser beam welding same problems can be solved by shielded gas welding with low concentrations of CO_2. For example, decreasing CO_2 concentration is modifying several components influencing arc stability, weld behaviour and seam geometry. Mixtures most frequently used are either 8 – 10% CO_2, 90-92% Ar or three component gas mixtures with additions of 3 – 5% CO_2 and 2 – 4% O_2, rest Ar, mainly aiming to decrease spattering and heat input. Generally, any decrease in concentration of high conductive CO_2 is decreasing heat transfer to weld metal, leading to narrowing of weld penetration but also decreasing distortion and residual stresses.

The shielding gas used affects several welding characteristics. Once understood which properties are most important to the given application, you can select the right welding technologies.

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UTILIZAREA COMBINAȚIILOR DE GAZE PROTECTOARE ÎN PROCESELE DE SUDARE PENTRU DOMENIUL AUTO

Lucrarea va prezenta o trecere în revistă a utilizării gazelor de protecție în sectorul automobilelor și principalele probleme cauzate de efectul gazelor de protecție. Tehnologiile de sudare în care se utilizează anumite combinații de gaze de protecție permit îmbunătățirea caracteristicilor de rezistență la oboseală și la coroziune cerute la îmbinările sudate ale pieselor de caroserie ale automobilelor, precum și o eficiență ridicată în procesul de producție. În această lucrare vor fi evidențiate sudarea cu arc protejat cu gaz CO2 cu conținut scăzut de CO2, sudarea Plasma-Arc HybridTM și sudarea hibridă cu arc laser și vor fi prezentate unele metode de îmbunătățire a parametrilor de sudare prin diferite combinații de gaze protectoare.

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