Aluminium welding within the automotive industry

Moving forward with weld quality – welding equipment characteristics and technical training

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Without doubt, the use of aluminium within the automotive industry and the development of aluminium welding technology are both continuing to expand. The continued developments of aluminium within this industry can be primarily attributed to this material's many desirable physical characteristics.

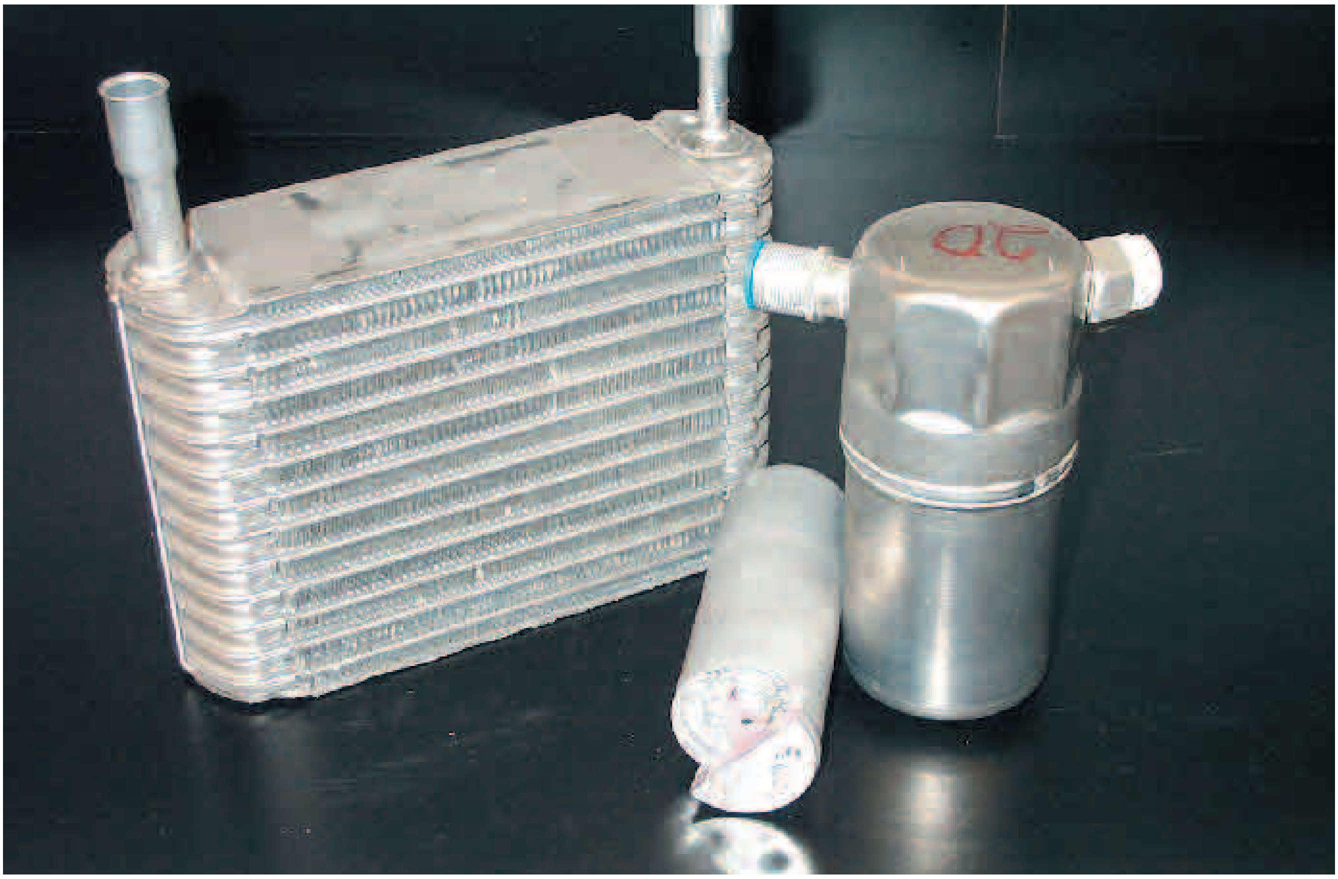

Fig 1. Typical non structural automotive application.

Aluminium provides its users with the opportunity to utilize a material which has comparatively light weight, high strength, versatility of both extruding and casting, and excellent corrosion resistant characteristics. When we consider this material's physical properties, in conjunction with the continually developing environmental issues, such as improving fuel efficiency and superior recycling capabilities, it becomes perfectly understandable why it is increasingly becoming the popular choice of engineers and designers for a variety of automotive applications. With the advancement of aluminium within this industry, we have seen both the need for developments within the area of welding equipment used for this somewhat specialized material, and also, the increased demand for technical training in aluminium welding technology.

Equipment Characteristics

When considering the developments in aluminium welding equipment, the friction stir welding of aluminium has probably been the most publicized in recent welding journals and has attracted much attention. The friction stir welding process has many unique and exciting characteristics when used to make certain joints in aluminium alloys. However, friction stir welding is somewhat limited in its application and, while excellent for some components, does not have the versatility of some of the other welding processes. This discussion shall be directed toward the development and use of one of the more traditional methods of welding aluminium, the Gas Metal Arc Welding (GMAW) or alternatively named Metal Inert Gas (MIG) welding process. This process has been used for the welding of aluminium for many years. Historically, the first aluminium welding operations were of a non-structural nature, performed on heat exchangers, radiators, cooling systems, and their associated components. Considerations for this type of welding have been primarily to consistently produce welds with minimum leakage rates. Procedure development has revolved around the use of high silicon content filler alloys with minimum consideration for strength characteristics with much emphasis placed on fluidity and the ability to seal weld joints in thin material. More recently, there have been major moves toward the fabrication of structural components such as engine cradles, front and rear suspension frames, drive shafts and wheels.

These welded components can often be subjected to dynamic loading in service and, consequently, can be susceptible to fatigue. Structural welded joints of this nature require very different considerations when developing welding procedures and maintaining welding quality that is acceptable for their service conditions. The requirement for higher integrity in structural welded joints in aluminium, along with the recognition of some unique characteristics of aluminium which can produce certain welding discontinuities, has promoted the necessity for a better understanding of welding equipment characteristics. Some of the inherent problems associated with the MIG welding of aluminium and the production of high integrity structural welds, when compared with the welding of steel, are: feedability, incomplete fusion at the start of a weld, and crater or termination cracking at the ends of the weld.

Feedability: This is the ability to consistently feed the spooled welding wire when MIG welding, without interruption, during the welding process. Feedability is probably the most common problem experienced when moving from MIG welding of steel to MIG welding of aluminium. Feedability is a far more significant issue with aluminium than steel. This is primarily due to the difference between the material's mechanical pro-

Figure 2. Structural applications like this wheel are becoming much more common within the automotive industry.

perties. Steel welding wire is rigged, can be fed more easily over a further distance, and can withstand far more mechanical abuse when compared to aluminium. Aluminium is softer, more susceptible to being deformed or shaved during the feeding operation, and, consequently, requires far more attention when selecting and setting up a feeding system for MIG welding. Feedability problems often express themselves in the forms of irregular wire feed or as burn-backs (the fusion of the welding wire to the inside of the contact tip). In order to prevent excessive problems with feedability of this nature, it is important to understand the entire feeding system and its effect on aluminium welding wire. If we start with the spool end of the feeding system, we must first consider the brake settings. Brake setting tension should be backed off to a minimum. Only sufficient brake pressure to prevent the spool from free-wheeling when welding has stopped is required. Electronic braking systems and electronic and mechanical combinations have been developed to provide more sensitivity within the braking system. Inlet and outlet guides, as well as liners, which are typically made from metallic material for steel welding, must be made from a non-metallic material such as nylon, to prevent abrasion and shaving of the aluminium wire. Drive rolls have been developed, often with U-type contours with edges that are chamfered and not sharp, that are smooth, aligned, and provide correct drive roll pressure. Excessive drive roll pressure can deform the aluminium wire and increase friction drag through the liner and contact tip. Contact tip I.D. and quality are of great importance. We are seeing the availability of contact tips made specifically for aluminium welding, which have smooth internal bores and the absence of sharp burrs on the inlet and outlet ends of the tips which can easily shave the softer aluminium alloys.

Aluminium welding wire is used in both push and pull feeder systems; however, limitations are recognized dependent on application and feeding distance. Push-pull feeder systems for aluminium have been developed and improved upon to help overcome feeding problems and may be used on more critical/specialized operations such as robotic and automated applications. More recently, the planetary drive push-pull system (ESAB Mongoose System) has become popular for aluminium welding, providing an extremely positive feeding system capable of delivering aluminium wire over greater distances with minimum burn-back problems.

The Hot Start Feature: Aluminium has a thermal conductivity about 6 times that of steel, and because of this ability to rapidly conduct heat away from the weld area, there has always been an inherent problem, particularly when starting a weld on this material. It is not uncommon to experience incomplete fusion at the start of an aluminium weld because of the material's high thermal conductivity. One method which can now be used to help overcome this problem, particularly on thicker sections of aluminium used in structural applications, is the use of equipment that has a hot start feature. This feature may allow the user to program the weld starting current characteristics independently from that of the general welding current parameters, thus providing the user with the ability to start the weld with a higher current density for a predetermined period before moving to the general welding conditions for the remainder of the weld. This allows the use of a higher heat input at the beginning of the weld that can help to overcome the dramatic heat sink associated with this material prior to the weld area becoming heated by the welding operation. The result of this technique is to eliminate, or significantly reduce, the probability of incomplete fusion at the start of the weld, and thereby improve the life expectancy of welded components subjected to high stress or fatigue loading.

The author conducting training in aluminium welding technology at the AlcoTec Training school.

Crater Fill Feature: Other characteristics of aluminium which can provide welding problems are associated with its thermal expansion, which is about twice that of steel, and its shrinkage on solidification, which is 6% by volume. This can increase both distortion and weld crater size. One common concern when welding aluminium is crater cracking or, what is sometimes called, termination cracking. When MIG welding with conventional equipment, once the trigger of the welding gun has been released, the arc is extinguished, and no additional filler metal is added to the weld pool to fill the crater. Consequently, if no further precautions are taken, a large crater will be left which will have a higher probability of cracking. Craters can be serious defects, and most welding standards require them to be filled and free from cracks. Run-off tabs, or other methods of locating weld craters on scrap material away from the weld, are not usually practical. However, if the weld pool size can be reduced before the arc is fully extinguished, the resulting crater may be very small or almost eliminated and, consequently, the weld may be free from cracks.

In the past a number of welding techniques have been used in an attempt to reduce this termination problem. Reversing the direction of travel at the end of a weld, increasing travel speed to reduce crater size, and providing suitable build-up and removing the crater area flush with the weld surface by mechanical means, are some of the methods which have been used. These methods are often difficult to control, require specialized training, and are not always successful in their objective. More recently, welding equipment has been developed for aluminium welding which has a built-in crater fill feature. This feature is designed to terminate the weld in a gradual manner by decreasing the welding current over a predetermined period as the weld is completed. This feature may be adjustable to enable the user to select the most favorable termination conditions, thereby preventing a crater from forming at the weld termination. Tests have shown this crater fill feature to be extremely user friendly and very effective in eliminating the crater cracking problem.

Other equipment features which may be significant:

Slow Run-In Start: This feature is desirable under circumstances that require precision starting characteristics to minimize start-up fusion defects and provide a starting profile that is acceptable when the weld overlaps at termination. It is also desirable to prevent wire-base contact problems (example, bird nesting) at the start of a weld when high feed rates are incorporated, particularly when using the softer aluminium filler alloys.

Burn-Back Control: This feature is desirable when the accurate and consistent positioning of the welding wire, in relationship to the completed weld, is required. When used with the crater fill option, the wire is effectively separated from the puddle, and it leaves a sharp end in preparation for the next weld start. It is particularly useful with those manufacturing procedures that require consistent restarting capabilities.

The need for technical training in aluminium welding technology:

The advancement of aluminium in the automotive industry, along with its increased use within the welding fabrication industry in general, has certainly promoted the development of specialized welding equipment design. Correspondingly, the increased use of aluminium welding has promoted the demand within industry for technically competent aluminium welding personnel. The need for welding engineers, technicians, inspectors, supervisors and welders who have experience and technical training in aluminium welding technology has increased. Unfortunately, because aluminium welding has traditionally represented such a small part of the overall welding industry, personnel with such qualifications have been difficult to find. Many of the universities and technical institutions, which have been involved in welding education, have neglected detailed instruction in aluminium welding technology. Consequently, it is not uncommon to find formally trained welding engineers with very little, if any, experience or in-depth training within this field.

In order to help remedy this problem, and in recognition of the need for technical training and support for those manufacturers who have moved into the aluminium welding industry, AlcoTec Wire Corporation provides specialized training in aluminium welding technology. AlcoTec is located in Traverse City, Michigan, U.S.A., and is recognized as both a world leader in the manufacturing of aluminium welding wire, and the ESAB Aluminium Welding Center of Excellence. AlcoTec's staff of metallurgical, welding, and quality engineers present numerous training courses that combine their many years of aluminium manufacturing experience with a knowledge of the industry equipment, specifications and quality requirements. Training courses, which have been developed over many years, are designed to incorporate both the theory and practical hands-on approach to the welding of aluminium alloys.

Moving forward with weld quality:

In order to successfully improve both aluminium welding quality and productivity, it is important to understand the many features of today's welding equipment, and how they may assist us in achieving our objectives. We must use these available features to reduce the probability of rework or defective welding and enhance our welding efficiency. It is also important to evaluate our human resources to ensure that we have technically competent welding engineering personnel. We must utilize technical training, when necessary, in order to develop our technical skills and promote the successful development of welding quality and improve manufacturing efficiency.

About the author

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