What's Wrong with Welding

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Many people involved with the use of steel in structures worry about welding. Every day, examples occur which demonstrate the lack of confidence in welding. What are the reasons for this ? What is wrong with welding ? The word "welding" obviously causes an emotional reaction with many people.

The layman "knows" welding is not reliable. He has had personal experience with the weld which broke on a kitchen stool or on his garage door or car trailer.

But in the structural industry is this suspicion of welding justified?—because if not, then it is interfering with the efficient use of welding. It is interesting to stop and reflect just how much the results obtained from welding are influenced by the attitude of mind with which it is approached. It is clear that soundness and reliability are affected by the approach of those involved in the design and manufacture, but so are the efficiency and economy of welded construction. Costs can be considerably, affected by the requirements and standards set. As there is no mathematical way in which these standards can be calculated, they are based largely upon what is loosely called "experience", and are inevitably very much influenced by attitudes of mind.

The idea behind this talk came largely from an overseas trip last year when the writer spent time with a number of structural companies in America. The clear impression was gained that the same degree of hesitancy does not exist in their approach to welded construction. The comparison of their practices with ours, in this industry, was most interesting and left the writer with the belief that the fear of welding which often exists in this country, inhibits our efficient use of it. To use welding to the best advantage, requires a fairly high level of competence and technical knowledge. A respect for these requirements is necessary. Such a respect is a positive and constructive factor —whereas a fear of welding is unhelpful and negative. Yet this fear is often evident in the structural industry.

Why is This ?

What are the reasons underlying this lack of confidence in welding ? There would appear to be two basic causes. Firstly the very obvious human influence which the welding operator has over the finished product and secondly the metallurgical effects which accompany the welding process.

Comparison of welding with an alternative method of joining, such as bolting, illustrates the first point. Bolts are mass produced on machines and the finished product shows no evidence of human influence. Inserting bolts in holes and tightening is a simple operation. Yet welding, particularly manual and semi-automatic but also automatic welding, shows clearly visible evidence of human influence on the finished weld.

Similarly, with regard to metallurgical effects, the user can completely ignore such considerations and obtain perfectly satisfactory results with bolted joints. Yet consideration of metallurgical effects which can occur is needed to use welding satisfactorily. One problem here is that metallurgical matters are notoriously worrying to the Engineer. There appear to be some form of mental barrier between the Engineer and problems related to metallurgy.

Problems have occurred with welding, just as they have in many other areas of engineering. However,

due at least in part to the two points mentioned above, particularly the mystery which lack of understanding brings to difficulties involving metallurgical factors, welding problems have tended to be misinterpreted. Welding is used very widely in many different industries, and very often we have seen the result of experience in one field misunderstood when applied to another. Precautions which are necessary to avoid difficulties in one field have been applied unnecessarily in another, because of lack of appreciation of essential differences in design or fabrication or loading and service conditions. One example of this is the application of "lessons" learned from fatigue loading conditions to statically loaded structures. Unnecessary worry about such points on connection details of statically loaded structures is not uncommon. Another, more subtle, example is the degree to which an Engineer's confidence in welding may be influenced by having had little opportunity for close personal contact with welding, and he may be unconsciously influenced by the welded furniture or car trailer at home which fractured. Generally this weld failed because it was grossly poor and laid under conditions completely lacking in any competent control. (The human factor mentioned above was given full opportunity to do its worst !) Much of the atmosphere of worry which surrounds welding is derived from such misinterpretation of the results of experience gained under one set of conditions, applied to a different set of circumstances.

It is also regrettable that so many of the people in the industry, who are interested in welding, are obsessed with the potential problems. Undoubtedly they have contributed very greatly to the hesitancy with which welding is viewed. They spend much time warning others of the many pitfalls contained in the welding process. This is unfortunate. In other industries, one finds supporters who are very much more aware of the advantages of their medium. They are quite conscious of the areas in which care is needed and ready to discuss them, but they appear to be imbued more with the advantages rather than the disadvantages.

Is it Justified ?

Is the relatively low level of confidence in structural welding justified ? If not, as stated earlier, then it is adding unwarranted costs. This in itself is to be avoided, and in addition is costing the welding industry work.

In general, the Americans are more ready to place their trust in welded construction of buildings and bridges than we are. A result of this is that the number of hours taken to make a job in Australia is higher by comparison, due to added specification and inspection requirements. We tend to spend time on various refinements and precautions which American practice would suggest are of very doubtful value to the job. This is particularly noticeable on bridge work and is undoubtedly a factor of significance in the low usage of steel on bridge work in this country.

Our reluctance to use higher strength steels is a further case of the effects of our pre-occupation with the problems of welded construction. These steels are being used in the industrialised countries all round the world to achieve more economical construction. The impression has been created here that the fabrication of these steels is far more difficult than is in fact the case. There is no doubt that they could be fabricated satisfactorily here today. We must learn to see such problems in proper perspective.

The emphasis we have put on difficulties of welding has led to the misapplication of experience from one set of circumstances to another. It has also led to the introduction of an emotional element into the assessment of many welding problems at the expense of a more objective and scientific evaluation. This emotional factor adds cost to the structural industry and must also result in work being diverted from steel to other forms of construction.

Human influence

As already stated, the human influence which the operator can exert over the quality of the welded joint is often a source of concern in relation to the welding process. As with any other occupation, the operator must of course have the ability to do his job. Yet the comments often made regarding the dependence of the finished job on the frame of mind of the operator, including the state of his liver, etc., are greatly overstated. Certainly the process relies on the correct manipulation of the arc by the operator and so the opportunity exists for appreciable fluctuations due to operator effects. However, in practice, in the structural industry, little evidence occurs to support the idea that this is a real problem providing the fabricator employs a reasonable degree of supervision. The author believes that competent supervision, including the laying down of suitable procedures, is the important factor. It is more important to emphasise the need for proper theoretical support behind the welding operation (to fix sound procedures, etc.) rather than the reliance of the process on the possible short-comings of the opera-

tor. Any problems due to inadequacy of the operator usually tend to be very obvious visually when they do occur on structural work. It is also worth remembering that reliance on the operator is not unique to the welding industry and can have effects of similar significance in other forms of construction.

The metallurgical implications associated with welding form another obstacle inhibiting confidence in welding. Engineers tend to put matters related to metallurgy in the "too hard" basket. Communication between metallurgists and engineers is not nearly as effective as it could be. Each operates in a different world. The metallurgist, being more a scientist, is interested in questions of transformation within the heat affected zone and with fracture. Whereas the engineer tends to be horrified at the problems such subjects suggest to him. This mental barrier, which is closely allied with lack of knowledge, tends to cause the engineer to see these problems in an exaggerated light.

In order to use welding effectively, however, it is very necessary to recognise the need to understand the process, and this includes an appreciation of some of the metallurgical effects. A positive, interested approach to welding enables more satisfactory and economical use to be made of it. An attitude which is negative and is accompanied by lack of knowledge and fear of the process must lead to increased cost and may well produce results which are unsatisfactory in some other way.

Whilst the designer and the fabricator should be as well informed as possible in relation to welding, there may be a good argument for the respective areas of responsibility to be more clearly defined. There is considerable overlapping of responsibility in our present practice. Perhaps more emphasis should be placed by designers on specifying performance required, rather than methods to be used in attaining this.

Status

When taking an objective view of the present day status of welding fabrication, the advances of the last 10 years must not be underestimated. Welding is being used under more demanding conditions today than 10 years ago, but again we must avoid looking at the negative side only. During this period, a vast amount of research has been conducted throughout the world and has produced results which are benefitting the industry. Often those involved in the industry are not fully aware of this happening. Similarly, practical experience in other countries as well as our own brings knowledge which we may overlook. Of equal importance, a better level of appreciation of welding is far more common today within the industry and more effort is made to keep up to date with this. Welding equipment and consumables have also been improved to the extent that the production of good results has become much easier. Too often these advances are overlooked by people specifying welding.

The Real Test

Looking at the service record of welds, how well do welded structures perform in service ? This is the real test. Considering structural work, such areas as high cycle fatigue, as in certain components of moving vehicles, and grossly inferior welding, as may be performed under "backyard" conditions, should be excluded as irrelevant, although both these fields have reflected on the reputation of welding generally. The performance of welded structures in service is good. The tolerance of a welded steel joint to abuse is not always realised. It normally has good ductility, notch toughness and strength. It can tolerate the presence of internal defects to a degree which is still not well known and would surprise many users. But welds laid under workshop conditions can be expected to have strength well in excess of the material joined. Fillet welds have strength far greater than the values indicated by normal design procedures. A welded joint must be seriously deficient in some aspect of its design or manufacture not to perform satisfactorily in service.

It is a pity then that we approach the use of welding so hesitantly. For instance, so few structural job specifications simply ask for : "welding to be performed in accordance with AS CA8". Instead, many specifications not only repeat certain clauses from the SAA code, but add various private ideas of the individual specification writers as well. Whilst this must be justified on certain occasions, wide-spread use of this approach is an indication of anxiety.

Summary

It is suggested that a problem with welding in the structural industry is the unreasonably low level of confidence which very many people who elect to use the process have in it. This is regrettable because the results and value obtained from welding can be very dependent on the philosophy with which it is approached. Experience has shown present day welded structures to give good, reliable results in service, yet the industry is over conscious of potential problems. A more positive approach is justified, where too often today it is negative. This could help to produce worthwhile economies in welded structures and help their competitive position with other types of construction.