Welding : Basics, Quality Control and Defect Analysis - Part I

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ABSTRACT

Welding in the construction Sector takes a major role throughout the world. Too many persons related to welding and nondestructive testing are involved in this unorganized sector and therefore it should be highlighted properly. This article is for the interested professionals, those who want to know the basics without passing through the tussles of metallurgy and tough discussions. This is based on experience in different projects and highlighted basic things to start welding and detail coverage on defects, its causes and radiographic images.

Keywords: Welding, NDT, Defect analysis

1.0 PREFACE

Most of the welding throughout the globe takes place in the unorganized sector, where new construction activities are there for the new projects. In the light of that, this article has been designed for the basic requirements in construction welding and analysis for the failures, i.e. repairs in accordance with construction language, without going through the metallurgy or other tough discussions. These are known to most of the related professionals, but the importance is still the high.

2.0 REQUIREMENTS

In each and every project, welding requirements are defined in the project specifications and also defined the codes and standards to be followed (e.g. ASME B31.3). We all know that mainly SMAW and GTAW processes are being used in construction sites and pipe welding is the major issue; therefore, our discussions will highlight mainly the pipe welding issues.

3.0 WPS AND PQR

First step before starting any weld is to establish the welding procedures. Welding procedure specification (WPS) has to be prepared first on the basis of materials to be welded and then the same shall be supported by Procedure qualification record (PQR) after testing through laboratory. This WPS shall always be available near the joints to be prepared and welded.

4.0 SKILLED WORKFORCE

Skilled pipe fitters and welders for every variety of welds shall be available for better quality of welding. They shall always be aware of the jobs to be done and shall be able to read the WPS properly; otherwise, repair percentage will go higher and higher. Screening is required during qualification test of welders.

5.0 CONSUMABLES

In case of GTAW, not only filler wire but also the purity of argon gas shall be checked for a good quality of welding. For SMAW, most important is the treatment of low hydrogen electrodes. Manufacturer's recommendations must be followed for the baking and holding of the electrodes, i.e. drying or re-drying procedures to be followed. After unpacking, electrodes shall be baked in a properly calibrated oven at 350°C to 400°C for 2 hours (or as required by the manufacturer). Then it shall be transferred to a holding oven at 100°C to 150°C (or as required by the manufacturer) and from there to the personal quiver of the welders. Normally, 3 baking cycles are allowed; and after that the electrodes must be destroyed. Hermetically sealed containers (vacuum packed) are available, from which low hydrogen type electrodes can directly be used for the welding.

6.0 CHECKS BEFORE WELDING

The followings to be checked during the preparation and before starting any welding joint as a minimum:

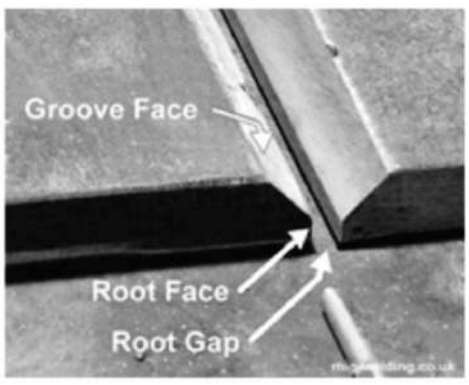
- Check drawing, weld position and weld symbol
- Check whether the procedure align with specification
- Check base material and consumable are defect free and in accordance with the specification
- Check for proper fit-up of joints
- Check cleanliness
- Check whether preheat is recommended
- Check calibration status of welding machine and quiver
- Check fulfillment of safety requirements

7.0 SAFETY DURING WELDING

Apart from the safety regulations specified for the project (e.g. Permit, Fire Extinguishers, Fire Blanket), risks like electrical shock, fumes, burns, fire, etc. shall be taken care properly. Another risk is UV radiation from welding arc, which is harmful for eyes and skin and therefore to be protected properly by helmet, gas mask, protective clothing, etc.

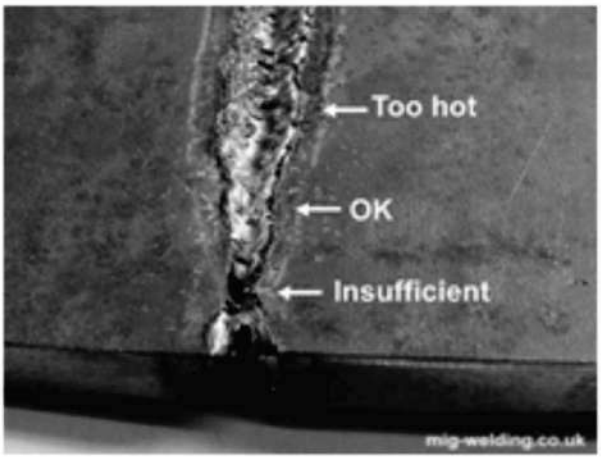
8.0 PREPARATION OF JOINTS

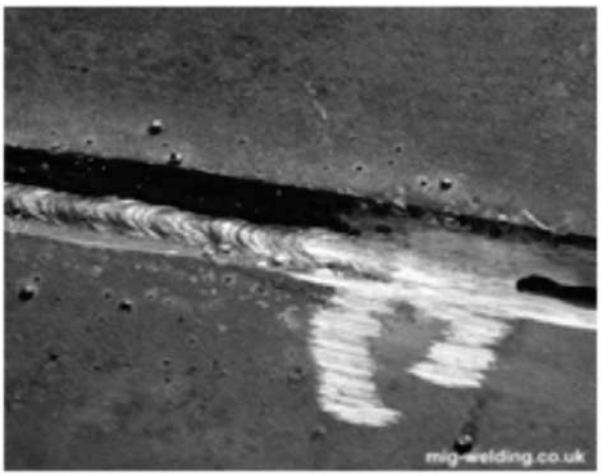
Single 'V' butt joints are widely used for full penetration pipe and plate welding with a limitation to the thickness up to 19 mm. Proper joint design shall be done to ensure penetration and strength of welding. Root gap and root face design shall depend upon the thickness of base material and electrode / filler wire dia.



9.0 ROOT RUN AND HOT PASS

Most important part in a weld is the root; if the root welding can be done properly, most of the problems will disappear. Normally, GTAW welding is recommended for the root run and hot pass (2nd run) and depending upon the thickness of the pipe, filling and capping processes are selected (either GTAW or SMAW). Apart from the welders, important role is there for pipe fitters, who should prepare the correct fit-up of the joints to be welded. If the joint design is not followed, there shall be every possibility for a potential repair. There is a very fine balance between insufficient penetration and blowing holes – a little weave can help to control the arc. The transition portion between electrodes should be ground taper to achieve the required heat by the time it reaches the gap, so that the proper penetration is ensured. It is not recommended to leave any joint only with root run; hot pass is required as a minimum, before leaving a joint for welding afterwards.

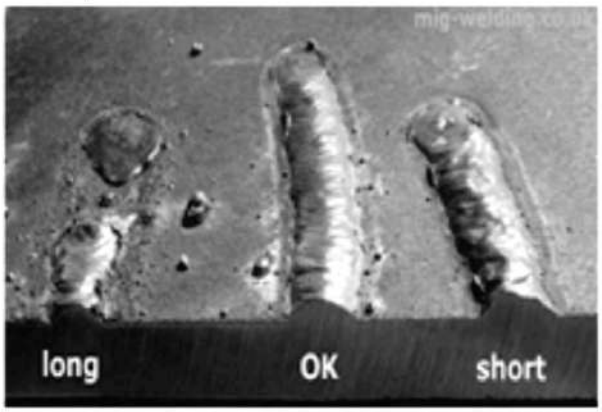


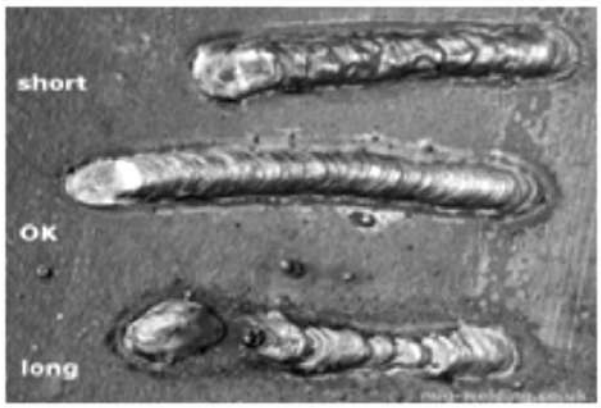


10.0 ARC WELDING FAULTS

10.1 Arc Length

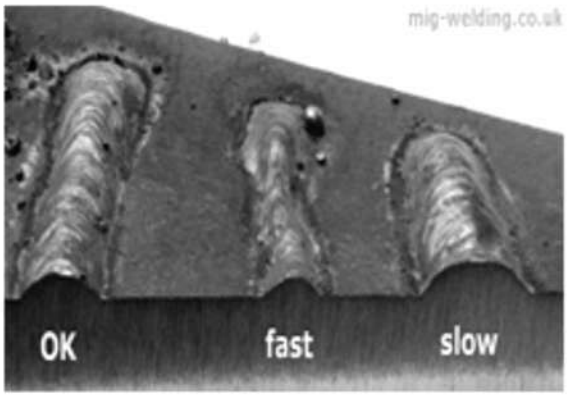
- **Arc length too short:** Short arc length will reduce the voltage and therefore reduces the heat input, resulting slag inclusion and lesser strength weld joints.
- **Arc length correct:** The weld joint will have consistent profile and minimal spatter in correct arc length.
- **Arc length too long:** Long arc length will increase the voltage and unstable arc, resulting a flat and wide weld with spatter and undercut.

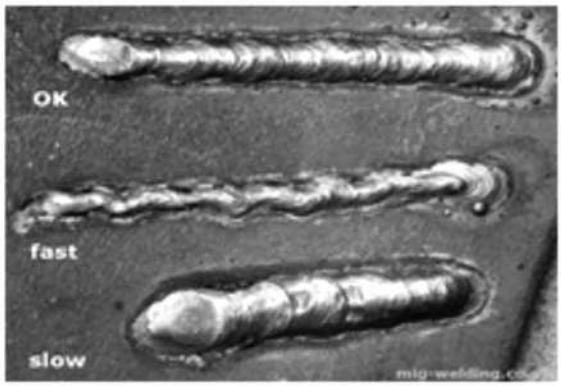




10.2 Travel Speed

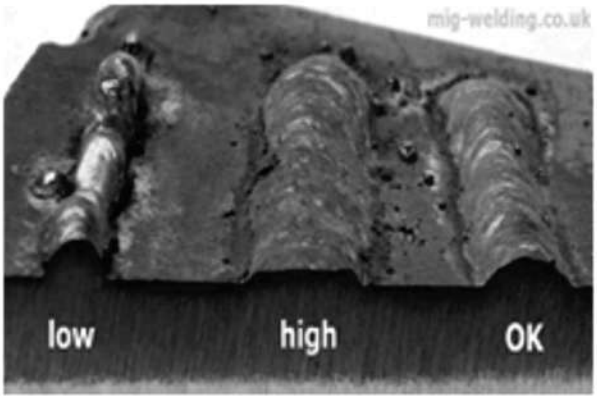
- **Travel speed correct:** The bead is fairly consistent and the ridges are semicircular where the travel speed is correct.
- **Travel speed too fast:** Excessive travel speed results in a thin weak bead and the ridges are elongated and triangular.
- **Travel speed too slow:** Too slow travel speed will produce non consistent bead and will collapse into the crater.





10.3 Current setting

- **Amps to low:** Setting the amps to low will result in a tall narrow bead and the arc will prone to stray towards one side of the weld pool.
- **Amps too high:** Setting the amps to high will result in a wide, flat and irregular bead with possible undercuts. A crater will form at the end and the slag will be difficult to remove from the edges of weld.
- **Amps correct:** With the amps set correctly, the bead will be consistent and round in shape and the slag will come out easily.



11.0 CHECKS DURING AND AFTER WELDING

The followings to be checked during and after completion of welding joint as a minimum:

- Check electrodes for size, type and storage
- Watch root run for susceptibility to cracking
- Inspect each weld pass for contour and cleanliness
- Check weld sequence
- Check for craters that need to be filled
- Check the size of weld by gauges
- Check for visual defects and finishing
- Determine if spatter is at acceptable level
- Verify marking of joints for traceability
- Update weld maps

12.0 PRODUCTIVITY

Productivity and quality always contradicts each other; if superiors pressurize for productivity, the quality of the weld will go down surely. But it is the duty of welding engineer or inspector to verify that the productivity per welder is up to the mark. While preparing the weld map, erection joints should be kept as minimum as possible. Since erection joints are always difficult, preference should be given to prefabrication joints. This may also help to increase productivity and minimize repairs. Productivity overview from Western Libya Gas Project from March 2003 to July 2004 (**Fig. 1**) and Borealis LD5 Project - Sweden from June 2008 to September 2009 (**Fig. 2**) are illustrated here below just for reference. This is based on the monthly production (Dia-inch) divided by average number of welders involved throughout the month and then again divided by the number of working days on that month.

13.0 NONDESTRUCTIVE TESTING

In construction sector, main NDT methods used are liquid penetrant testing and radiography. Radiography takes the major role in detecting the quality of pipe welding. It may either be X-ray or γ-ray. Though γ-ray used in vast, X-ray is mandatory in some projects. Acceptance criteria of the joints shall be as per specified standard.

14.0 REPAIR ANALYSIS

For a project, normally 3% repair of total butt-welded joints is acceptable. Lesser the better; but if it is more, root cause of the failure must be analyzed to eliminate it. Action plan should be chalked out for the corrective action. An example of repair analysis from NATPET Project, KSA (from April 2006 to September 2007) is illustrated here below for reference (**Fig. 3**).

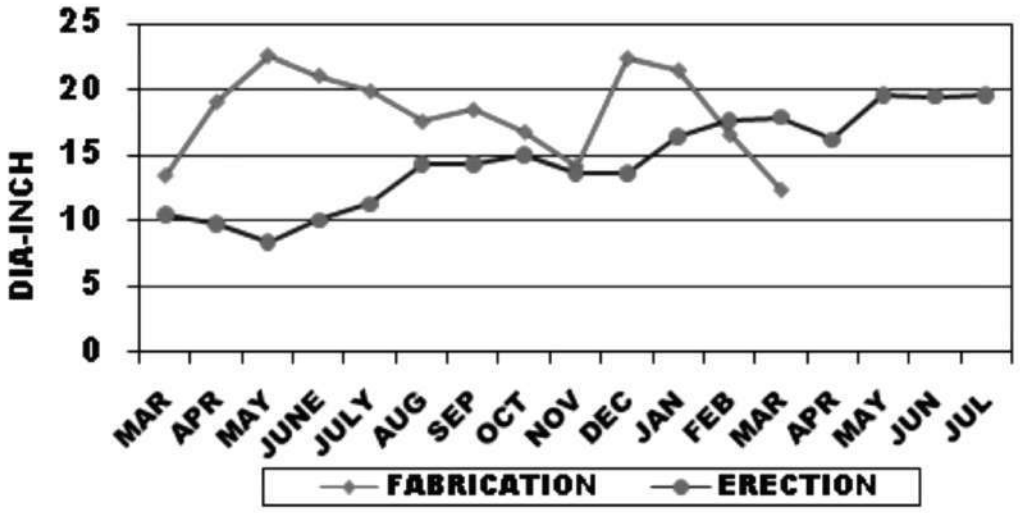


Fig. 1 : Production Analysis Per Welder Per Day (WLGP)

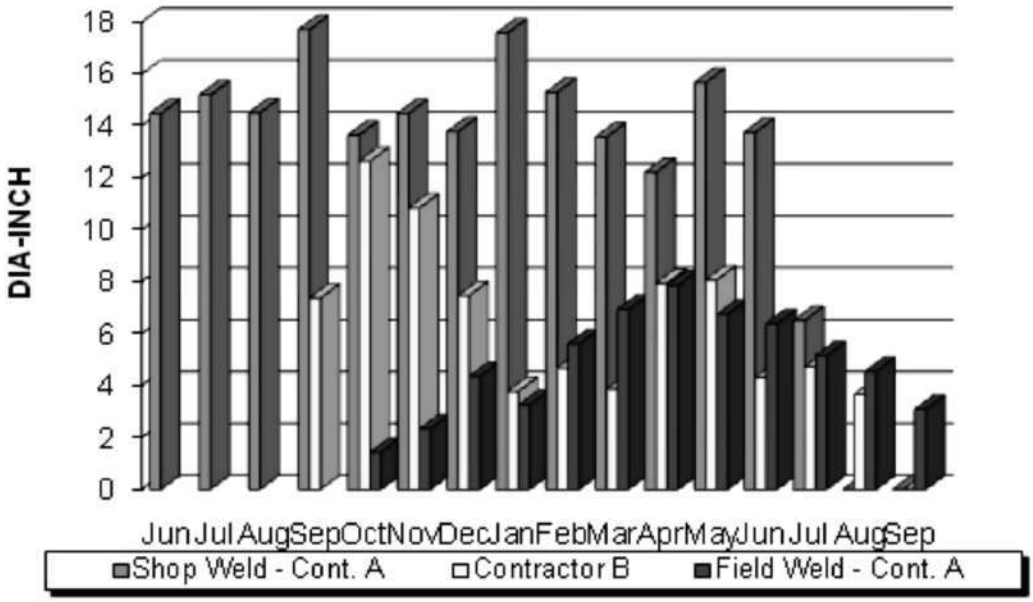


Fig. 2 : Average Productivity Per Available Welder Per Day (LD5)

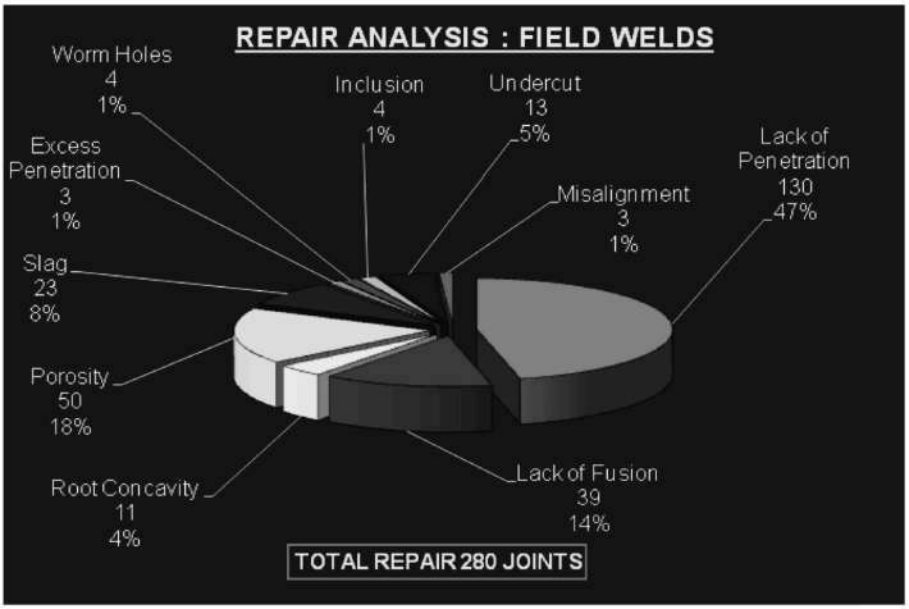


Fig. 3

15.0 DEFECTS IN WELDING, ITS RADIOGRAPHIC IMAGE AND PROBABLE CAUSES

Refer Part II in next issue.

16.0 CONCLUSION

This article will be helpful for the interested professionals, those who are new to welding and those who want to know the practical knowledge related to welding in construction sites in an easier way, without going through the tussles of metallurgy and tough discussions.

17.0 ACKNOWLEDGEMENTS:

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