Reduction in through put time of drum shell manufacturing by single-V welding configuration

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Abstract: The present work highlights the outcomes of the case study that investigate the reduction in through put time of drum shell manufacturing, which earlier employed a double-V butt welding configuration for joining the ends of the plates after rolling the plates into cylindrical form, while the proposed method makes use of single-V type configuration to fabricate the drum shells with ceramic backing strip arrangement. The proposed work eliminates some redundant operations like inside welding, back grinding and other side edge preparations thereby reducing the production time of drum shell manufacturing. 38% improvement in production rate of drum shells was observed by proposed method compared to the earlier method.

Key words: Production time, single-V type welding configuration, ceramic backing strip, drum shell manufacturing.

1. Introduction
Through put time (TPT) corresponds to the amount of time required for a product to pass through a manufacturing process, thereby being converted from raw material into a finished product. The concept also applies to the processing of raw materials into a component or sub-assembly, so that decrease in TPT results in improvement of productivity and increase in profitability. The bulk of the time spent in manufacturing not only constitutes the components such as material transfer, operation time, inspection or queuing, but also the type of method employed for production. Therefore it is necessary to eliminate some redundant operations by adopting new methods to control production time. In Thermax Limited, Pune, drum shells were manufactured by double-V type welding configuration for L-seam and C-seam, which consumed major part of the time in inside welding, back grinding and reverting plate for both side weld edge preparation. This work emphasizes to resolve the aforementioned difficulties by adopting new method that makes use of single-V type welding configuration for L-seam joints by providing ceramic backing strip attachment.

2. Background of Project
In the boilers, drums are highly pressurized components, which require very strong and thick welds. Drums consist of L-seams and C-seams of shell to shell / dished ends and nozzle welds on shell / dished ends. Drums are exposed to high pressure and temperature up to 150 kgf/cm² and 370° C
respectively. L-seams are shell closure welds which withstand very high pressure, C-seams are shell to shell and shell to dished end welds.

Figure 1 shows schematic of boiler drum where the location of L-seam and C-seam welds are indicated. Number of shells to be employed depends upon the capacity of boiler and customer’s requirements.

2.1 Existing method of welding configuration:
Figure 2 shows the existing method of double-V type welding configuration. L-seam and C-seam welding operations were performed using double-V type configuration which required both side welding, in which SMAW process is used for root run at inside of the shell. After root run, SAW process was employed for completing the welding of inside V-groove followed by back grinding to remove root run to achieve soundness of weld metal from outside. Subsequently, SAW process is deployed for welding outside V-groove to complete the process.

2.2 Proposed method of welding configuration:
The proposed work employs single-V type welding instead of double-V type welding configuration with ceramic backing strip with same quality of weld to overcome those problems. The schematic of proposed method is shown in figure 3 in which the test plates were prepared with an included angle of 40°, root face of 1mm and root gap of 4 to 5 mm to obtain full penetration. The proposed method eliminates the redundant operations observed in the earlier procedure followed and contributes to reduce the TPT of drum shell manufacturing.

Thus the present work aims at the following objectives.

i. To reduce TPT (Through Put Time) required for boiler drum shell manufacturing.
ii. To improve productivity of drum shell and drum manufacturing.
iii. To eliminate inside welding.
iv. To eliminate back grinding.
v. To eliminate plate reverting for other side weld edge preparation.

Backing Strip Arrangement: A backing strip is a strip of metal / non-metal placed on the backside/root side of the joint. The backing strip is made up of a ceramic material Al₂O₃ which does not react.
chemically with molten metal and welding consumables. In all the cases, it is important that the backing strip as well as the surfaces of the joint should be clean to avoid porosity and slag inclusions in the weld. It is also important that the backing strip fits intact with the base metal. Otherwise, the molten weld metal can run out through any gap between the strip and the base metal at the root of the joint.

3. Conduction of Experimentation

3.1 Test plate specifications:
The material used for this experiment is SA-516 Grade 70 carbon steel, with size of 360×900×50 mm³. Table 1 indicates the composition of some major elements found in SA-516 steel while table 2 presents the mechanical properties of SA-516 steel plate employed in the proposed study.

| Material | %  | Material | %  |
|----------|----|----------|----|
| C        | 0.2000 | Si      | 0.3500 |
| Mn       | 1.1900 | Nb      | 0.0300 |
| Ni       | 0.2700 | Ti      | 0.0180 |
| Al       | 0.0370 | Cu      | 0.0100 |
| Cr       | 0.0350 | Fe      | Balance |

| Property       | Value |
|----------------|-------|
| Ultimate tensile strength | 562 MPa |
| Yield strength     | 407 MPa |
| Elongation         | 30 %  |

3.2 Methodology:
Figure 4 illustrates overview of steps followed in proposed method; figure 5 shows clear view of attachment of ceramic backing strip to test plate and figure 6 shows complete weld of test plate ready for testing. Figure 7 shows specimens prepared for testing which are mentioned below.

i. Side bend test
ii. Macro test
iii. Hardness test
iv. Charpy impact test
v. Transverse tensile test
vi. All-weld tensile test

The above mentioned tests were conducted as per ASME and IBR codes. All non-destructive tests were performed in accordance with standard procedures by qualified technicians in the metrology laboratory at Thermax Ltd, Pune. The test results of proposed method were found satisfactory for all the destructive and non-destructive examinations conducted, maintaining the quality of the welds of the existing method.

4. Comparison of Existing and Proposed Method

This section illustrates results and comparison between existing double-V type configuration and proposed single-V type welding configuration of L-seam joint on drum shells. Table 3 illustrates comparison between existing and proposed method in terms of operations, weld edge preparation and weld metal deposition. Proposed method consumes slightly higher weld metal deposition compared to existing method. Outcomes of the proposed method are discussed below.

TPT required to manufacture drum shell from the existing method is 54 hours whereas proposal method takes 39 hours. The TPT savings from proposed method for one drum shell is 15 hours that results in enhancement of productivity of drum shell manufacturing by 38.4 % i.e. increase in production of drum shells from 375 nos to 519 nos annually. Therefore improvement in productivity results to increment in drum manufacturing.
Figure 4. Steps followed in experimentation.

Figure 5. Attachment of ceramic backing strip on plate.

Figure 6. Test plate after full welding.

Figure 7. Specimens prepared for testing (1. Side bend test 2. Macro test 3. Hardness test 4. Charpy impact test 5. Transverse tensile test, 6. All-weld tensile test)
Table 3. Comparison between existing and proposed method

| Parameter               | Existing Method                                      | Proposed Method                                      |
|-------------------------|------------------------------------------------------|------------------------------------------------------|
| Weld edge preparation   | 1/3rd – 2/3rd of plate thickness for double V        | Single V                                             |
| Included angle          | Outside - 35°                                        | Only outside - 40°                                   |
|                         | Inside - 60°                                         |                                                      |
| Cutting method          | Oxy- fuel flame                                      | Oxy- fuel flame                                      |
| WEP                     | Two times                                            | One time                                             |
| Set-up for welding      | C- type bridge welding from outside                  | C- type bridge welding from inside,                  |
|                         |                                                      | Ceramic backing strip arrangement from inside        |
| Root pass welding       | 2 passes of FCAW from inside                         | 2 passes of FCAW from outside and removal of ceramic strip |
| Inside welding          | SAW process                                          | ---                                                  |
| Back grinding           | From outside                                         | ---                                                  |
| Groove NDT              | MPT                                                  | ---                                                  |
| Outside welding         | SAW process                                          | SAW process                                          |
| TPT Required for one drum shell | 54 hours                                           | 39 hours                                             |
| Weld metal deposition   | 8.16 kg /meter ( For 50 mm thick)                    | 8.23 kg /meter ( For 50 mm thick)                    |
| Drum shells manufacturing | 375 nos. annually                                   | 519 nos. annually                                    |

5. Conclusion

The following conclusions are drawn from the investigations of proposed single-V type welding configuration.

i. Elimination of inside welding and back grinding process was achieved.
ii. Elimination of Plate handling to other side weld edge preparation was achieved.
iii. Reduction in through put time of drum shell manufacturing.
iv. Enhancement of productivity of drum shell manufacturing by 38.4 %.
v. Saving in miscellaneous costs, which include cost of WEP, cost of grinding wheel, electricity saving and labour cost.

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