Scientific Journal of Impact Factor (SJIF): 4.14
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 3, Issue 12, December -2016

To Reduce cycle time in the welding procedure of nozzle on the shell of the Heat Exchanger

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Abstract —*This electronic document is a "live" template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document. The paper focuses on the study of Heat Exchangers during welding of nozzle on the shell* CARRIED *out in the industry. In Heat Exchangers during welding of nozzle on the shell the number of temporary attachments required are many in the process and a lot of time is consumed to set-up all the temporary attachments for the nozzle set-up on the shell. As a counter measure, a fixture is proposed herewith to overcome this problem faced by the industrial practices. This proposed fixture will support the nozzle with rigidity during the welding of the nozzle on the shell in the industries fabricating heat exchanger or similar equipment. The fixture will resist the distortion of the shape & size and allow to carry out the entire welding procedure of nozzle welding on the shell of the heat exchanger in one go thereby reducing cycle time.*

Keywords*-Cycle time reduction, Fixture installation, Heat exchangers, Nozzle, Nozzle set-up, Shell, Welding,*

I. INTRODUCTION

In conventional nozzle setup in heat exchangers generally the temporary attachments are required i.e. like welding some small supports on the job which can be utilized for set up purpose. Some material of shell have special requirements that whenever we have to weld anything (even a small tack) , It needs to be welded with preheat of 150 deg. and which should be maintained during welding and after completion it is required to post heat at 300 deg. for 4 hours, If this is not followed it causes weld to crack. So it is not feasible to waste so much time for temporary attachments.
Say for example if the weight of nozzle is in the range of 2.5 to 2.7 ton, so for the set-up of such nozzles with conventional temporary attachment would be much more complicated with more number of attachment required to support such high load.

Accuracy is the most important factor. There is always a clear doubt that whether accuracy in set up of nozzle with temporary attachment method will be sufficient or not. As the number of temporary attachments increases it is not easy to place them accurately. So there is a requirement of an equipment in this case a fixture which will set up such high load nozzle accurately and with less time consumed (with no temporary attachment required). In case of nozzle in large numbers (Example:-11to12 nozzles) to shell set up is also a feasible reason for fixturing as it will reduce cycle time by some margin.

II. Thick Shell Fabrication

A steel plate of designed thickness are cut to required size. This plate is then passed through rolling machine to turn it into required cylindrical shape. The both end edges i.e. the long seam ends are welded together by SMAW, so that the required cylindrical shape of shell can be achieved.
For the projects, say for example a shell is fabricated out of 91mm thick plate rolled in cylindrical shape as required. If the shell length is too long then the shell is made in different sections (lengthwise). This is because the plate rolling machines have some limitations over the shell diameter and length of the plate that can be rolled. This necessitates the shell to be fabricated in different small lengths, which are then welded together.
The sequence of fabrication of shells and the various steps followed are as follows-

2.1 Inspection and Identification

The plate dimensions (Length, width), required for shell is calculated and plates of same dimensions are cut and the weld edge is prepared. In this step, the plates from the vendor are brought to the manufacturing site and the necessary inspection is done. Various characteristics like the dimensions, material, surface finish etc. are inspected and are cleared for manufacturing. Also, the correct purchase number, project number and plate identification number are stamped on the plate.

2.2 Weld edge preparation

In this step, the edges of the plate which has to be welded later are given the necessary shape which is required during welding. This is done by gas arc cutting and is then ground to the necessary surface finish.

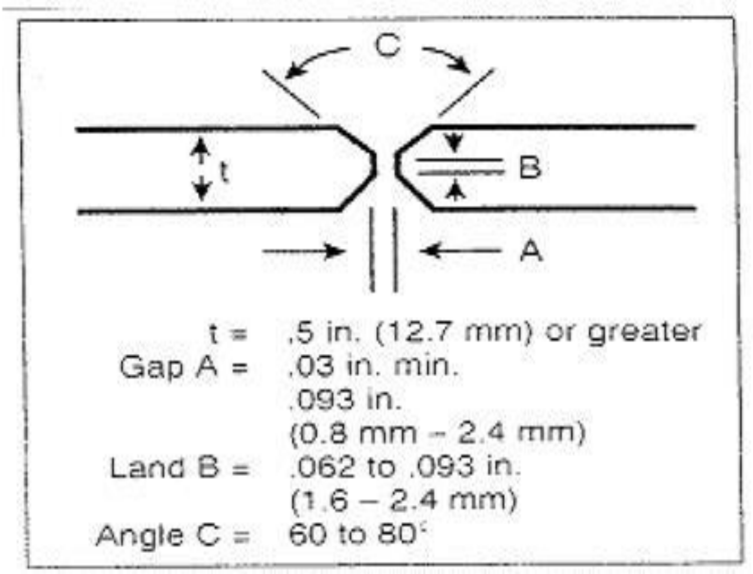
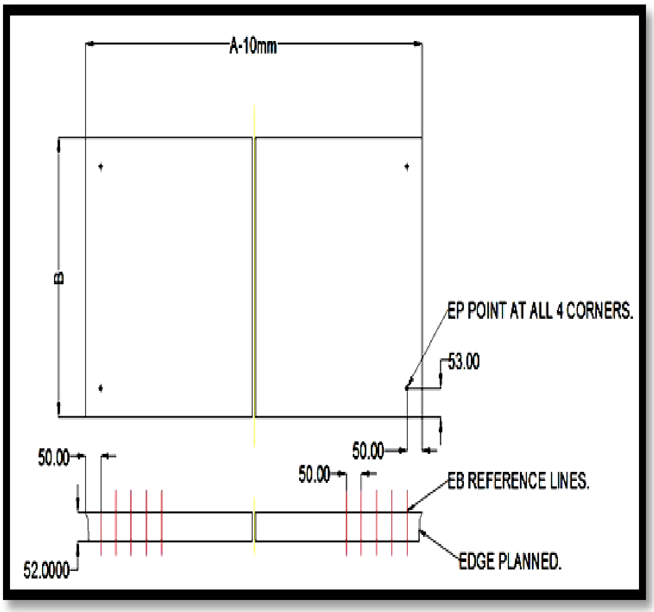
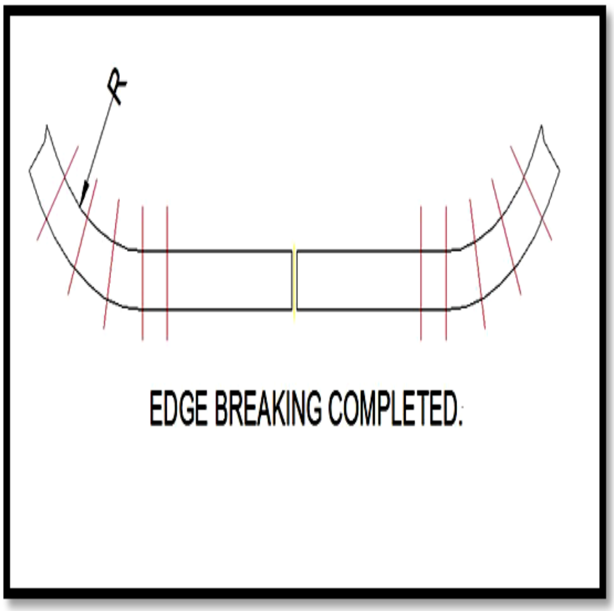


Fig. Typical Double V Joint for plate
Both side accessible

2.3 Edge Breaking

After the weld edge preparation, the edges of the shell are broken and given a slight curve so that rolling becomes easier and the distortion and damage cause to the plate during rolling is reduced.





2.4 Rolling

After edge breaking, the plate is rolled in a rolling machine to give it a circular shape. This is one of the most crucial operations in the shell fabrication procedure. In this process, the operator passes the plate through the rolling machine and then rolls the plate to form a shell. The long seam ends of the plates were being joined together by Shielded Metal Arc Welding. The double-V joint was provided for welding.

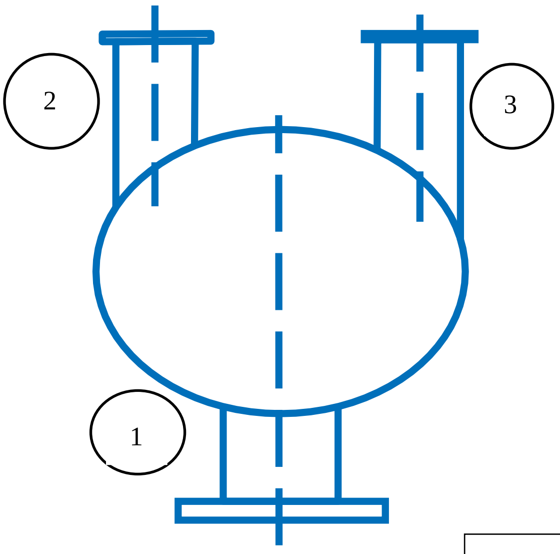
However, for joining this 91mm thick joint, the welding procedure was not conventional. A new welding procedure, called balanced welding was adopted as the rolling machine had suffered a breakdown. The conventional welding was avoided, because the thick shell fabricated with conventional welding joint was found to be distorted in shape and size after such welding and was required to be re-rolled to restore the original shape & size.

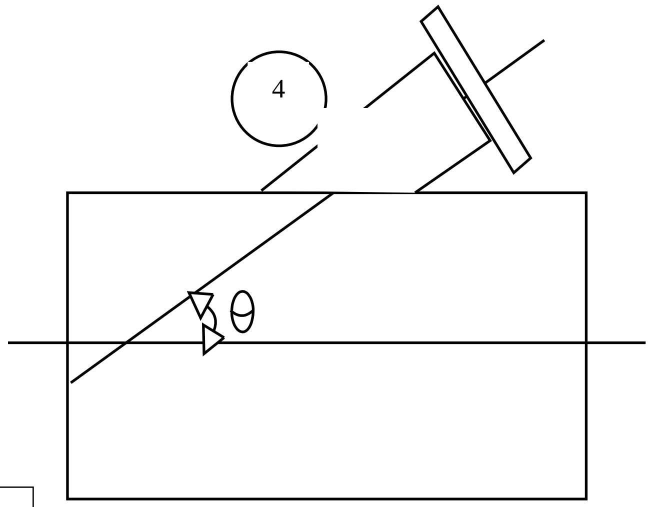
III. Nozzle

A nozzle (from nose, meaning 'small spout') is a tube of varying cross-sectional area (usually axisymmetric) aiming at increasing the speed of an outflow, and controlling its direction and shape. Nozzle flow always generates forces associated to the change in flow momentum, as we can feel by handholding a hose and opening the tap. In the simplest case of a rocket nozzle, relative motion is created by ejecting mass from a chamber backwards through the nozzle, with the reaction forces acting mainly on the opposite chamber wall, with a small contribution from nozzle walls. The nozzle is said to begin where the chamber diameter begins to decrease (by the way, we assume the nozzle is axisymmetric, i.e. with circular cross-sections, in spite that rectangular cross-sections, said two-dimensional nozzles, are sometimes used, particularly for their ease of directionability).

The meridian nozzle shape is irrelevant with the 1D isentropic model; the flow is only dependent on cross-section area ratios. A nozzle is a device designed to control the direction or characteristics of a fluid flow (especially to increase velocity) as it exits (or enters) an enclosed chamber or pipe.

A nozzle is often a pipe or tube of varying cross sectional area, and it can be used to direct or modify the flow of a fluid (liquid or gas). Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them. In a nozzle, the velocity of fluid increases at the expense of its pressure energy
Nozzles are the openings provided on job for the process or functional requirements.
These openings may be in the form of flange connections or threaded connections or pipe.





3.1 Functions and Type of connections of Nozzle

Functions	Types of connection
1) Inlet	1) Flanged
2) Outlet	Flanged
3) Manway / hand hole	3) Flanged / pipe
4) Thermometer pocket	4) Threaded coupling
5) sight glass/ lightglass	5) Threaded
6) Level indicator	6) Threaded coupling
7) Drain	7) Flanged
8) Pressure Guage Connection	8) Treading Coupling
9) Sampling Connection	9) Sampling Cock
10) For Agitator Shaft	10) Flanged
11) For Cleaning device	11) Flange/Pipe

IV. FIXTURE INSTALLATION CONCEPT

The desired fixture must be strong and compact enough to support a heavy weight nozzle of weight ranging from say for example 2.5 Ton to 3.5 Ton. So an I-Beam can be provided along with a round pillar both can be designed together to take most of weight of the nozzle. So the length of I-beam used for distributing the load of the nozzle should be more than the nozzle cut-out diameter say in the range of 100-200mm more which can be enable to take the support of the shell. Height of the I-beam + round pillar should be less than the shell diameter because to set the projection it is required to place a hydraulic jack or mechanical jack below the I-beam and the pillar. Using the hydraulic jack it will be possible to set the projection. For making the nozzle top face level two face side arms can be provided with adjustable screws, so that by adjusting those setting proper level can be a very simple task.

V. FIXTURE INSTALLATION CRITERIA

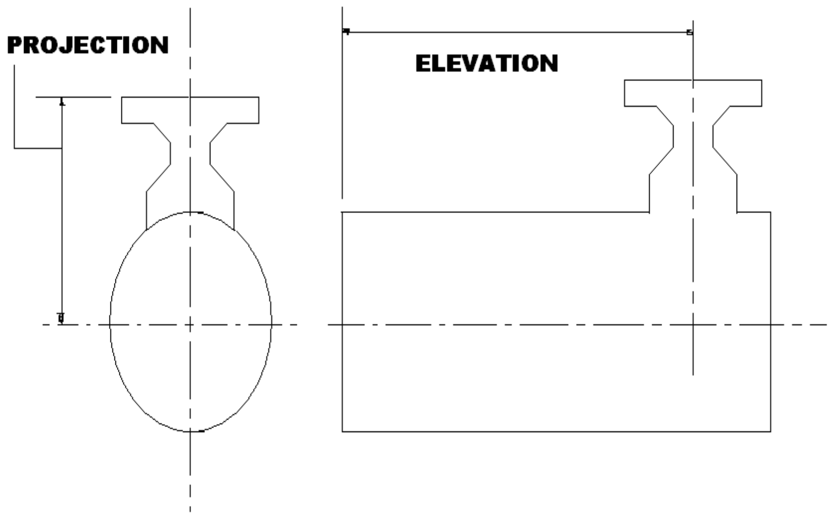
1. Provide Rigid Support: The foremost function of the fixture installation should be to provide rigid support for the nozzle to be welded on the shell, to resist any kind of buckling of the nozzle that is to be supported on the fixture proposed.

1. Reusability: The fixture should be reusable multiple times, to make it economically viable and save overall time.
2. Single fixture for of different diameters of shell and nozzle cut-outs: The fixture must have adjustability to use for different diameters of shells and nozzle cut-outs.
3. Space for movement of welding machine: The design must provide space to facilitate free movement of welding machine from inside the thick shell.
4. Easy installation: The fixture can be easily installed within short time.
5. Easy removal: The fixture should be dismantled easily after nozzle welding on the shell, for next use.

VI. STEPS TO BE FOLLOWED IN NOZZLE SETUP

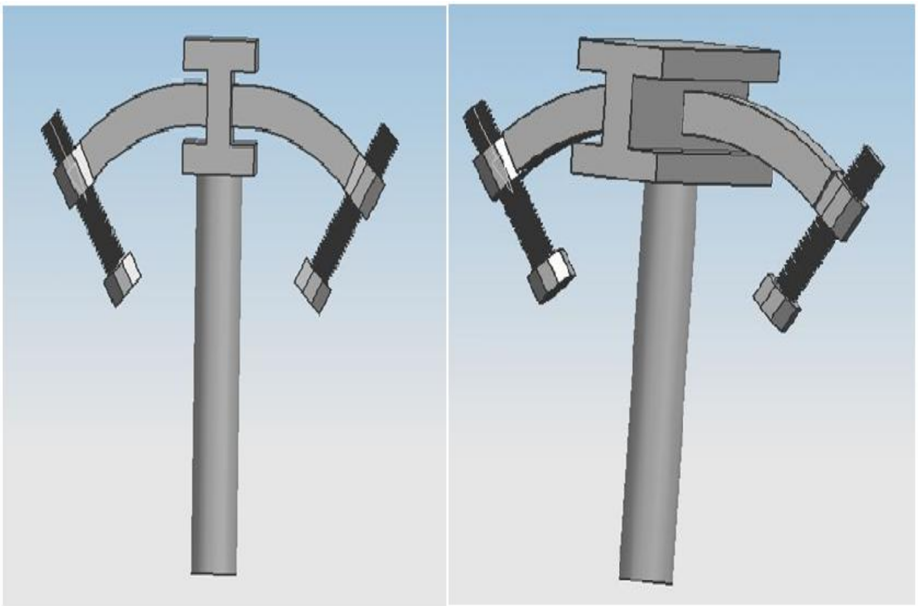
When the Nozzle is to be placed in the Cut-out made on the shell the following things should be set as per requirements mentioned in the drawing provided:-

1. PROJECTION: Projection is distance between the centre of shell to the top face of nozzle.
2. ELEVATION: Elevation is distance along the axis of shell from any reference plane.
3. OFFSET: Offset is gap between perimeter of cut-out and nozzle perimeter. This ensures the proper root gap is maintained.
4. LEVEL: Level is the parallelism of top face of nozzle.

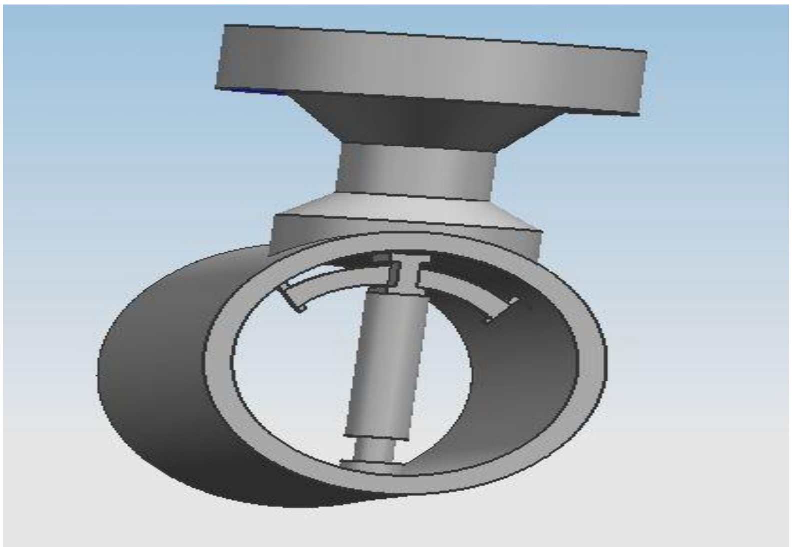


VII. PROPOSED FIXTURE 3-D MODEL

All the elements designed should be made of carbon steel. The fixture design consists of an I-Beam structure, which will support and take the maximum weight of the nozzle to be set-up on the shell of a heat exchanger. The Round pillar which will support the I-beam will carry loads of forces of the I-Beam. Two side-arms are provided on both the sides of the I-Beam with adjustable screws to make the nozzle top face level. A hydraulic jack is provided below the pillar to set the projection.



1. An I-Beam is provided along with a round pillar both are designed together to take most of weight of the nozzle. The length of I-beam used for distributing the load of the nozzle should be more than the nozzle cut-out diameter say in the range of 100-200mm more which can be enable to take the support of the shell.
2. As most of the weight is proposed to be supported by the I-Beam it is then easier to set the offset & elevation with the help of jib crane or by wedge.
3. Height of the I-beam + round pillar is considered and taken less than the shell diameter because to set the projection it is required to place a hydraulic jack or mechanical jack below the I-beam and the pillar.
4. For making the nozzle top face level two face side arms are provided with adjustable screws, so that by adjusting them setting proper level can be a very simple task.

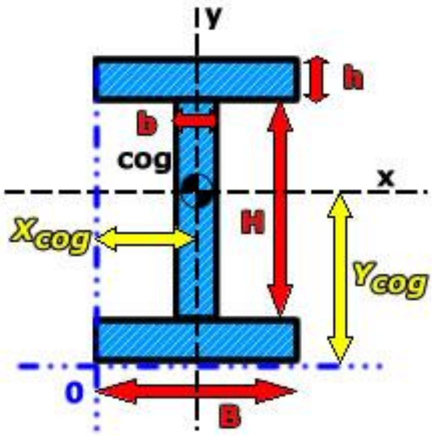


VIII. FABRICATION OF PROPOSED FIXTURE

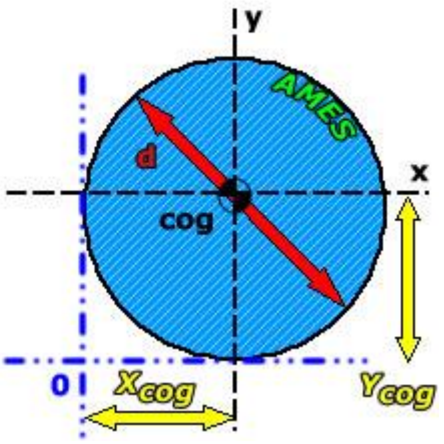
1. The entire fixture is proposed to be made out of Carbon steel.
2. The assistance of the proposed fixture can be used in fabrication process of nozzle welding or nozzle set-upon the shell having different diameter ranges, different cut-out regions where the nozzle is to be welded and shell having

different thicknesses. Hence the dimension of the proposed fixture may vary as per the variation in diameter ranges and thickness of the thick shells. The dimensions mentioned here are assumed as per the observations made in the workshop, having diameter range of shells between 1.80 metre to 2.20 metre and shell thickness between 85 mm to 95mm.

3. It is desired that the fixture should be strong and compact enough to support nozzle of weight ranging from 2.5 to 3.0 ton which will enable it to take the support of the shell.
4. The I-Beam structure proposed in the fixture for distributing the load, its length is assumed to be in the range of 150-200mm more than the nozzle cut-out diameter.
5. The height of the I-Beam and the round pillar on which the I-Beam is proposed to be placed, there height together combined is taken the range of 280-320mm less than the shell diameter. The reason behind keeping their height less than the shell diameter is because it is proposed to place a hydraulic or a mechanical jack below the round pillar. Use of the hydraulic or the mechanical jack will make it possible to set the projection.

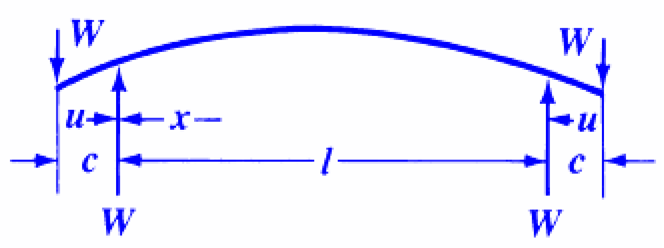


Step	Parameter/Condition	Symbol	Equation
1	Cross section area	A	$A = 2Bh + Hb$
2	Area moment of inertia	I_{xx}	$I_{xx} = H^3b/12 + 2[h^3B/12 + hB(H+h)^2/4]$
3	Area moment of inertia	I_{yy}	$I_{yy} = b^3H/12 + 2(B^3h/12)$
4	Section modulus	S_{xx}	$S_{xx} = 2I_{xx}/(H + 2h)$
5	Section modulus	S_{yy}	$S_{yy} = 2I_{yy}/B$
6	Center of gravity	x_{cog}	$x_{cog}=B/2$
7	Center of gravity	y_{cog}	$y_{cog}=H/2 + h$
8	Mass	M	$M = AL\rho$
9	Radius of gyration	r	r = (I/A)^0.5
10	Polar moment of inertia	J	$J = I_{xx} + I_{yy}$



Step	Parameter/Condition	Symbol	Equation
1	Cross section area	A	$A = \pi d^2/4$
2	Area moment of inertia	I_{xx}	$I_{xx} = \pi d^4/64$
3	Area moment of inertia	I_{yy}	$I_{yy} = \pi d^4/64$
4	Section modulus	S_{xx}	$S_{xx} = 2I_{xx}/d$
5	Section modulus	S_{yy}	$S_{yy} = 2I_{yy}/d$
6	Center of gravity	x_{cog}	$x_{cog}=d/2$
7	Center of gravity	y_{cog}	$y_{cog}=d/2$
8	Mass	M	$M = AL\rho$
9	Radius of gyration	r	r = (I/A)^0.5
10	Polar moment of inertia	J	$J = I_{xx} + I_{yy}$

- **<u>List Of Equations for two face side arms</u>:0**



Stress Between loads and nearest support

$$s = \frac{W}{Z}(c - u)$$

Stress Between the two supports

$$s = \frac{Wc}{Z}$$

Stress at supports and all points along length between supports

$$\frac{Wc}{Z}$$

Deflection between supports

$$y = -\frac{Wcx}{2EI}(l-x)$$

Deflection between load nearest (Adjacent) support

$$y = \frac{Wu}{6EI}[3c(l+u)-u^2]$$

Deflection at the center of the Beam

$$-\frac{Wcl^2}{8EI}$$

Deflection at loads

$$\frac{Wc^2}{6EI}(2c+3l)$$

IX. RESULTS & DISCUSSIONS

The efforts, time consumption for Nozzle set-up on the shell shall be reduced substantially & will make the process speedy & economical. The proposed 3-D model design of fixture includes the provisions, to make it suitable for multiple re-uses. Also the provision of hydraulic jack or mechanical jack, makes it eligible to be adjusted and used in Nozzle set-up process on the shells having different diameters.
The fixture is reusable, adjustable for different diameters and can be installed & dismantled easily. These qualities make the fixture assistance cut down in cost of fabrication reducing the time consumption, effort & labour required in the process of Nozzle Set-Up on the shell. Since the fixture is proposed to be made from strong & durable carbon steel, the fixture can be used for very long time. Hence the investment in the fabrication of the fixture shall have very negligible financial effect.

1. The proposed fixture requires considerable initial investment. But the investment can be recovered with in few applications considering the following.
2. The fixture can be reused for at least 100 such applications.
3. The present process of doing temporary attachments shall be eliminated saving time & expenses.
4. Comparing use of fixture for replacing the conventional method of doing temporary attachments, at least 3-4 shifts of process are saved in cost avoiding the delay in project.
5. This prototype, has a potential to be used in other applications of heavy engineering processes with little modifications.

X. SUMMARY & CONCLUSIONS

The introduction of the proposed fixture assistance in the process of nozzle set-up on the shell of a heat exchanger shall reduce the time consumption and efforts of the nozzle set-up on the shell process.

The application of conventional method of the temporary attachments method of welding and not the proposed fixture for the set-up of nozzle on the shell will delay the fabrication process. The conventional process of doing the temporary attachment procedure is cumbersome & time consuming. The application of proposed fixture during fabrication eliminates the requirement of temporary attachments for set-up of nozzle on the shell. Hence, with proposed fixture's assistance, the efforts and time consumption shall be substantially reduced making fabrication process more economical. The use of proposed fixture in the Set-up of nozzle on the shell, eliminates both the time consuming requirements i.e. requirement for temporary attachments. Hence the Set-up of nozzle on the shell process shall be substantially improved to make it cheaper and speedy operation.

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