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International
Journal
Of Modern Engineering Research (IJMER)

"Design & Development of Insertion Mechanism For Assemblage of Shell & Tube Heat Exchanger"

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ABSTRACT:- *Device whose primary purpose is the transfer of heat energy between two fluids at different temperature is named as heat exchanger [1.]Manufacturing Company of tube heat exchanger implements manual way for inserting tube bundle against shell. This manual way of inserting tube bundle inside shell involves challenges such as Centre alignment of shell & tube bundle, manual pushing of tube bundle inside shell. This method of insertion may either leads to damage of inner periphery of shell or baffle of tube bundle [4]. Rather than this, manual method of tube bundle insertion needs more labors & more time is needed to complete the entire activity. This review proposes semi-automatic equipment which makes tube bundle insertion process more safe & reliable. Using this equipment around 70% time saving can be achieved [1] for tube bundle insertion activity with reduced numbers of labors as well.*

Keywords:- *Shell & tube heat exchanger, Screw jack, Assembly of screw jack.*

I. INTRODUCTION

Heat exchanger is one of the key elements of the petrochemical industries and thermal plants, which is having nonlinear, multivariable and non-stationary process [4]. Shell and tube type heat exchanger consists of a number of tubes through which one fluid flows. Another fluid flows through the shell which encloses the tubes and other supporting items like baffles, tube header sheets, gaskets etc. manufacturing company of shell and tube heat exchanger having major task to assemble the all components which is very tedious job and it take lot of time which results in company efficiency as well as the quality of product . So now develop a new mechanism for assembly of shell and tube heat exchanger which recover the all issues.

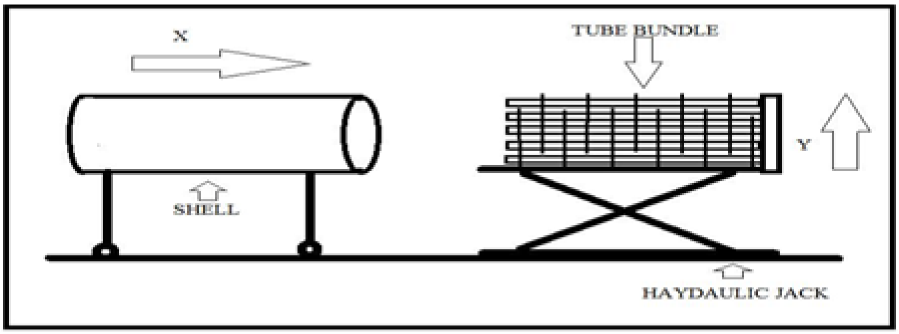
II. PROBLEM STATEMENT

Company is facing a problem of assemblage of heat exchanger in which there is eccentricity between shell axis and tube bundle axis during assembly Which causes distortion in tube and baffle plates and our Project is to design and develop suitable insertion mechanism for 45 ton heat exchanger capacity, which will be less time consuming, more efficient, versatile, and more reliable.

III. STUDY OF DIFFERENT MECHANISMS

1) Hydraulic jack mechanism
2) Electric motor mechanism
3) Screw jack mechanism

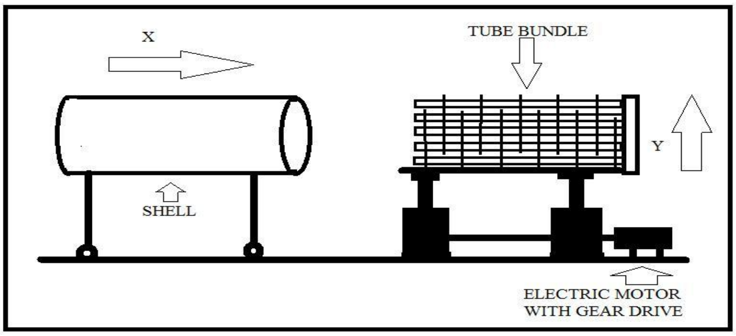
HYDRAULIC JACK MECHANISM



In this hydraulic jack mechanism the movements of the shell and tube bundle are in X-axis and Y-axis direction respectively to eliminate the problem of eccentricity between the shell and tube bundle [1].

A jack is a device that uses force to lift heavy loads. The primary mechanism with which force is applied varies, depending on the specific type of jack, but is typically a screw thread or a hydraulic cylinder. Jacks can be categorized based on the type of force they employ: mechanical or hydraulic [8]. Mechanical jacks, such as car jacks and house jacks, lift heavy equipment and are rated based on lifting capacity (for example, the number of tons they can lift). Hydraulic jack tend to be stronger and can lift heavier loads higher, and include bottle jacks and floor jacks. HYDRAULIC JACKS depend on force generated by pressure. Essentially, if two cylinders (a large and a small one) are connected and force is applied to one cylinder, equal pressure is generated in both cylinders. However, because one cylinder has a larger area, the force the larger cylinder produces will be higher, although the pressure in the two cylinders will remain the same. Hydraulic jacks depend on this basic principle to lift heavy loads: they use pump plungers to move oil through two cylinders. The plunger is first drawn back, which opens the suction valve ball within and draws oil into the pump chamber. As the plunger is pushed forward, the oil moves through an external discharge check valve into the cylinder chamber, and the suction valve closes, which results in pressure building within the cylinder.

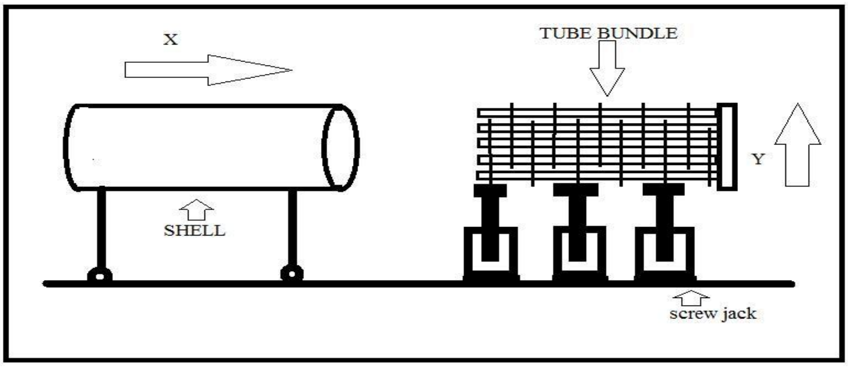
ELECTRIC MOTOR MECHANISM



In this motorized jack mechanism the movement of the shell and tube bundle is in X-axis and Y-axis direction respectively to eliminate the problem of eccentricity between the shell and tube bundle [1].

The efforts required in achieving the desired output can be effectively and economically be decreased by the implementation of better designs. Power screws are used to convert rotary motion into reciprocating motion. In motorized screw jack mechanism we use electric motor to raise the load at desired height. To give rotational motion of the electric motor in to the vertical rotational motion we use spur gear mechanism to reduce the RPM as well as the required vertical motion [6]. In this mechanism we have to first of all set the height of the shell and tube bundle buy water tube level method. After adjusting the height we have to insert tube bundle into the shell which, in insert the tube bundle in shell we have to move shell towards the bundle or bundle towards the shell. If we are inserting the tube bundle into the shell there we provide the roller contact bearing below the baffle plates. Uses of sliding bearing reduce the pushing force and increase the worker efficiency, as well as we fixing the direction of movement of tube bundle. Inserting tube bundle into the shell requires the experienced and skilled labor. It is very slow and risky process to insert the tube bundle into the shell, while insertion they have to match the center of shell and tube bundle.

SCREW JACK MECHANISM



In this screw jack mechanism the movements of the shell and tube bundle are in X- axis and Y- axis direction respectively .to eliminates the problem of eccentricity between the shell and tube bundle. In this process we are keeping tube bundle in static position and shell is inserting over the tube bundle to insert shell or to move shell towards the tube bundle we use rollers and to maintain the high and position of tube bundle we using number of jack as support [1]. Jack is put below the baffle plates giving support to the tube bundle. If we putting screw jack below the tube shape of tubes may get damage which leads to failure of heat exchanger. The main use of baffle plate is to bind tubes with specified distance and giving support. In screw jack mechanism we first of all set the height of shell and tube bundle by using the water tube level. After setting height of shell and tube bundle fix the direction of movement of shell and tube bundle i.e. For shell horizontal direction is fixed and for tube bundle up-down direction. Then the main process is to insert shell over the tube bundle which is the main risky work it requires skill and experienced workers to carry out this process. As we are moving shell towards tube bundle must see to matching the center of both, slowly shell over the tube bundle and consequently removing the jack from below the tube bundle .same process is carry out till full insertion of the tube bundle into the shell

IV. COMPARISION TABLE

As it is a seasonal product of company, so after usage we can implement screw jacks in their other routine products.

Conclusion made: From above comparison table, we selected Screw Jack Mechanism because it's high reliability, versatility & less cost consumption.

Parameters	Hydraulic Jack Mechanism	Electric Motor Mechanism	Screw Jack Mechanism
Design & Manufacturing Complexity	More	Moderate	Less
Skilled Labour Requirement	Required	Required	Not necessary
Range of Product Handling Capacity	Less	Moderate	Wide
Space required	More	More	Less
Operational Time	Less	Moderate	Moderate
Efficiency of Operation	More	Moderate	Moderate

V. MATERIAL SELECTION

The conventional mild steel which is cost effective is not promising the requirement due to its lower strength we need to switch to higher strength material so we choose carbon steel SA 106 Gr B.

S.NO	COMPONENTS	MATERIAL
1	BODY	SA516 Gr70
2	SCREW	SA516 Gr70
3	NUT	SA516 Gr70
4	BASE PLATE	SA516 Gr70
5	STIFFNER	SA516 Gr70
6	FRAME	IS 2062 Gr B

The purpose of selecting same material for nut and screw:

- Wear due to friction occurs only when there is a relative motion between nut and screw. In the operation the screw jack role is just to support the load , care is take that only slight movement of screw under is permissible since the height of screw jack is adjusted before tube bundle is place over the screw jack.

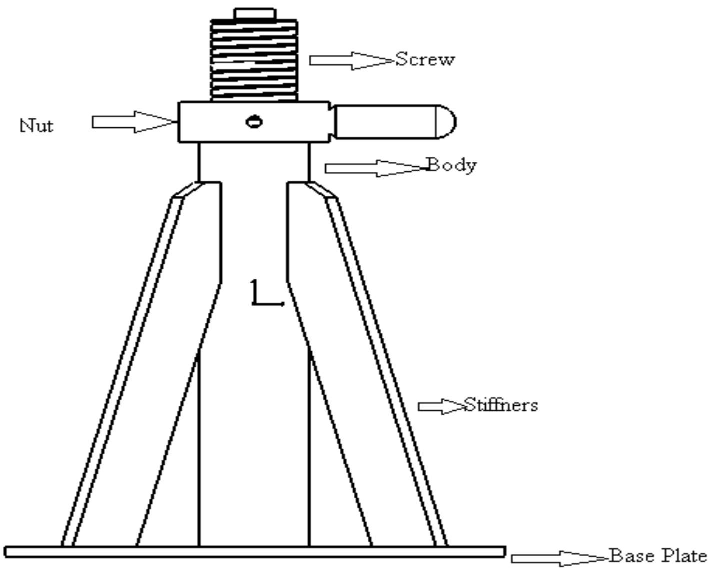
- As cost was not the major issue in selecting the material so higher grade of Carbon Steel is selected.

VI. GENERAL CONSIDERATIONS

1. Screw jack is manually operated according to ergonomics hand force should not exceed 300 N [1].
2. Heat exchanger capacity: 45 Ton.
3. The conventional mild steel which is cost effective is not promising the requirement due to its lower strength thus we need to switch to higher strength material so we choose carbon steel SA 106 Gr B.
4. Screw has single start square thread, assuming pitch = 4 mm.
5. Material used for frame is C channel made up of mild steel of grade IS 2062 Gr B.
6. Taking coefficient of friction as 0.1, thread thickness at the root as 4.5mm.
7. Taking factor of safety = 5
8. The jack should be robust.
9. Chain block used to pull the shell has a capacity of 10 tons.
10. Rollers used under the shell are normal rollers used in fabrication plant to rotate the pressure vessel of smaller size.

VII. DIFFERENT PARTS OF SCREW JACK

- Frame
- Screw
- Nut
- Stiffeners
- Tommy bar
- Base plat



VIII. DESIGN OF MODIFIED SCREW JACK[12]

DESIGN OF SCREW

Core diameter = 84 mm
Outer diameter =88 mm
Mean diameter =86 mm
Thread pitch =P=4

Torque required to raise the load=2141758.05 N/mm^2
Lead angle =1.27°
Friction angle = 5.17°
Torsion shear stress = 18.4035 N/mm^2
Principal shear stress = 18.7042 N/mm^2

BUCKLING OF SCREW

Max height to raise the load =270mm
Area A=1910^2
Total hand force applied by four workers P= 1440N
Slenderness ratio= l/k = 9.373
Critical load =4453609.465 N

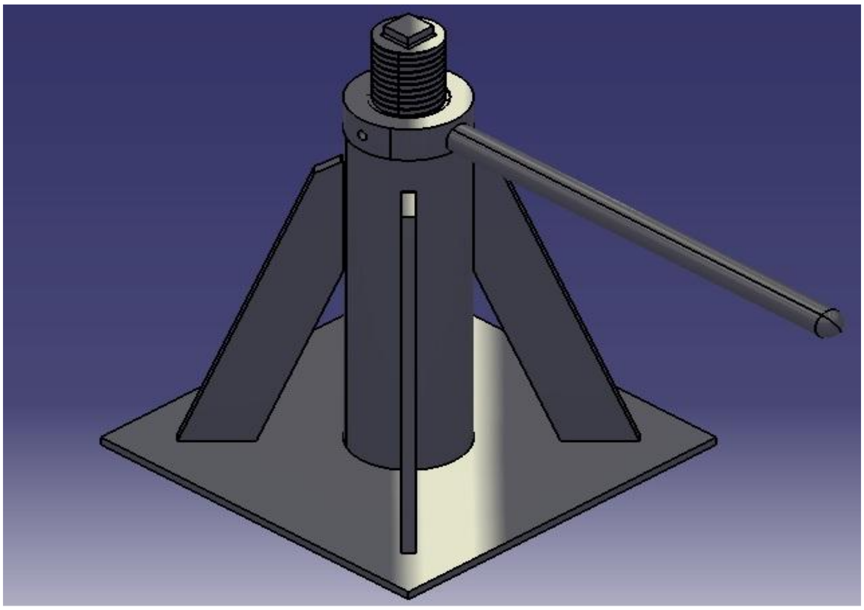
DESIGN OF FRAME

Slenderness ratio = l/k = 10.686
Critical load =489.5 KN

DESIGN OF NUT

Height of nut 80
Transverse shear stress = 39.90 N/mm^2
FOS of nut = 5.28

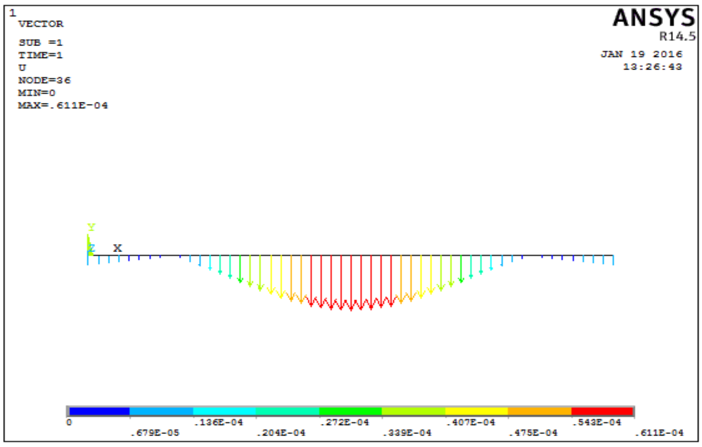
IX. CAD MODEL OF MODIFIED SCREW JACK



X. FINITE ELEMENT ANALYSIS USING ANSYS

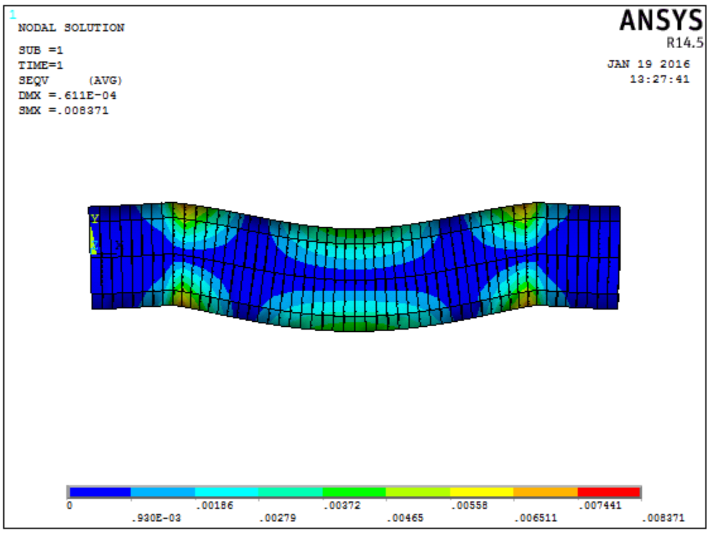
Force to be raise=45ton
Allowable factor of safety=5

ANALYSIS OF CONVENTIONAL METHOD:



Vector plot

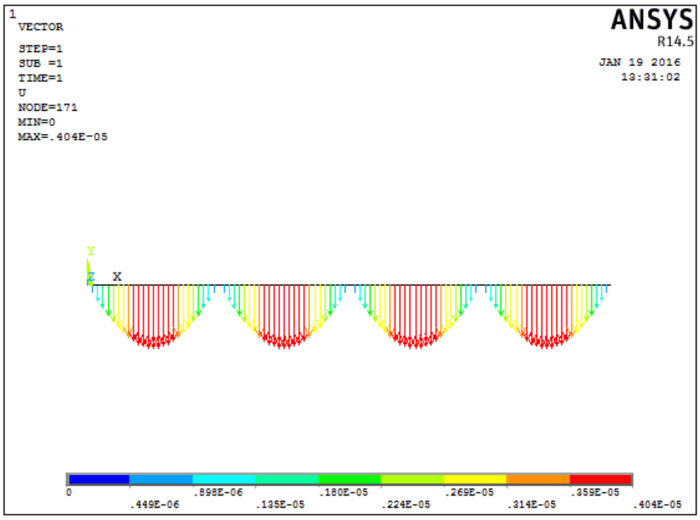
Maximum deflection=0.611×10^{-4}mm



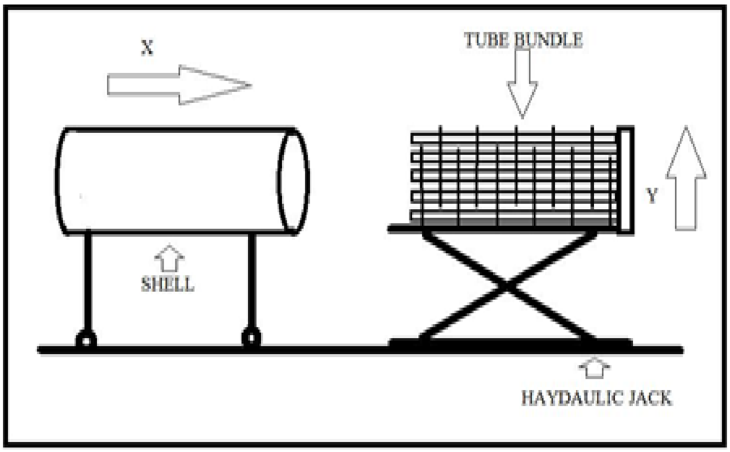
Von-misses stress

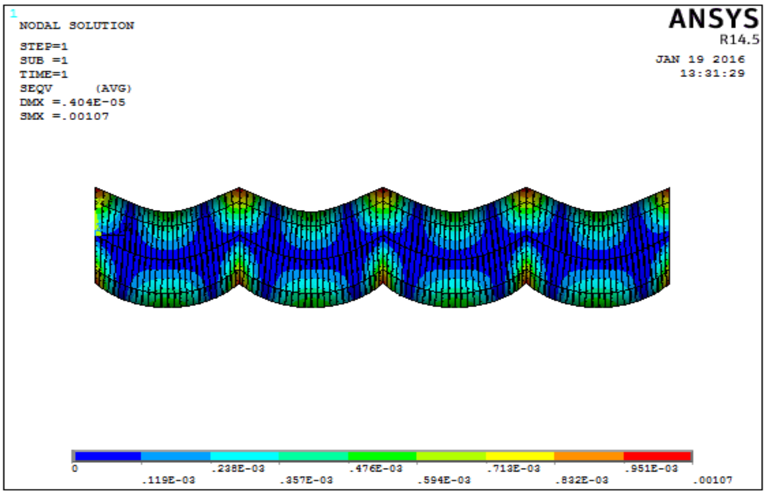
Maximum stress =.00107 N/mm^2

ANALYSIS OF MODIFIED METHOD:



Vector plot





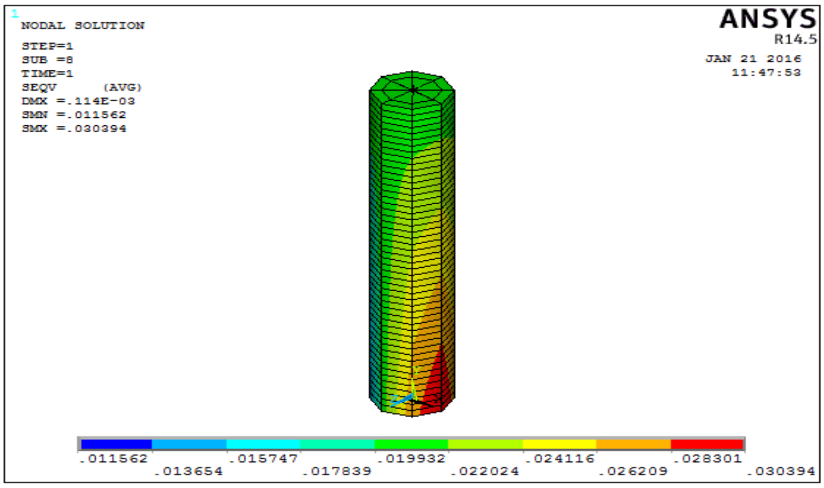
Von misses stress

Maximum stress =.00107 N/mm^2

CONCLUSION OF ANSYS RESULTS

From Comparison of ANSYS results for Conventional method of cranes Vs Modified screw jack method, we found out that deflection is maximum in case of conventional method, while it goes o reducing in modified method from vector plot. Stress induced in conventional method of assembly is greater than modified method from Von-misses stress plot.

BUCKLING ANALYSIS



Eigen buckling plot

Aximum deflection =0.114×10^{-3} mm aximum stress =0.30394 N/mm^2

XI. CONCLUSION

The design of "Mechanism for insertion of tube bundle assembly in shell and tube heat exchanger" was done successfully. After implementation the report show that the new mechanism is lot more promising than the earlier method of assembly, it also reduced the fatigue on the worker which lead the assembly to be carried Out smoothly [5].

The mechanism shows how simple and innovative ideas can be used to do some heavy and tiring task which also comes with cost effectiveness and no power consumption. It can also be seen that time required to do the work earlier is also reduced significantly along with increase in productivity.

XII. FUTURE SCOPE

- The pitch of current screw jack is 4mm this means for one whole revolution of the nut the 4 mm of height can be increased this can be further improved by increasing the pitch of the square thread to get more accurate lead of the screw [2].
- The width of stiffeners can in increase to increase the effective area below the stiffeners. This would increase the support strength of the stiffeners.
- Instead of ordinary rollers to move the shell multi turn rollers must be used. With the help of multi turn roller we can ensure that the shell in being travelled in straight line direction.
- The thread length in the screw is around 200mm, this length can be further be increased so as to increase the height of nut, which would result in more number of threads in the nut and this will increase its load carrying capacity.
- By using hydraulic jack efficiency of operation will be more.

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