Design of Coil Handling Fixture With Locking Arrangement

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Abstract- *The present work is focused towards design and development of new fixture for lifting the coils to prevent accidents. The main problem faced by the employees while handling fixture was slippage of coils, as wire ropes were used to lift the coils. Many accidents cases were reported. To overcome this problem designing of fixture with safety measures became essential. We started off with analyzing the process to find out the root cause of the problem. Considering the PFMEA, designed the fixture. After developing the fixture, results were phenomenal as we were expecting that leads to both tangible and non-tangible benefits.*

Keywords- Analysis, Ishikawa Diagram, Design of Frame, Cost.

I. INTRODUCTION

In the plant various types of coils are manufactured i.e. Economiser, Super heater, and Evaporator. Following are the function of each coil manufactured in Plant no. 1.

1.1 Economiser:-

Economizer is a heat exchanger through which the feed water is pumped. Another flue gas heat recovery method is through the use on an economizer. The economizer heats the feed water to improve steam boiler efficiency and reduce heat loss to the stack. The increased heat in the feedwater reduces the boiler's requirement for fuel and combustion air. In the economizer arrangement, the flue gas leaves the steam boiler and enters the economizer where it make contact with the heat transfer surface, in the form of water tubes, through which the steam boiler feed water flows. Since the flue gas is at higher temperature than the water, the flue gas is cooled and the water temperature is increased. Cooling the flue gas reduces its heat loss in amount equal to the increased heat in the feed water to the steam boiler.

1.2 Super Heater:-

A super heater is a device used to convert *saturated steam* or wet steam into *dry steam* used in steam engines or in processes, such as steam reforming. There are three types of super heaters namely: radiant, convection, and separately fired. A super heater can vary in size from a few tens of feet to several hundred feet (a few meters to some hundred meters).

1.3 Evaporator:-

Evaporator is a device that is used to turn the liquid form of Chemical into its gaseous form. The liquid is evaporated or Vaporized into a gas while absorbing heat in the process. It can also be used to remove water or other liquids from mixtures.

Fig1. Coils Image.

II. PROBLEM STATEMENT

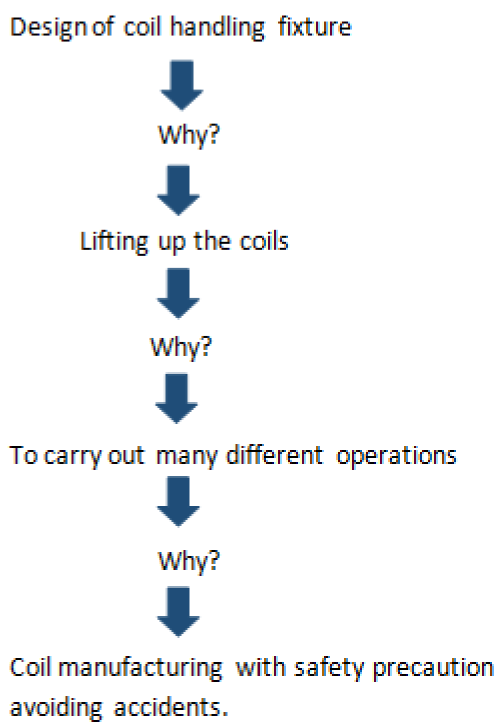
In plant various types of coils are manufactured i.e. Economiser, Superheater, and Evaporator. These coils are of heavy weight ranging from 0.5 tons to 1.4 tons. It becomes very difficult to handle coils with such heavy weight, which leads to increase in time of transporting coils from one location of plant to other location of plant for carrying many other operations on it which are required for coil manufacturing. To ease employees with these handling of coil a fixture is required to design called **'Coil handling fixture.** This fixture easily lifts the coils from one position to another with the help of **EOT cranes**.

In this fixture, a strip is inserted into bottom of frame in order to give support to the coils. While lifting the coil, due to slippage of strip chances of accident are high which will lead to fall of coils which may prove to be fatal for operator. To avoid slippage, a locking provision is to be given in the fixture for strip to remain in stable position, So to avoid such incidents, a locking Provision is required for strip to give a safe environment for operators.

III. ANALYSIS

To identify the root possible cause of the occurrence of accidentsanalysing the process is to be done. So Why-Why Analysis is chosen for identifying the root cause. The direct causes which cannot be predicted were seen after the Why-Why Analysis. Why-Why Analysis is mentioned below.

3.1 Why-Why Analysis:-



3.2 Ishikawa Diagram:

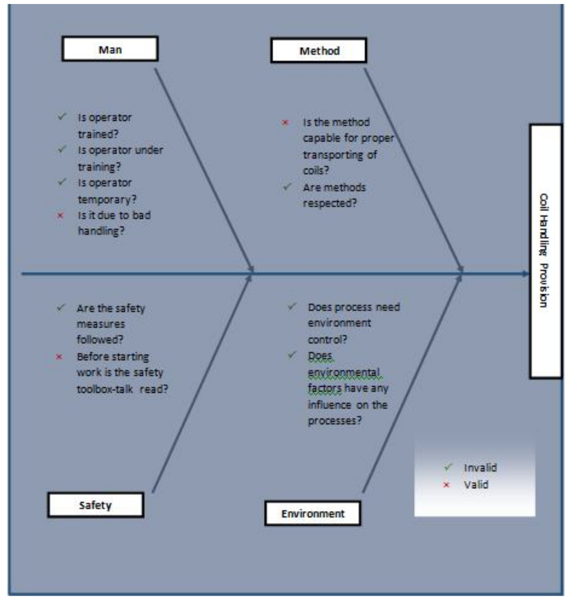


Fig2. ISHIKAWA Diagram for Root cause.

Ishikawa Diagram helps to conclude the root cause of the problem. After this we did Hypothesis test, it is the test, in which the possible causes detected in ISIKAWA Diagram are observed on field and check whether those causes are valid or invalid. If the hypothesis is valid then we have to take measure action over it and if not then leave it as it is. Through ISHIKAWA Diagram Analysis, three Causes are popped up. Those are as follows.

- Is it due to bad handling
- Is the method capable for proper transporting of coils
- Before starting work is the toolbox-talk is read

The mentioned above are the possible causes for coil handling on shop floor. To identify they are valid or not on field, observation is required. Following table will give Complete Understanding.

3.3 Test of Hypothesis:

Trail	Designed Test	Observation	Conclusion
1	Is it due to bad handling	Yes, as they don't use any proper handling methods that are to be used to avoid accidents	Hypothesis Valid
2	Is the method capable for proper transporting of coils	No, the method use for transporting coil is risky as it can cause accidents and lead to loss of lives.	Hypothesis Valid
3	Before starting work is the toolbox-talk read	No, toolbox-talk is not read, as it contains all the safety information that are to be followed by each and every employee working on shop floor.	Hypothesis Invalid

Table1. Hypothesis Test.

All type of possible Analysis are done, finally concluded to take some necessary and effective action against this flaws.

Considering the safety parameters and efficient and easy way to handle and transport these highly weighted coils and long lengthen coils a proper fixture is to be design that allows proper handling and smooth flow of coils from one place of plant to other place of plant.

IV. OBJECTIVE

- To give safe working environment for operators
- To reduce time required to handle coils
- Increase productivity

4.1 Material list for making this fixture:-

- Two 2000 mm circular tubes.
- Four 1630 mm circular tubes.
- Four hooks for lifting the fixture.
- (285x150)-(200x80) mm rectangular section.
- 28 mm square rod.
- Key of T section.

4.2 Procedure:-

- The EOT crane used for lifting purpose has SWL capacity of about 5 ton(can be greater than 5 depending on application).
- According to the chart, crane can lift 100% of its capacity when the job is completely$90^0$to the surface of job/fixture as shown in above chart
- But as the rope of crane diverts/tilts from 90^0 its lifting capacity starts decreasing e.g. at 60^0 it can lift 86% of its capacity, therefore its capacity became 5 x 0.86= 4.3 ton capacity.
- Frame is rectangular in design which is symmetric and is made of circular hollow rods welded end to end to form a proper lifting fixture.
- It is having a rod in between for distributing the load over the entire frame.
- The standard distance of the rope of crane is 2.3m.
- One end of rope is attached to crane and another to hook of the lifting fixture.
- Like this total 4 ropes are attached to every (four) hooks.
- By this std. distance and using trigonometric concepts we can calculate hook to hook distance of the fixture (as shown in design calculation).
- Then hooks that are of U section are firmly welded to frame at the proper calculated distance.
- Extra distance of the frame beyond the hook is extended and calculated.
- Below the upper frame 4 rectangular sections having a rectangular hole in them are welded to the frame just beneath the hooks.
- These sections serve the purpose of inserting the two strips in 4 rectangular holes. The strip has 2 main following purposes:
    a) It holds the heavy coils in frame so that it cannot fall down.
    b) It gives extra support to the entire fixture for easily transporting the coils.
- After this whole procedure, this fixture is laid down over the coils which are to be lifted and then strip is inserted passing from the spaces between the

consecutive layers of coils. Maximum 2 to 3 layers of coils are being lifted.

- When the strip insertion is done, a key, T-shape is inserted into the keyhole of strip so that it locks the strip which prevents slipping from the frame.
- Maximum bending moment is calculated so as to check whether the frame or the strip bends.
- All the fixtures are painted by red oxide for prevention from rust and corrosion.
- After painting of red oxide, yellow colored oil paint is applied and then the fixture is ready to use..

V. DESIGN

Design calculation of super heater coil:-

Tube= Ø 38.1mm* 5mm thick.
Developed length= 196000 mm

ρ = m / v

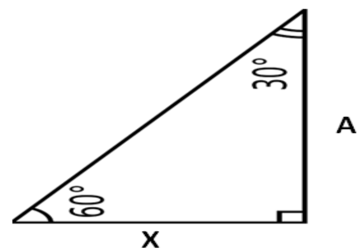
v= π / 4 (D^2-d^2) * L

v= π / 4 (38.1^2-28.1^2) * 196000
v= $101.90*10^6 mm^2$
v=$101.90*10^{-3} m^2$
ρ = 7850 kg/mm^3
As we know that,
M= ρ* V
= 7850 x$101.90*10^6$ x 10^{-9}
M= 799.96 Kg
W= m * g
W= 799.96* 9.81
W= 0.784 Ton
Therefore,
W= 0.8Ton….. (Rounded)

5.1 Design of Frame Dimensions:-

At 60° crane can lift 86% of crane's capacity and crane's maximum capacity is 5 ton. Therefore we took angle 60° with reference of load lifting chart as shown below.

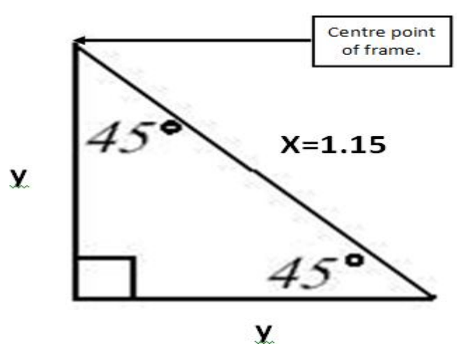
Fig3. Weight Lifting Capacity



To determine the dimensions of frame, we have assumed side 'A' and side 'X' which formed right angled triangle of 30^0-60^0-90^0. Side X will act as hypotenuse of other triangle as show below. Hypotenuse of this triangle is a wire rope with 2.3m length
Length of wire rope = 2.3m
x = 2.3 sin 30^0

X= 1.15m

As we calculated the length 'X', we further need to find out the dimensions of frame. As we know that X = 1.15m we can calculate the other two values of 45^0-45^0-90^0right angled triangle. Using 45^0-45^0-90^0 rule



Y= X/√2
= 1.15/√2

Y= 0.8131m

With the above calculations we found out the distance from centre point of frame.

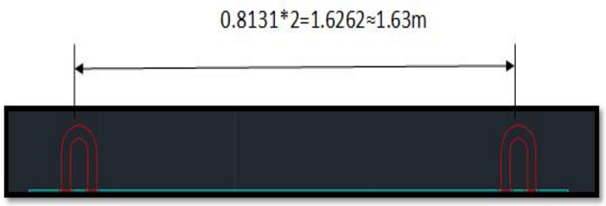


Fig4. Hook to Hook Distance

5.2 Design of Diameter of Frame:-

Fig5. Design of Frame

Fig6. Design of Frame

5.3 Top View of Frame:-

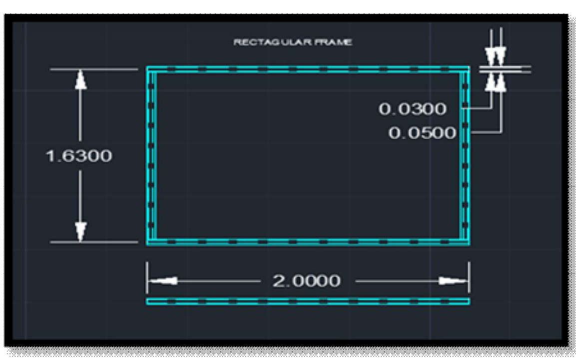


Fig7. Frame With Diameter and Top View

5.4 Design of Rectangular Section:-

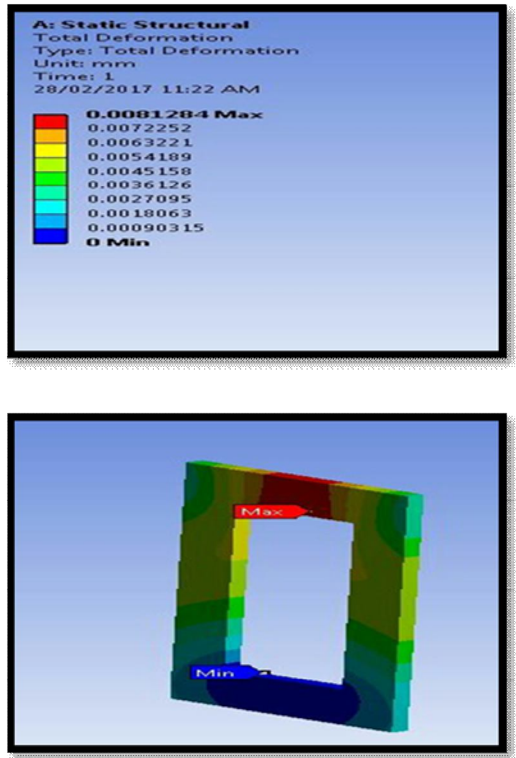
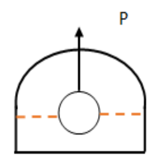


Fig8. Rectangle Section

5.5 Design calculation of hook:-



τ=Shear Stress, P=Load applied, A=Area subjected to loading

$\tau = 0.5 x \sigma_t$ $A = (b-d) \times t$

$= 0.5x276$ $= (100-50) \times 30$

$= 138 N/mm^2$ $= 1500 mm^2$

$\tau = P/A$

$= 2500/1500$ ....Considering Load Acting on Frame One Hook.

$= 1.667 N/mm^2$

As calculated τ is less than the Allowable τ for Carbon Steel material. So design is safe.

Welding Fillet Size (for rectangular section):-

Let the fillet size is 20mm*10mm.
Where, 20 mm is Fillet size
10 mm is Fillet Width.

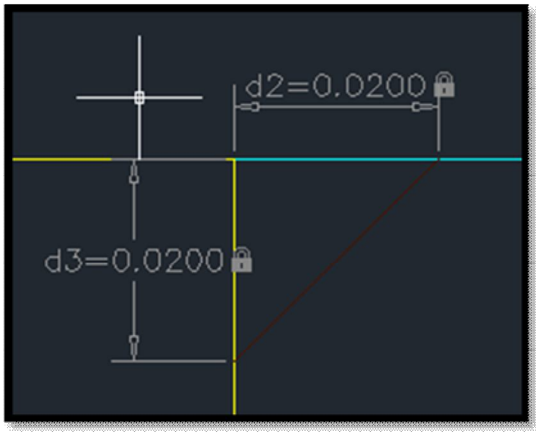


Fig9. Welding fillet size (Rectangle)

Normal stress:

σ_x =P/A = P/(t * l)...........(t=hcos45^0)

= P/(0.707 * h * l)

=2000/(0.707x2x20x10) ……………2000N is for single Rectangle.

σ_x=7.07N/mm^2

Shear stress:

$\tau = 1.118 * P/(hxl)$

=1.118*2000/(2*20*10)

=5.59 N/mm^2

Maximum normal stress:

σ_{max} =1.618*P/(2*h*l)

=8.09 N/mm^2

As the maximum Stress is less than the actual (i.e.70 N/mm^2), so fillet size is safe.

Welding Fillet size (for hook section):-

Let the fillet size is 10mm.

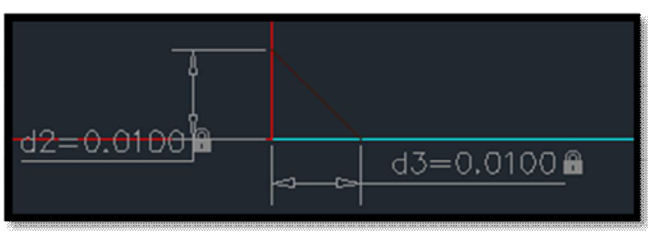


Fig10. Weld Fillet Size for Hook

Diameter of hook is 32.5mm.(all dimensions are in mm)

Normal stress:

σ_x = P/A = P/(t x l).....(t=hcos45^0)

=P/(0.707 x h x l)

=9309.77/(0.707 x 2 x π x 32.5 x10)

σ_x =6.441N/mm^2

Shear stress:

$\tau = 1.118 * P/(h * l)$

= 1.118*9307.77/(2 * π * 32.5 *10)

=5.0959 N/mm^2

Maximum normal stress:

σ_{max}= 1.618*P/ (h*l)

=7.37 N/mm^2

As the maximum Stress is less than the actual(i.e.70 N/mm^2), so our fillet size is safe.

5.6 Design of Square Strip:-

Maximum load on two strips 8000N so load on a single strip will be 4000N

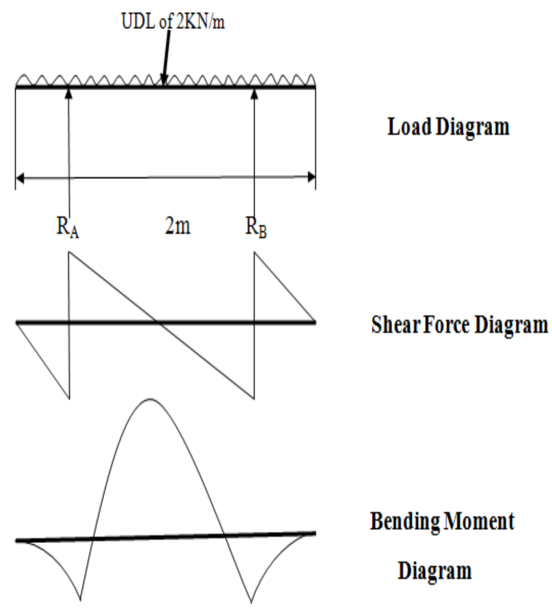


Fig11. Shear Force and Bending Moment Diagram

R_A= 2KN

R_B= 2KN

Bending Moment Calculation:-

BM_C = (W*L^2/2)-R_A*0.815

=2000*1*(1/2)-2000*0.815

= -630 Nm

Let,

D= Side of square Strip.

σ= Bending stress at a distance Y from neutral axis (MPa)

Y= Distance from neutral axis

M=Max^m Bending Moment

I= Mass Moment of Inertia

We know that,

σ/y = M/I

S_{yt} = 255N/mm^2

Factor of safety= 1.5

We know that,

σ/y = M/I

Y= (D-d)/2 = (40-34)/2 = 3mm

$I = (D^4-d^4)/12 = (40^4-34^4)/12 = 101972\ mm^4$

σ / 3 = 630 / 101972

$\sigma = 18.53\ N/mm^2$

As calculated σ is less than the applicable σ for Carbon Steel material. So design is safe.

Fig12. Square strips.

5.7 Design of key:-

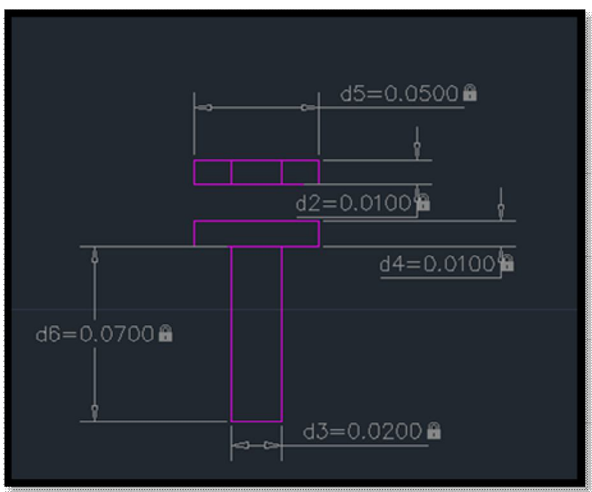


Fig13. Key

5.8 Design of Lifting Hook:-

Load in hook = 1000 kg

Size of Hook = M20

Shear Stress in Induced on Hooks:-

Shear Stress Induced in hook = Ť

= Load / Area

= $1000 * 10 * 4/3.142 * (20^2)$

$= 31.81\ N/mm^2$

Syt Yield stress of IS-2062, E-250 = 250 N/ $mm^{2,}$

Factor of Safety is considered 3.

Allowable Shear Stress = 250 / 3 = 83.33 N/mm^2

Shear Stress Induced in hook = 31.81 N/mm^2,

Allowable Shear Stress = 83.33 N/mm^2,

Hence, Hook is safe in Shear.

Load in each hook = 1000 kg

Cross section Size of Hook = Ø25

Shear Stress in Induced on Hooks (Cross section Area) -:

Shear Stress Induced in hook = Ť

= Load / Area

= $1000 * 10 * 4/3.142 * (25^2)$

$= 20.37\ N/mm^2$

Syt Yield stress of IS-2062, E-250 = 250 N/ $mm^{2,}$

Factor of Safety is considered 3.

Allowable Shear Stress = 250 / 3 = 83.33 N/mm^2

Shear Stress Induced in hook = 20.37 N/mm^2,

Allowable Shear Stress = 83.33 N/mm^2,

Hence, Hook is safe in Shear.

5.9 Design Of Coil Lifting Fixture:-

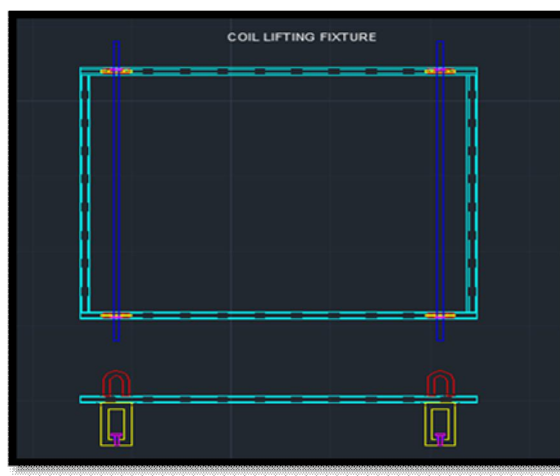


Fig14. Coil Lifting Fixture.

5.10 Design of Coil Lifting Assembly:-

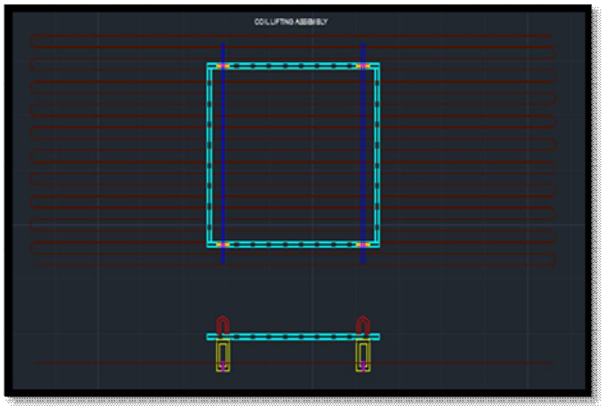


Fig15. Coil Handling Assembly.

Fig16. Coil Handling Fixtures Before and After Action Implemented.

VI. RESULTS

Fig17. Results after Implementation

From the above bar graph it is clear that the risk factor involved before in lifting coil and transporting it from one place to another place within the plant consist of higher risk factor and lower safety. After the implementation risk factor involved in transporting coil from one place to another place within plant is less and safety is improved that helped in improving the efficiency and effectiveness of transporting coils.

6.1 Benefits:-

- Easy to operate and handle.
- Fixture is safe to use.
- To reduce time and increase productivity.

6.2 Cost Table:-

	Weight of Frame	Weight of Rectangular Section.	Weight of Square Strip	Total weight in Kg.	Total Actual Cost in Rs.,	Total Scrap Cost in Rs.	Total Cost Saved in Rs.
Weight in Kg	103.42	13.94	8.0855	125.55			
Actual Cost	80	80	80		10,036		
Scrap cost	35	35	35			4,390	
No. of Fixtures Developed	8				80,288	35,120	
Total Cost Saving							45,168

Table2. Cost Saved.

VII. CONCLUSION

By the design calculation we can conclude that this fixture is safe while doing operation of lifting coils. So our main objective is acquired. During designing of this fixture the factor of safety is considered, because of that this fixture is safe to use and easy for handling. By observation we know that the time is reduced for handling of coils and our second objective is acquired.

VIII. ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incompatible without the mention of people who made it possible, because after all success is the epitome of hard work, perseverance and most of all those guidance and encouragement crowned my efforts and success.

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We are also grateful to all teaching staff of our department who helped directly or indirectly and lent us useful suggestions in our project work.

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