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DESIGN AND FABRICATION OF MIG-MAG MACHINE CARRIER UNIT FOR LOCOMOTIVE WORKSHOP

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Abstract

This paper aims at designing and fabrication of material handling equipment i.e. MIG MAG welding machine carrier unit for the locomotive workshop. Carrier unit should have characteristics like the ease of handling, low cost and safety of the user. A unit has to be designed such that it can be moved to all the corners of the workshop. The carrier unit comprises of inverter, wire feeder, arrangement of two gas cylinders and various accessories. The study focuses on improvement and development in the present material handling management system in the locomotive workshop. The selection of suitable materials for the fabrication of a carrier unit is done by using lightweight and durable material.

Keywords: material handling system, MIG-MAG carrier unit, frame design, ergonomic aspects

1. Introduction

Material handling is an art or science of transporting, packing, storing and convenience of use of products. It simultaneously deals with the movement i.e. horizontal, vertical or combination of both of materials manually or mechanically. Right from entering the industry gate in the form of a raw material to leaving the industry in the form of a finished good the material goes through various processes of handling as the material has to be turned, moved and positioned on the respective machines to produce the required output, there are also the inter-department transfers of materials or finished goods. Therefore having a proper material handling system is one of the most essential requirements of production planning.

The movement of materials utilizes space, time and also increases the production cost of the material. Detailed analysis of factors such as shape, weight, size, the condition of the material, the frequency of the movement and path has to be done to design an efficient material handling system which would efficiently use the available manpower as well machinery to give maximum output.

The advantages of having a well-developed material handling system are as follows:-

- About 21% of permanent injuries and 25% of temporary injuries at the workplace are caused due to poor material handling systems. This reduces workforces and also adds the cost of compensation. This loss can be prevented by using proper material handling systems and trained workers.
- It helps in reducing the production cost as it provides well-planned warehouse so the damage of raw material due to long storing periods is prevented. It also reduces the size of the warehouse as the planned intake and usage plays an important role in material handling system.
- Damage of material during transport is also reduced as the material handling system minimizes the distances by adopting the shortest routes, uses gravity assistance for movement wherever possible, design containers or trolleys to economize handling.
- Due to well-planned system customer satisfaction is also achieved.

Therefore the paper focuses on the design and fabrication of a carrier unit for MIG-MAG welding machine to reduce human efforts and add to the productivity of the locomotive workshop. It throws light on the problems faced by the workers at the workshop and the solution provided.

2. Problem Definition

Depending upon the interaction done with the workers at the locomotive workshop it is observed that they face a lot of problems when operating MIG-MAG welding machine. Some of the problems faced by the workers are:-

- The machine being a bulky unit is not easy to transport, it either requires huge manpower or overhead cranes in both ways there is a huge risk as it can seriously injure the worker if the machine by mistake loses balance and falls off.
- The welding unit has a lot of components like the gas cylinder, wire feeder, main machine unit, welding gun, welding electrodes, wires and pipes. These components are interconnected with each other. Therefore moving all the parts as well as the main unit at the same time is a hectic as well as a risky process.
- One of the main accidents which occur in the welding process is electric shock. Due to lack of proper dedicated components, there are cases of severe electric shocks which result in fatal injuries to the workers.
- Due to messy arrangements, welding tools like screen and electrodes get misplaced which caused inconvenience to the workers which lead to less productivity.
- Due to manually transporting the heavy unit, some of the workers are facing some serious musculoskeletal problems like slip disc, spondylosis and many other muscular issues.
- Continued manual transportation also results in many skeletal issues due to fatigue. These type of injuries can result in some permanent health damage.

Therefore a trolley which can sustain the weight of the complete unit with ease is required. The trolley should be able to carry all the components at the same time and should be provided with dedicated slot to all the components to avoid the problem of electric shocks and wear and tear. Also, proper insulation should be provided with the electric plug of the machine. Thus, with the development of this trolley, the concept of 5s Principles is fulfilled. The aim is to design a trolley which can reduce human efforts and increase the productivity of the locomotive workshop.

3. Literature Review

There has been a lot of research done in the material handling equipment’s design. A lot of new innovations have been discovered, as well as modifications were carried out under these studies. The aim was always to improve the design and reduce human effort to make the equipment more user-friendly.

Based on the various experiment performed on many workers it is found that a handle height of 110 cm allows the users to exert minimum force during the initial pushing. The handle height of 110 cm and a wheel diameter of 150 mm will reduce the discomfort of industry workers pushing trolleys. Even though the experiments are conducted using the local population, the results are applicable to the global population with similar anthropometric data.[1]

A mechanism for straightforward transportation of masses over stairs. Keeping this concept in mind, the project tries to design a stair rising handcart which may carry objects (up to 150kg) up the steps with less effort compared to carrying them manually by hand. In all both rolling and climbing modes gives a new transportation mode over stairs and rough surfaces with maximum inclination angle 44 degrees. The design helps us to make a stair climbing mechanism.[2]

Unloading is easier in multi-direction, only by turning the trolley rather than the vehicle in order to make the work more economical and efficient. The major outcomes of multi-directional dumper have overcome space requirement which often results in road blocking. This paper suggests inversion in the existing mechanism providing the unloading in 180-degree rotations. The mechanism prevents blocking of the road, saves time and enhances productivity at the lowest cost. Various analysis are done based on speed and power and the resulting efficiencies are compared.[3]

In today’s world due to shorter product life cycle and evolving business needs the need for change in traditional manufacturing systems and services from production facilities have raised. Today the manufacturing units face changes like data integration i.e. availability, authenticity and complete analysis of given data has become difficult to achieve. This problem can be solved by process integration within and across enterprise boundaries and real-time Information access on hand-held devices. Problems like process flexibility and security are also huge challenges manufacturing units and can be overcome by predictive maintenance. Hence step by step approach to these problems can lead to an optimum solution.[4]

Welding process has been used extensively in the manufacturing unit for joining two metals. It has proved to be very useful and plays a vital role in manufacturing of huge metallic vessels like ships, aircraft, bridges, automobiles and pressure vessels. But along with all the pros welding process can also be exposed to a lot of risks and dangers to the operator performing the welding. Workers face hazards like electric shocks, dangerous gases and fumes, improper handling leading to serious injuries. These problems can be solved by designing a well-protected and planned manufacturing system. Also, skilled labor can help to reduce the no. of accidents significantly and ensure greater safety.[5]

Material handling system is used to ensure that the right amount of material is delivered to the right destination at the right time and minimum cost. It is a very essential part of industry planning as it can amount to 30-75% of total product cost. An efficiently designed material handling system ensures reduction in product cost, better utilization of manpower, proper inventory planning and reduces manufacturing cycle time significantly. [6]

Due to globalization and highly competitive environment, there is a constant search for better performance and cost reduction. Internal material handling is one such part of the material handling system which affects the productivity as well as product cost, therefore a well-planned, as well as well-equipped internal material handling, is required. It increases reliability, reduces cost and improves overall customer satisfaction.[7]

4. Work carried out

4.1. Design

The proposed design has three major compartments which are two for the place of the welding machine and the other one is for gas tank compartment. The cart will also have a place for the wire to be hanged so that it does not look muddled which will make things easier for the welders during the process or moving it to another place. The welding cart is to be able to support the weight of the welding machine. The design of this project generates the concept process with finalizing the design. The modelling of the project will be done in PTC CREO Parametric 03 and the design and analysis will be done in ANSYS Workbench 14. After the final design is decided then the fabrication will be done as the material selection is decided with the supervisor of the locomotive workshop.

Design calculations:

Stress analysis:

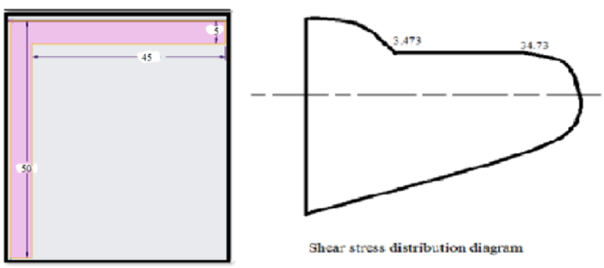

Fig.1- Cross Section Beam and Shear Stress Distribution Diagram

Here
A1 = Area of one section of L cross section bar.
A2 = Area of the other section of L cross section bar.

$A_1 = 50*5$
$= 250mm^2$ (1)
$A_2 = 45*5$
$= 225mm^2$ (2)
$Y_1 = 47.5mm$
$X_1 = 25mm$
$Y_2 = 22.5mm$
$X_2 = 2.5mm$
$Y = ((A_1*Y_1)+(A_2*Y_2))/(A_1+A_2)$ (from 1 and 2)
$= ((250*47.5)+(225*22.5))/(250+225)$
$= 35.658mm$ (3)

$X = ((A_1*X_1)+(A_2*X_2))/(A_1+A_2)$ (from 1 and 2)
$= ((250*25)+(225*2.5))/(250+225)$
$= 14.342mm$ (4)
$\tau = (Fs*A*Y)/(I*b)$
$Fs = 6600N=660kg$
$A = A_1+A_2$
$= 250+225$
$= 475mm^2$
$Ixx = (((b_2*d_1^3)/12)+A_1*Y^2)+(((b_2*d_2^3)/12)+A_2*Y^2)$
$=(((50*5^3)/12)+(250*(47.5)2))+(((5*45^3)/12)$
$+(225*(35.658-22.5)^2))$
$= 112.51*10^3mm^4$ (5)
$\tau_1 = \tau_4 = 0$
$\tau_2 = (6600*50*5*11.842)/(112.51*10^3*50)$
$= 3.473\ N/mm^2$ (6)
$\tau_3 = (6600*50*5*11.842)/(112.51*10^3*5)$
$= 34.733\ N/mm^2$ (7)
$\tau_{ind} = (6600*5*35.658*17.829)/(112.51*10^3*5)$
$= 37.294\ N/mm^2$ (8)

Width analysis:

Heavy side-

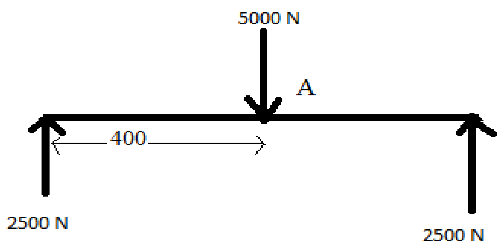

Fig 2. FBD of heavy side

$MA=2500*400=1*10^6$ N-mm
=103 N-m (9)

Light side-

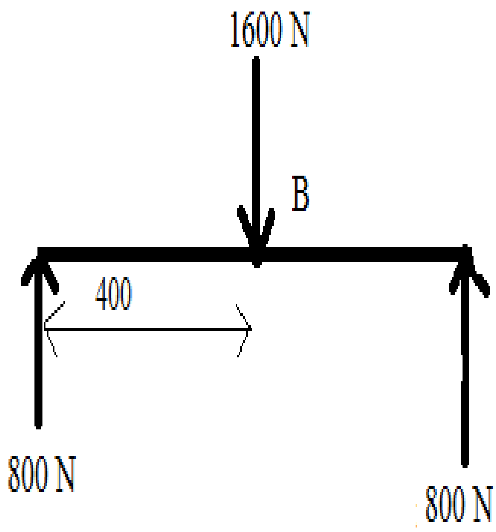

Fig 3. FBD of light side

MB=800*400=320*1000 N-mm
=320 N-m (10)

Length analysis:

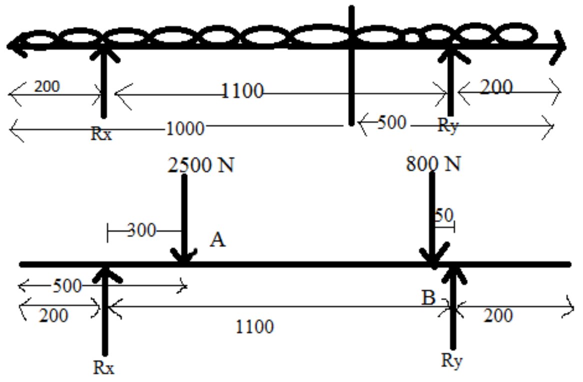

Fig 4. FBD for length analysis

∑M@Ry=0
Rx*1100=800*50 + 2500*800
=1854.55 N (11)
Ry=3300*Rx (from 11)
=3300-1854.55
=1445.45 N (12)
M@A=Rx*300 (from 11)
=1854.55*300
=556.37*10^3 N-mm
=556.37 N-m (13)
M@B=Ry*50 (from 12)
=1445.45*50
=72.273*10^3 N-mm
=72.273 N-m (14)

For L-section, material available is IS 2062

Table 1. Material Stresses

Material	σ_{yield} (N/mm^2)	σ_{ult} (N/mm^2)
IS 2062 E250 A	250	410
IS 2062 E250 B	250	410
IS 2062 E250 C	250	410

σ_{bind} =(M_{max}*Y)/I (from 3, 5 and 13)
=(556.37*10^3*35.658)/(112.51*10^3)
=176.33 N/mm^2 (15)
σ_{bper}= σ_{ult} /FOS (from Table 1)
=410/2
=205 N/mm^2 (16)
τ_{per} =205/2
=102.5 N/mm^2 (17)
$\sigma_{bind} < \sigma_{bper}$
176.33<205 N/mm^2 (from 15 and 16)
$\tau_{ind} < \tau_{per}$
37.294<102.5 N/mm^2 (from 8 and 17)

Hence, Design is safe

4.2 Construction

After performing the measuring the load of the complete MIG-MAG welding unit the above-mentioned stress analysis is done to calculate the stresses induced on the base frame of the trolley. After the calculations, the complete trolley is designed where the bottom compartment is reserved for main machine unit and flat sheet support is provided above the main unit for wire feeder of the unit. Dedicated drawers are made beside the wire feeder in order to keep the welding accessories. The front and rear side of the trolley is separated by a wired mesh to avoid the collision of parts within themselves. The gas cylinders are kept at the rear side of the trolley which has chain arrangements to support the cylinders. A provision of a hook is done at the right of the trolley so that the wire and pipe windings can be placed over it. Also, handle arrangements are made at the rear side at the height of 110 cm. it is a four-wheeler trolley which can sustain the weight of complete welding unit and can be moved from one place to other by one worker which reduces a lot of human effort (Fig.4).

.Fig.5 Trolley

4.3. Manufacturing/Fabrication

Materials selection was carried out and suitable material which is capable of detaining the total load calculated by considering the weight of inverter, 2 gas filled cylinders, wire feeder, metal sheet, ply and its accessories. The material selected for the fabrication was IS 2062. The cross-section used was L shaped angles as the strength calculated For L shape was more than circular, square and other types of cross-sections referring to design calculations. Collection of material was done according to the requirement and bill of material as shown in table1. The raw material was marked with the required dimension with the help of measuring and marking instruments and further processed for cutting. The material was cut into required dimension by using a cutting machine and then ground or surface finished by grinding machine before welding machine. Special cuts and 45-degree cuts were done by co2 gas welding. Workspace and floor were made into the same level by removing the burr on it using a grinding machine.

Materials required for the base frame (1500 mm*900 mm) i.e. 2 L-shape angles of 1500 mm and 900 mm each cut at 45 degrees for the rectangular frame and 2 angles of 500 mm having special 90 degrees cut for plates on the rectangular frame were gathered on the workspace and welded using co2 gas welding as mentioned in Fig. 4. After the fabrication of base frame metal steel was welded on it using co2 gas welding on which inverter will be placed, space for the cylinders is provided in 500 mm of frame length from total 1500 mm in rest of the part two C-frames were welded at a distance of 500 mm and 850 mm each respectively of height 1200 mm. The C-frame and the end side opposite to cylinder side from the wire feeder frame of 1000 mm*900 mm where ply is welded on which feeder will be placed at the height of 790 mm. A hook was welded on the side of feeder frame to hold wires. Half metal circles are welded at the distance of half of the cylinder height to restrict cylinders from slipping and are locked using chains. The inverter space is covered with the net for the restriction of inverter towards the cylinder. T handle will be used for carrier unit. Four turning wheels will be used for its movement. All the welding processes are done using co2 welding and surface finish given by grinding machine. For the aesthetic look, carrier unit is painted with red paint as shown in Fig 5.

Fig.6. Manufactured trolley.

Table 2. Bill of Material

Sr No.	Description			quantity	material	weight	cut	size
	Length	width	thickness					
	mm	mm	mm			kg		
1	1500	93	5	2	IS2062 E250A	10.905	45^0	Both
2	900	93	5	5	IS2062 E250A	16.426	45^0	Both
3	900	93	5	4	IS2062 E250A	13.140	Special cut	
4	490	93	5	2	IS2062 E250A	3.577	Special cut	
5	1200	93	5	4	IS2062 E250A	17.521	45^0	Single
6	350	93	5	2	IS2062 E250A	2.555	Special cut	
7	212	93	5	8	IS2062 E250A	6.190	45^0	Single
8	750	93	5	4	IS2062 E250A	10.950	Special cut	
9	790	93	5	2	IS2062 E250A	5.767	45^0	Single
10	1500	900	1.7	1	SS301	18.015		
11	900	250	1.7	1	SS302	3.002		
12	890	745	1.7	1	SS303	8.848		
hook				2				
wheels				4				
chain	1000			4				
net	1150	890						

5. Conclusion

The following conclusions can be derived based on the design of carrier trolley:-

- Selection of cross section of channel The and its dimension for the frame has been designed successfully; as τ_{ind} = 37.294 N/mm2 is less than τ_{per} = 102.5 N/mm2 which means design is safe.
- Dedicated compartments have been provided to ease the handling and transporting process.
- Ergonomic concepts are taken into consideration for construction of the trolley.
- All the factors like work environment and frequency of usage of the trolley is also considered.

Further development in this construction can be made in the direction of automating the trolley by attaching a motor assembly to it. Also provision of foldable trolley can be made in future. Hence the material handling equipment of MIG-MAG machine carrier unit can be designed using above data.

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