# Material Handling Systems in Casting Industry

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***Abstract***- *Material handling plays an important role in manufacturing and logistics in any industry. In the process or manufacturing industry, raw materials and products need to be transported from one manufacturing stage to another. Material handling equipment are designed such that they facilitate easy, cheap, fast and safe loading and unloading with least human interference*

*Material Handling involves short-distance movement within the confines of a building and a transportation vehicle. It utilizes a wide range of manual, semi-automated, and automated equipment and includes consideration of the protection, storage, and control of material throughout their manufacturing, warehousing, distribution, and disposal. Material handling is a necessary and significant component of any productive activity.*

*A case study is carried out at Kapilansh Dhatu Udyog Pvt. Ltd, Nagpur, a pioneering in Castings manufacturing various types of CI pipes using Centrifugal casting at very high temperature. These pipes are heavy and usually require a crane and human intervention to move them from one place to another which may be fatal for the workers.*

*The present study was related to the different type of material handling system used by the company and the expectation from the authorities is to curtail down the man power during the process. The data related to the production, current condition of material handling in the plant, plant layout etc was collected & some information was provided by the company. We concluded our work by designing a much reliable &preferred industrial trolley as a means of material handling for Company. The CAD model of the trolley and scissor lift was designed by software SOLIDWORKS. After that FE model and analysis is done on FEA software hyper-mesh and NASTRAN.From the results of the design, we can conclude that stresses obtained in static analysis are within the limits; hence the designs of trolley and scissor lift are safe.*

***Keywords***- Material-Handling,Solidworks, Hypermesh-Nastran, Trolley, Scissor Lift.

## I. INTRODUCTION

Material handling is a necessary and significant component of any production process. Material handling means providing the right amount of material, in good condition, at right place, right time, in the right position and for the minimum handling cost using the right method. It is simply picking up, moving, and lying down of materials through manufacture. It applies to the movement of raw materials, parts in process, finished goods, packing materials, and disposal of

Scraps. In general, hundreds and thousand tons of materials are handled daily requiring the use of large amount of manpower while the movement of materials takes place from one processing area to another or from one department to another department of the plant. The cost of material handling contributes significantly to the total cost of manufacturing.
In the modern era of competition, this has acquired greater importance due to growing need for reducing the manufacturing cost. The importance of material handling function is greater in those industries where the ratio of handling cost to the processing cost is large. Today material handling is rightly considered as one of the most potentially lucrative areas for reduction of costs. A properly designed and integrated material handling system provides tremendous cost saving opportunities and customer services improvement potential.

Fig: 1 Material handling Done Manually.

## II. LITERATURE REVIEW

**1) Guilherme Bergmann Borges Vieira, Alberto Pandolfo**

The highly competitive environment, linked to the globalization phenomena, demands from companies more agility, better performance and the constant search for cost reduction. Materials handling is intrinsically associated with production flow. Because of this, it has direct influence on transit time, resources usage, and service levels. The objective was to evaluate, in a systematic way, the impact of implemented changes in materials handling management on the internal customers' perceptions of cost, safety in service, service reliability, agility and overall satisfaction. A literature review preceded a case study in the company's manufacturing unit and the questionnaires were completed by 26 employees directly involved in the process. Analyzing the answers, it was possible to suggest that internal customers understood that the new materials handling management system enlarged service agility and reliability and reduced costs, which caused an improvement in overall satisfaction. [8]

**2) Prof. A.V. Gaur, Prof.Dr. M.S. Pawar**

Material Handling involves the movement of materials from one place to another for the purpose of processing or storing. According to American Material Handling society,' Material Handling is an art and science of involving the movement, packing and storing of subsystems in any form. Thus material handling function includes all types of movements vertical, horizontal or combination of both and of all types of material fluid, semi fluid and discrete items and of movements required for packing and storing. The material handling function is considered as one of the most important activities of the production function as out of total time spent by the materials inside the plant area, about 20% of the time is utilized for actual processing on them while remaining 80 % of the time is spent in moving from one place to another, waiting for processing or finding place in sub-stores. Moreover about 20% of the total production cost is traceable as material handling cost. The relative percentage will vary according to the type of product, plant layout, production method, availability of resources like men, machine etc. In most manufacturing systems, the material handling system plays a critical role since it is primarily responsible for providing the right material at the right place, and at the right time. A poorly designed material handling system interferes with the efficient operation of a manufacturing concern and in the long-term it may lead to a substantial loss in productivity. [6]

**3) A. Daniyan , A. O. Adeodu**

In the process or manufacturing industry, raw materials and products need to be transported from one manufacturing stage to another. Material handling equipment are designed such that they facilitate easy, cheap, fast and safe loading and unloading with least human interference. For instance, belt conveyor system can be employed for easy handling of materials beyond human capacity in terms of weight and height. This paper discusses the design calculations and considerations of belt conveyor system for limestone using 3 rolls idlers, in terms of size, length, capacity and speed, roller diameter, power and tension, idler spacing, type of drive unit, diameter, location and arrangement of pulley, angle and axis of rotation, control mode, intended application, product to be handled as well as its maximum loading capacity in order ensure fast, continuous and efficient movement of crushed limestone while avoiding halt or fatalities during loading and unloading.[2]

**4) Michael G. Kay**

Material handling (MH) involves "short-distance movement that usually takes place within the confines of a building such as a plant or a warehouse and between a building and a transportation agency." It can be used to create "time and place utility" through the handling, storage, and control of material, as distinct from manufacturing (i.e., fabrication and assembly operations), which creates "form utility" by changing the shape, form, and makeup of material. It is often said that MH only adds to the cost of a product, it does not add to the value of a product. Although MH does not provide a product with form utility, the time and place utility provided by MH can add real value to a product, i.e., the value of a product can increase after MH has taken place. [7]

**5) Prof. (Dr) V.V.Sople**

Material handling cannot be avoided in logistics, but can certainly be reduced to minimum levels. The productivity potential of logistics can be exploited by selecting the right type of handling equipment. The selection of material handling equipment cannot be done in isolation, without considering the storage system. Investment in the material handling system will be sheer waste if it is not compatible to the warehouse layout plan. The layout will create obstacles for free movement of equipment and goods, resulting in poor equipment productivity. Recent trends indicate preference for automated system with higher logistics productivity to enhance the effectiveness of human energy in material movement. [5]

**6) Akincilar, Cameron Rad**

In today's fierce competitive global markets, customers are demanding adjustable lot sizes, shorter lead times, higher quality and flexibility; in short, they want it all.

In order to stay competitive in the market, companies need to attain both customer satisfaction and cost reduction in production operations. Material Handling Systems (MHS) is the place to accomplish this goal, since they have a direct impact on production. Therefore, the aim of this study was to design an in-house MHS that could be efficient for the production it serves. With this intention, a case-study has been conducted in Bosch Rexroth Japan. During the study, the information gathered through various sources; interviews, observations and measurements. Further, the gathered data is evaluated according to main pillars of the theoretical framework, which includes design principles and physical elements, information and software, human and management. [4].

**7) F.T.S. Chan**

A key task in the material handling system design process is the selection and configuration of equipment for material transport and storage in a facility. Material handling equipment selection is a complex, tedious task. However, there are few tools other than checklists to assist engineers in the selection of appropriate, cost-effective material handling equipment. This paper describes the development of an intelligent material handling equipment selection system called MHESA (Material Handling Equipment Selection Advisor). The MHESA is composed of three modules: a database to store equipment types with their specifications; a knowledge-based expert system for assisting material handling equipment selection; and an analytic hierarchy process (AHP) model to choose the most favorable equipment type. [3]

## III. RESEARCH METHODOLOGY

The research methodology may be summarized as,

1) Objectives of work
2) Identification of Problems
3) Data Accumulation.
4) CAD Model Generation
5) Finite Element of Model Generation.
6) Static Analysis of MH system Using FEA Approach.
7) Calculations.
8) Result Discussion.
9) Conclusion.

## IV. PROBLEMS STATEMENT

*A. Manual handling of the products between the work stations:* The present system available is for handling of pipes is of overhead Mono rail conveyor. The handling includes utilisation of in all 3 labours for handling of pipes and also time required is also more and cost involved is also more. The chances of accident are more in the present system.

*B. Bulky Mechanical drives are used for lowering the stocks after Annealing process:* The present system available is very much bulky, as the present system includes motor for operation connected with gear box which is again driven by belt drive and pulley and again connected with gear box and the output of gear Box is connected to shaft to which the shaft to which arm is attached for lowering of pipes.

*C. Delay in annealing process due to inadequate layout requires reheating of product, in turn a monetary loss:* Due to present pipes in the furnace there is no space for heating of newly produced pipes so pipes are required to keep on either gantry or on floor due to which there is delay in annealing process and results in monetary loss.

*D. Safety measures require extra attention and care at specific locations:* Lots of safety measure is to be taken for producing, handling, heat treatment etc of the pipes. If not taken may result fatal for the person in the vicinity of the area of operations. As the pipe which is heated is of 700 degree Celsius and annealing is for 900 degree Celsius.

## V. FORMULATION AND CALCULATION

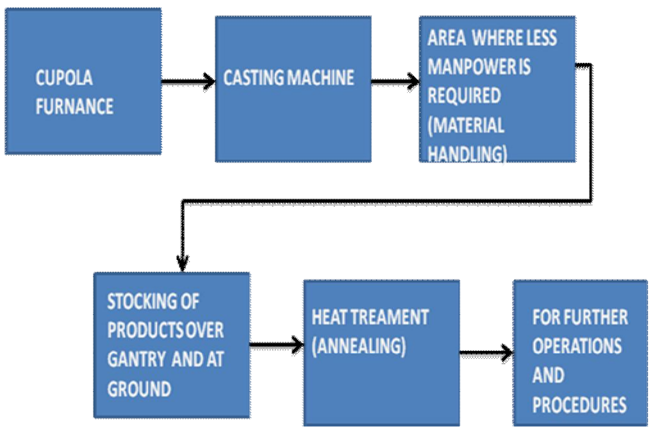


Fig2: Line diagram of system flow.

**CASE1:**

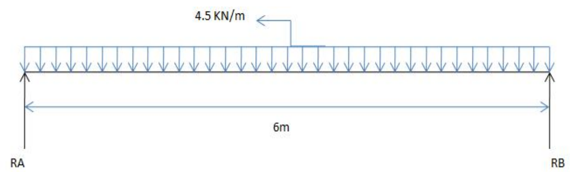


Fig3: Forces acting on Beam.

Calculations of trolley
Mass of single pipe = 550 Kg

5pipes = 550 X 5 = 2750 Kg
2750 X 9.81 = 26977.5 N = 27KN

This force is shared by 2 members and each member having 10 load points,
27 / 6 = 4.5 KN
$\Sigma Fy$=0
RA + RB = 27 KN
RB = RA = 13.5 KN

**Shear force:**
SFA = 0
SFA= 13.5 KN
SFB = -13.5 KN

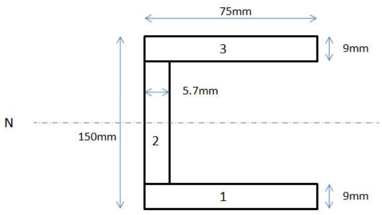


Fig4: C/s of channel

SFB=0

**Max. Bending Moment:**
BMA = BMB = 0
BMC = (13.5 X 3) - (4.5 X 3 X 1.5) = 20.25 KN-m
BM = 20250000 N.mm.

**Using parallel axis theorem:**

1) M.I part 1
$I_1=Ig_1+a_1h_{12}$
$I_1=b_1d_1^3/12+a_1h_1^2$
Where, $h_1$ = y^ - y1
Y^ = 75mm
$y_1$ = 9/2 = 4.5mm
$h_1$= 70.5mm.
$I_1=75\times9^3/12+675\times70.52$
$\boldsymbol{I1=3359475\ mm^4}$

2) M.I part 2
$I_2=Ig_2+a_2h_2^2$
$I_2=b_2d_2^3/12+a_2h_2^2$
Where, $h^2$ = y^ - $y^2$
Y^ = 75mm
$y_2$ = 9 + 132/2 = 75 mm.
$h_2$= 0mm
$I_2=5.7\times132^3/12+752.4\times0^2$
$\boldsymbol{I_2=1092485\ mm^4}$

3) M.I part 3
$I_3=Ig_3+a_3h_3^2$
$I_3=b_3d_3^3/12+a_3h_3^2$
Where, $h_3$ = y^ - $y^3$
Y^ = 75mm
y3 = 9+132 + 9/2 = 145.5mm
h3= 70.5mm
$I3=75\times9+675\times70.5^2/12$
$\boldsymbol{I3=3359475\ mm^4}$

I = $I_1 + I_2 + I_3$
I = 3359475 + 1092485 + 3359475
***I = 7811435mm^4*** 
Y = 150/2=75mm
$\sigma=M/I\times Y$

**CASE2:**
Total load acting on cylinder;

Mass to be lift = 550 X 5 = 2750 Kg
Mass of Top Frame = 441.5 Kg
Mass of upper link = 461 Kg
Mass of lower link = 342 Kg
Total Load = 2750 + 442 + 461 + 342
= 3995 x 9.81
= 39190.959.191 KN

**CASE3**:
Pressure applied to the Hydraulic cylinder,
P = F/ A
Where,
F = $W+ W_A 2\tan\theta$
$\theta$= angle of scissor arm with horizontal (21degree)
F = force needed to hold the scissors lift
W = the weight of the payload and platform
$W_A$ = combine weight of the two scissors arms.
Weight of the arm = mass of the scissors arm × acceleration due to gravity
W = 3191.5 x 9.81 = 31308.6 N
$W_A$ = 803 x 9.81 = 7877.4 N
F = 31308.6+ 7877.42tan21
F = 91.8 KN
P = 91822 / 6362
***P = 14.43 N/mm²***


**CASE4:**

Buckling of Hydraulic

Pcr = $\pi^2 EI/Le^2$

Column end condition: Both end Pinned,

Le = L = 0.82m = 820mm

E = 210000 MPa

$I = \pi/64D^4$

$I = \pi/64 \times 90^4$

$I$ = 3220623.34 mm4

Pcr = $\pi^2 X$ 210000 $X$ 3220623.34/820$^2$

***Pcr = 9927.3 KN***

Pcr> P = STABLE STRUCTURE

## VI. CAD MODEL

1) The CAD model for the trolley and scissor mechanism is,

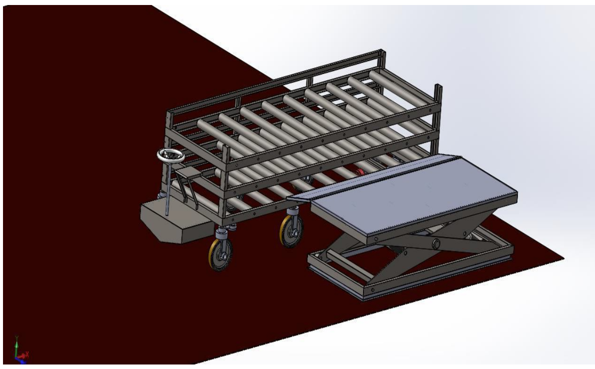

Fig4: trolley and scissor mechanism

The main components of the mechanism are.

1. The scissor lift (consisting of hydraulic cylinders, switches, etc)
2. Trolley (material-Structure steel, driving mechanism, steering mechanism, castor wheels).

2) The CAD model at entrance of Annealing furnace,

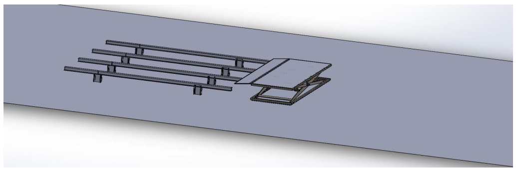

Fig5: Entrance of Annealing Furnance.

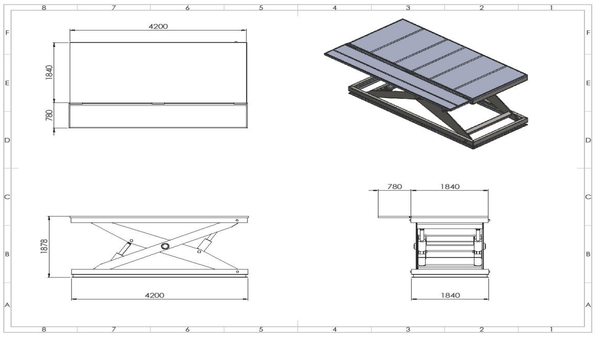


Fig6: Detailing of scissor lift.

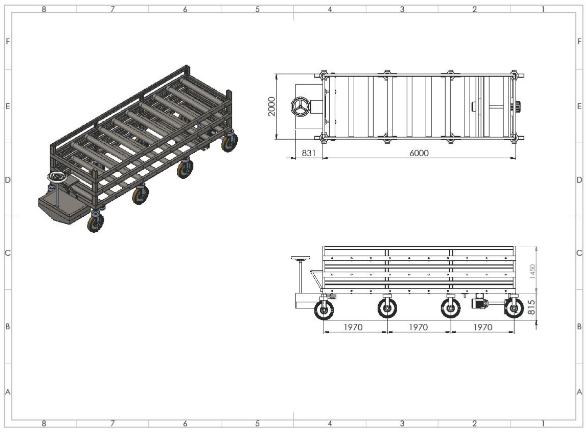


Fig6: Detailing of trolley

## VII. FINITE ELEMENT ANALYSIS

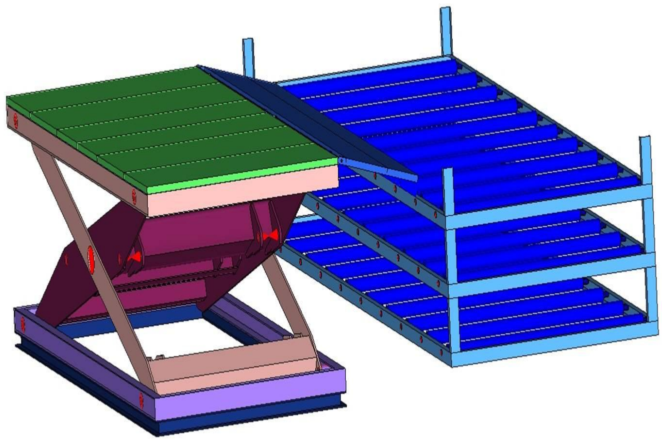

Fig7: Meshed model

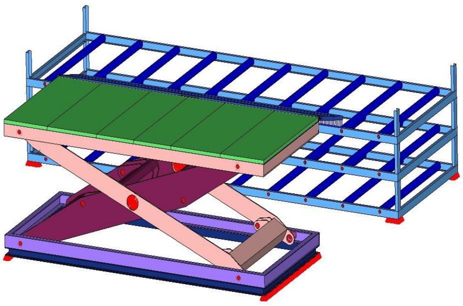

Fig8: Applying constraints to model

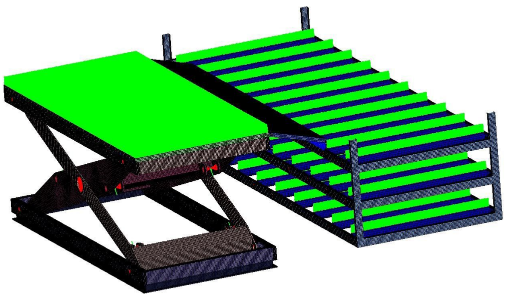

Fig9: Applying Forces to model

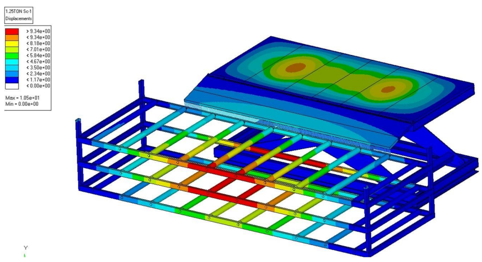

Fig10: Results: Displacement=10mm.

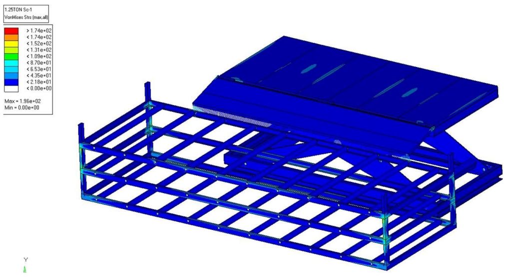

Fig11: Results: Stresses=196Mpa

From the results we can see the stresses developed in the material are considerably less than the yield stress of the material.

| Material | Tensile Strength | 0.2% Yield Strength |
|---|---|---|
| 4.6 (Carbon Steel) | 414 N/mm² | 248 N/mm² |
| 5.8 (Carbon Steel) | 510 N/mm² | 393 N/mm² |
| 8.8 (Alloy Steel) | 828 N/mm² | 635 N/mm² |
| 10.9 (Alloy Steel) | 1035 N/mm² | 897 N/mm² |
| A2-70 (Stainless Steel) | 700 N/mm² | 450 N/mm² |
| A4-80 (Stainless Steel) | 800 N/mm² | 600 N/mm² |

Table 1: Properties of Materials

## VIII. TIME ESTIMATION

### *1). Time Calculation*

*Per shift process: (8hrs/day)*

1. Maximum 411 pipes manufactured everyday per shift by six machines
2. Minimum 3 labors are required to shift 2 pipes from 1 place to another
3. Time required to shift 2 pipes = 0.5 min=30secs
4. Time required to shift 411 pipes = (411/2) x 0.5 = 102.75 min (1.71hrs)
5. This process is quite time consuming
6. Require more number of labors
7. Pipes are heated up to 700 degrees that is very dangerous to workers
8. Require more efforts of workers
9. Proposed setup moves 15 pipes at a time with only one labor
10. Time required to shift 15 pipe = 1.5 min
11. Time required to shift 411 pipes = (411/15) x 1.5 = 41.1 min
    (0.685hr=0.7hr)
12. This process can save time up to 0.7 hour everyday per shift.
13. Only one labor can operate this system.
14. 13.Heated pipes are not in contact with labor, increases safety
15. Require less effort of worker.

### *2). Time Estimation*

A. Existing Setup (3 Labours) for one shift.
   1. Time required to shift 2pipes = 0.5 min
   2. Time required to shift 411 pipes = (411/2) x 0.5 =102.75min (1.71hrs)

B. Proposed Setup (1 Labour)
   1. Time required to shift 15 pipe = 1.5min

2. Time required to shift 411 pipes = (411/15) x 1.5 = 41.1 min
1. (0.685hr=0.7hr)
2. This setup can save 1.025 hr everyday per shift.

***3). Cost Estimation***

A. Existing Setup (3 Labors) for one shift.
Payment/shift- 3x300 = Rs. 900 /day
Payment/year- Rs. 2, 85,300 /year

B. Proposed Setup (1 Labor)
Payment/shift- 1x300 = Rs. 300 /day
Payment/year- Rs. 95,100 /year
This setup can save up to 1, 90,200 every year.

## IX. ESTIMATED TIME FOR SCISSOR MECHANISM TO WORK

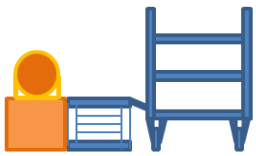

Fig 12:-Initial position of Mechanism and Trolley

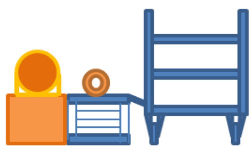

Fig 13:-***1:30min***: Maximum time required to roll pipe from furnace to bed

Fig 7.3:-***15 sec***: Hydraulic lift duel time or lifting time

Fig 14:-***1:30min*****:** Maximum time required to roll pipe from bed to trolley.

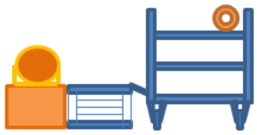

Fig 15**:-*15sec***: Hydraulic lift duel time

During the discussion with operator. It was revealed that the time of casting cycle is 4min. So the whole process of loading and unloading of pipe from SPG machine to scissor lift or scissor lift to trolley should be completed within 4min.

The maximum cycle time we assume is,
1:30+0:15+1:30+0:15 = 3min30sec

Hence, the time required for the loading and unloading of pipe is less than the cycle time we accumulate.

## X. CONCLUSION AND SUGGESTED FURTHER WORK

***1). CONCLUSION.***

In this case study, material handling system consisting of Scissor Lift and Trolley were designed using CAD. Static analysis on meshed model of industrial trolley is done by using NASTRAN. The maximum displacement and stresses were found to be10mm and 196MPa. These values are found to be within limit with respect to the permissible Stress and displacement. This project helps to reduce chances of accident, reduction of operational floor space, Minimum interference with the work, increase in the working efficiency and at less time and efforts. This project also assists projectee to get hands on CAD and FEA software, and experienced the in-depth knowledge of the project design and its analysis and makes aware with the industrial environment.

***2). SUGGESTED FURTHER WORK.***

Although a lot of work has been done to design a perfect standard design of industrial movable trolley, there still remains undeniable scope of future enhancement and improvement in this design. These improvements if pursued will lead to better operation, better design, and reduced cost, diverse application indifferent engineering fields. Thus with these benefits in sight, the scope of the future work on this industrial trolley cannot be ignored. Following are the list of activities that can be individually Or collectively carried out by researchers to achieve the above mentioned benefits.

1. The structure of the body can be designed with different material than structural steel such as composites, this will reduce the weight of the body significantly.
2. Most of the times structures fail due to fatigue loading, hence there is a scope for improvement of the fatigue life of industrial trolley.
3. If these future research activities are carried out by the researchers it will also benefit the research associate to get insight into the design aspect of industrial trolley design improvement for material handling for KAPILANSH DHATU, NAGPUR.

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