Design And Analysis of Manual Movement of Tools Carrier on Frame Structure

Rajashekhar M Sunadholi[1], Praveen M. P[2]
[1]PG student, East Point College of Engineering & Technology
Bangalore-560049
[2]Associate Professor, East Point College of Engineering & Technology
Bangalore - 560049

***Abstract*--A well-defined and Systematic methodology is essential to reducing extra man movement (MURA) and deleting the overburden (MURI), which in turn has considerable influence on the cost reduction of industry. The manual movement of tools carrier helps in carrying the tools from one place to another place with help of rope and pulley mechanism and bearings provided to the tools carrier in touch up operation at assembly department. These tools are bit heavy to carry them from place to another place to use them on vehicle which is moving on the conveyer. This equipment helps to reduce effort and the force required to perform task of worker and to reduce reaching and bending for carrying of the tools from the previous place. In this paper the Pokayoke design and development is done in the Kaizen area at Toyota Kirloskar Motors to eliminate the extra process (MURA) and idle time of worker. "The project work that is manual movement of the tools carrier on frame structure is designed and implemented in touch up operation area in trim assembly line for Toyota kirloskar motors."**

***Keywords: Pokayoke, MURA, MURI, Kaizen, Tools carrier*.**

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1. INTRODUCTION

Work plays a central role in the majority of adult lives at many social economic levels. It maintains income and contributes to individual identity and social status. There is emerging evidence that continued participation in a work role has therapeutic benefits. From the point of view of employment, the term "extra movement" refers to that the process which takes a lot of time to maintain a suitable job and to progress within that job are remarkably lower than the general processes due to some abnormality in working area.

At Toyota Kirloskar Motors, In touch up operation area at trim assembly line, different kinds of tools like cotton bond, hammer, torque wrench, puller, bump and dent removing rod and gauges are used for correct fitting of doors to vehicle body and clearance level of external parts with its opening areas are checked. Parts which are not properly assembled with required part are identified and repaired using these tools. As these processes take place, one of the Team Member brings these tools from the previous place to work on the vehicles for the touch up operation. This process leads to extra moment (MUDA) of Team member. To eliminate these problems more trails are done with different methods and finally the problems are reported. The current work looks at the existing problem of tool movement. Further, design and fabrication of the tool carrier and the frame structure is done to ease the manual movement of tools as per TKM working Standards.

2. LITERATURE SURVEY

2.1 Poka-Yoke

The Poka-Yoke (a Japanese word that means mistake-proofing) technique was first developed in 1961 by Shigeo Shingo. Poka-Yoke uses devices on process equipment to prevent the human or machine errors that result in defects, or to inexpensively inspect each item produced to determine whether it is acceptable or defective. Poka-Yoke-designed manufacturing devices are one of the bases of Shingo's zero quality control concepts, which mean that the defect rate in a production system is zero. Poka-Yoke design can dramatically decrease the risk of producing defectives products (Shingo, 1986). The Poka-Yoke philosophy also aims to make work easier and prevent errors caused by monotony or other process-related causes. In many productive environments, there is a tendency to equate speed with productivity. Traditional engineering processes are designed to increase the efficiency of an operation by enabling people and machines to work faster, and processes are usually complicated to achieve greater speed; yet it is these complications which cause many of the errors people and equipment make, resulting in more defective products.

By contrast, the Poka-Yoke philosophy aims to increase productivity by simplifying processes, making them more efficient, reducing the number of errors that need to be corrected, and increasing the overall efficiency of the system. Poka-Yoke can be used wherever errors can occur and can be applied to any type of processes and helps workers to be "right first time", enhancing the quality of the product and the overall output of the process. Poka-Yoke

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supports efforts to eliminate waste caused by: over production, inventory, waiting, transportation, motion, over processing, quality defects, reprioritization and also waste caused by people's skills. Most importantly, Poka-Yoke was developed with the aim of making work easier for workers without disabilities, and as such demonstrate the value of often simple adaptations tailored to the job at hand.

It is often assumed that adaptations to support the diversity of situations faced by disabled workers present a huge challenge for designers. In fact, the extra intellectual effort needed to overcome disability often results in a better final design for both the disabled and non-disabled users.

Poka-Yoke represents a suite of simple and relatively inexpensive ways of improving access to work and the productivity and performance of disabled and non-disabled workers, and a powerful tool for implementing Universal Design in the workplace [2].

2.2. Manual handling of tools in industries:

Manual handling involves any activity that requires the use of force exerted by a person to lift, lower, push, pull, carry or otherwise move or hold an object. There are common postures found in the working environment in industries are standing, sitting, reaching and moving. Some of the users may need or want to stand at the work station. For this case, an appropriate desk can be designed and selected for the type of work being performed. Desk height for a standing operator can range from 28-43" that can be considered when designing workplace products or space. Knowing what parameters to design for while the user is seated can help to increase the comfort of the user, while sitting or standing, an individual at work will usually have to reach for something [3].

Products are designed in working area so that the workers will have to reach in order to minimize awkward or unhealthy position. Users will move around in their environment to bring file papers, answer a phone, or stretch. An occasional break from sitting is encouraged because it helps to stimulate muscles, and increases blood flow, which decreases fatigue. The work place should be comfortable for users and adapt their needs [4].

The work place products are designed keeping in the mind that can lead to high productivity and lower risk of injury and illness. So by considering these factors every product that are used by the workers in working area are provided by the organization according to the standards followed in anthropometric data. So If the load of the object is light than it can be carried at required area by hands, if the load of the object is very heavy than it is transferred to the required area by the mechanical or transmission devices.

2.3 Introduction to power transmission devices:

There are many different types of transmission devices. The most common are listed below:

a) Belts: In case of belts friction between the belt and pulley is used to transmit power. There is always some amount of slip between belt and pulleys, therefore exact velocity ratio cannot be obtained. So belt drive is not a positive drive. Hence belt drive is used where exact velocity ratio is not required. The following types of belts shown in figure,

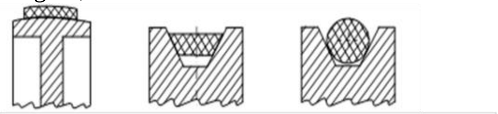

Figure1. Types of belts and pulleys

The belt drives are of the following types. They are Open belt drive and Cross belt drive.

1) Open belt drive: Open belt drive is used when sense of rotation of both the pulleys is same. It is desirable to keep the tight side of the belt on the lower side and slack side at the top to increase the angle of contact on the pulleys. This type of drive is shown in the figure.

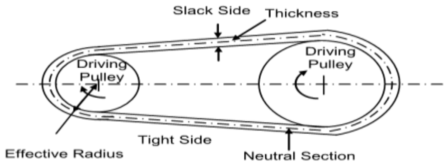

Figure 2. Open belt drive.

2) Cross belt drive: In case of cross belt drive, the pulleys rotate in the opposite direction. The angle of contact of belt on both the pulleys is equal. This drive is shown in the figure 3. The belt has to bend in two different planes. As a result of this belt wears very fast and therefore this type of drive is not preferred for power transmission. This can be used for transmission of speed at low power.

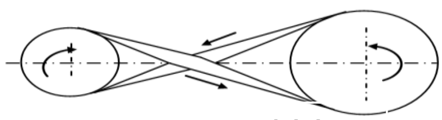

Figure 3. Cross belt drive

b) Chain: Like belts, chains can be used for larger centre distances. They are made of metal and due to this chain is heavier than the belt but they are flexible like belts. It also requires lubrication from time to time. The chain and chain drive are shown in Figure 4; the sprockets are used in place of pulleys. The projected teeth of sprockets fit in the recesses of the chain. The belt drive is not a positive drive because of creep and slip. The chain drive is a positive drive.

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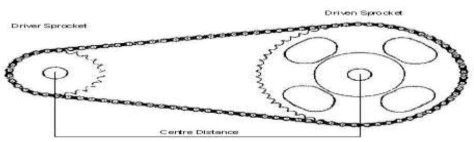

Figure 4. Cross belt drive

a) **Gears:** Gears are also used for power transmission. This is accomplished by the successive engagement of teeth. The two gears transmit motion by the direct contact like chain drive. The drive between the two gears can be represented by using plain cylinders or discs 1 and 2 having diameters equal to their pitch circles as shown in Figure 5.

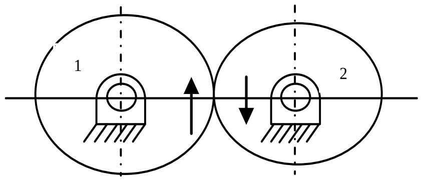

Figure 5. Gear drive

Among these transmission devices, the belt drive is very economic and easy to use for transferring the load from one point to another point. Therefore in many case we use rope and pulley system as belt drive to carry the load at long distances so we can use rope and pulley as open belt drive [7].

The industrial trucks which are provided with different names include tools carrier, trolley or dolly are used in the industry as transport systems for transferring the parts to the required department. These trucks are like containers in which different tools or parts are placed in it and these parts may require at different places like weld shop, paint shop, assembly shop etc, which are transferred by providing the power transmission devices to these carriers. Hence different kinds of mechanisms are used to transfer the load to the required area. During design of any product which is required at working area are made by considering the different ergonomic factors [9].

3. EXPERIMENTATION AND METHODOLOGY

3.1 Concept Selection:

Concept selection is the process of evaluating concept with respect to customer needs and other criteria, comparing the relative strengths and weakness of the concepts, and selecting one or more concepts for further investigation or development.

- We use some method, implicit or explicit, for selecting concepts, Decision techniques employed for selecting concepts range from intuitive approaches to structured methods.
- Successful design is facilitated by structured concept selection. We recommend a process called ***Concept Screening Matrix***.
- Concept screening uses a reference concept to evaluate concept variant against selection criteria and it uses a coarse comparison system to narrow the range of concepts under consideration.
- Concept selection is applied not only during concept development but throughout the subsequent design and development process.

Concept selection uses matrix as the basis of six-step selection process. The six steps are:

1. Prepare the concepts.
2. Rate the concepts.
3. Select one or more concepts [1].

- Hand sketch of the Selected concept

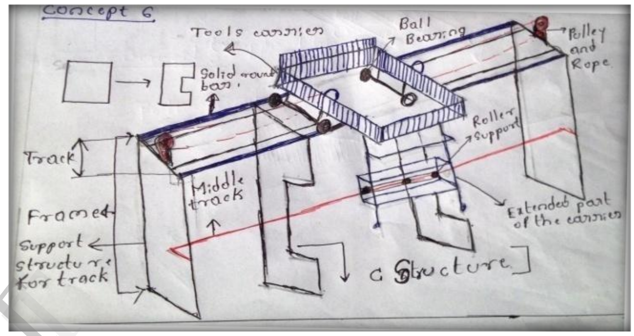

Figure 6. Tools carrier on frame structure created concept

3.2 Description of the concept:

Tools carrier is provided with ball bearing which moves on the track part where round solid bar is attached at the end of the track to avoid the falling of carrier from the track, pulley with required structure is provided on the both ends of the track. One end of the rope is connected to the carrier and other end is made to pass over one side of the pulley from there it is passed below the tools carrier and again it is passed over the pulley on the other side of the track to other end of the tools carrier. Just by pulling and pushing mechanism of the pulley with rope makes tools carrier to move by the hands with less effort in handling of the tools in different required point.

This tack is supported by the two support structure part at the both ends and two C structure part in the middle. Tools carrier is extended from one side of the track to hang the puller and bump removing bar. This extended part is made to move on the middle track with roller support. Middle support part is given of C section in order to pass the extended part of the tools carrier.

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3.3 2-D and 3-D full model

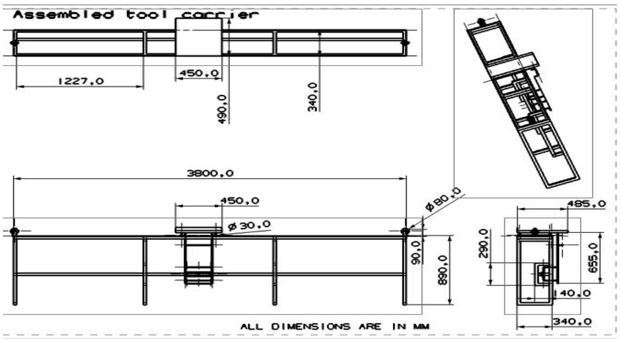


Figure 7: Detail Design of equipment in 2D

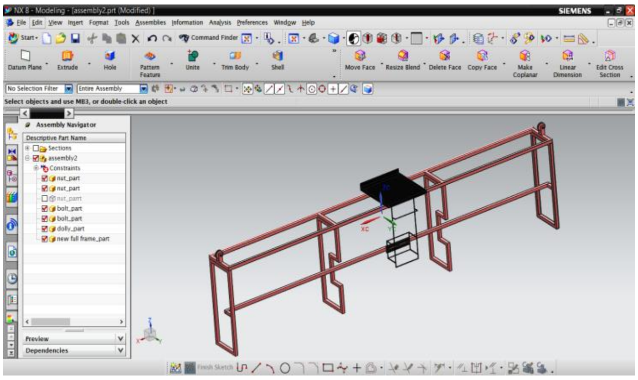


Figure 8: Detail Design of equipment in 3D

3.4*Part Analysis Condition:*

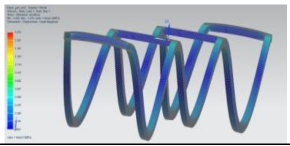
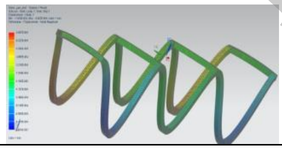
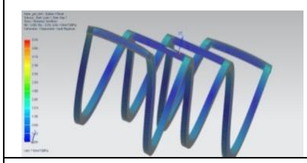
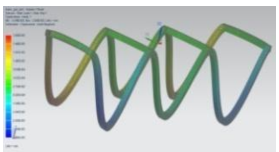
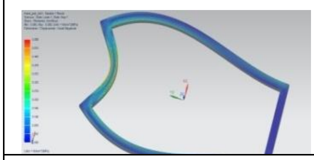
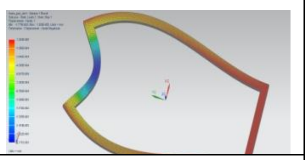
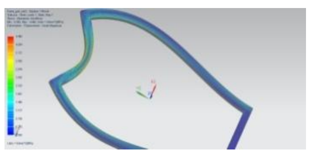
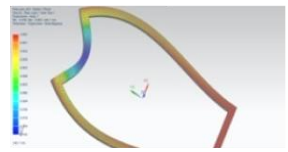
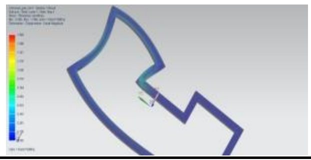
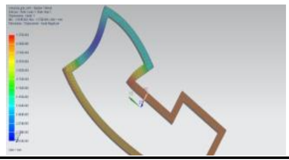
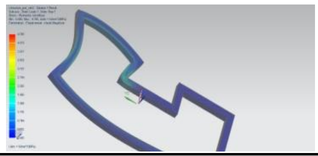
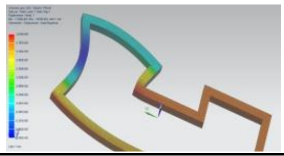
VON-MISES Stress	Displacement
Track part: Load= 100N	
	
Track part: Load= 300N	
	
Support structure part: Load=100N	
	
Support structure part: Load=800N	
	
C Support structure: Load=100N	
	
C Support structure: Load=300N	
	

Figure 9. Testing Condition for frame structure

3.41 Testing result table:

Components	Load		Max stress (Mpa or N/mm^2)	Deformation (mm)	
	N	Kg		Min	Max
Track part	100	10	1.67E02	-1.015E-03	9.897E-04
	200	20	3.34E02	-2.030E-03	1.979E-03
	300	30	5.010E02	-3.045E-03	2.969E-03
Support structure part	100	10	0.558E02	-1.771E-03	1.303E-05
	500	50	2.79E02	-8.855E-03	6.515E-05
	800	80	4.466E02	-1.42E-02	1.0E-03
C Support structure part	100	10	1.568E02	-2.514E-03	1.272E-04
	200	20	3.137E02	-5.028E-03	2.544E-04
	300	30	4.705E02	-7.542E-03	3.816E-04

Table1. Testing Result Table

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All above figures show the structural analysis of the Frame part which includes track part, support structure part and C support structure part. From the **NX-NASTRON** results, we see the different loading condition and the corresponding change in maximum stress and displacement conditions under varying loading conditions from the above table. From the above table the ***maximum principal stress*** for ***mild steel*** is found to be ***340Mpa***.

a) **Track part:**
   - Minimum load=100N to 200N
   - Maximum load=200N to 300N

b) **support structure part:**
   - load=100N to 500N
   - Maximum load=500N to 800N

Table1. Testing Result Table

c) **C support structure part:**
   - Minimum load=100N to 200N
   - Maximum load=200N to 300N

3.6 Production ramp up:

3.6.1 Construction and working methodology

- Construction includes providing the tools carrier with bearings so that as the bearing rotates it results in the tools carrier movement to move on the track part of 3800mm long. To avoid falling of tools carrier a round solid bar of diameter 10mm and length of 3800mm is fixed on the tack at the both ends.

- The track part is fixed on the two supporting structures of height 850mm at both ends of the track. Two C support structures are provided at the middle of the track. The extended part of the tool carrier is made to pass inside the C section of the C support structure which moves on the middle track with roller support.
- The track part which is supported by the supporting structures is called as “Frame structure”. At the end of the track on both the sides, pulleys of 80mm major diameter is fixed at the middle section of the track.
- Dimensions of the different parts are shown above. Parts are joined by arc welding at required points during fabrication process. Bars which are used for the frame structure is hollow with 2mm wall thickness.
- **Working methodology**: As the vehicle enters the touch up operation area, the team member will pull the tool carrier from the previous place with all tools inside the carrier manually. This pulling action results in ensuring that the tools carrier moves aided by the rotary motion of the pulleys. Tools can be taken from the carrier and used at required point, and once the work is completed the tools are placed on the carrier and used during next cycle.

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4. IMPLEMENTATION AND RESULT

The manual movement of the tools carrier is successfully **implemented** in plant 1, in trim inspection line at the touch up operation in assembly department. Safety precautions that are as essential as per the required Toyota Kirloskar Motor standards are taken which includes the markings on the floor warning the workers with respect to the extended or protruded parts of the tool carrier set up.

The pictures below show the pre and post implementation of the tool carrier mechanism.

Figure 10* pre implementation of the tools carrier

Figure 11* post implementation of the tools carrier

pictures taken with authorized permission

5. CONCLUSION

Manual movement of tools carrier on the frame structure provides best design in handling or carrying the tools from one place to the other place. The main aim of the project is to reduce the effort of workers of assembly department in handling of the tools and reaching to the required working point. The manual movement of the tools carrier is simple in design which consists of tool carrier where different tools are placed and is moved on track with the help of bearing provided at the bottom and pulley and rope mechanism. This tools carrier is made to move at required height of frame structure in order to reduce the bending action of the worker. Maintenance of the entire

structure is relatively simple and can be done by a non skilled worker.
After conducting a number of trials, some of the objectives of the project have been fulfilled.

- To reduce effort and the force required to perform task by the worker
- To reduce contact pressure on the hands and shoulders of the worker
- To reduce reaching and bending for carrying of the tools from the previous place.

So the manual movement of tools carrier on the frame structure is successfully implemented in touch up operation in assembly department at Toyota Kirloskar Motors industry.

5.1. Future Scope:

Tools carrier can be moved automatically without man power by using the concept of Automation. Automation is defined as the use of control systems and information technology in order to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Mechanization provides human operators with machinery to assist them with the muscular requirements of work; automation greatly decreases the need for human sensory and mental requirements as well. This tool carrier can be further improved by considering the aesthetic factors and ergonomic factors.

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