Design and Fabrication of Automated Loading Trolley for Missile and Canister

Syed Nazishuddin Quadri Fasiuddin
Department of Mechanical Engineering
College of Engineering Pune(COEP),
Pune-411005, Maharashtra, India
Syednq12.mech@coep.ac.in

Abstract

The paper is all about designing an automatic system which will be used to load missiles in respective canisters. Till now the loading is done manually but it takes so much time as well as requires lot of human efforts hence basically our aim is to reduce loading time and the workforce required. This loading operation need to be performed automatically. For the said purpose Electro-Mechanical mechanism is designed. This mechanism performs required operation with accomplishing the time and efforts requirement efficiently.

The peculiar characteristics of the development of this mechanism are versatility in utilising it for loading any type of missile into to the canister.

Keywords
Missile canister, Missile Trolley, Automation, Design & Manufacturing, modelling and simulation.

1. Introduction

When different types of missiles are produced in the laboratories and manufacturing workshops of Defence Research and Development Organisation, R&DE(E), DRDO. The transportation of those missiles is always a problem. While transporting the missiles from one place to another they are loaded in a Canister. Since the missiles bulky and is composed of multiple parts of which most of them are very delicate ones which can be damaged if the missile is not handled properly. The first and most difficult task in the process is to load the missile into the Canister. The process generally used for this task is a rope and drum mechanism in which the rope guides the missile into the Canister. This process involves lot of manual interference and is prone to errors and also creates a risk of accidents. In addition to all this, loading the missile in the Canister is also a time consuming task.

To eliminate the shortcomings of existing mechanism it is essential to have an automatic mechanism which will help people to load the missile quickly, safely and with minimum chances of damage to the missile & any kind of damage.

1.1 Problem Definition
Basically, the project is undertaken for designing a facility that will enable the people working on a missile to align and load the missile in the Canister in which it is transported. So the project statement is as below:

“Design and Fabrication of Automated Loading Trolley for Missile and Canister.”

As our problem statement states the missile is to be aligned with the axis of the Canister and then it is to be inserted into it automatically.

1.2 Problem Constraints

The mechanism has to be design under the following constraints:
- Irregular surfaces.
- Cost.
- Alignment of missile with canister Guiderail.
- Weight of missile and canister.
- Dimensions (Missile & Canister).
- Closed Canister.
- Missile can’t be held on Nose portion & Central fragile portion.
- Missile is to be entered from rear side.
- Higher factor of safety (Overdesign).

1.3 Objective of project

Based on the problem definition the primary objective of the project is to minimize the missile loading time into the canister by making the mechanism Automatic. Following objectives were taken into consideration.

1.3.1 Objective related to Design

- To design an Electro-mechanical mechanism, this is versatile.
- To reduce the missile loading time as much as possible.
- The design should be safe and optimized.
- Use of Process failure mode effect analysis (PFMEA).

1.3.2 Objectives related to Manufacturing

- Selection of reliable and good strength materials.
- Selection of proper machining processes and manufacturing methods like Lean Technology, Just in time Technology (JIT), Six Sigma Techniques).

1.3.3 Objective Related to cost

- Initial cost of the project should be minimum.
- Operating cost of the mechanism should be as low as possible.
- We will be performing the Value Analysis of the project to reduce the overall cost of the mechanism.

1.3.4 Objective related to size, shape and weight objectives

- The mechanism should be compact based on the requirement.
- The weight of the unit is kept low for easy transportation.

1.3.5 Objectives related to Reliability and maintenance

- Due to the simple design techniques and good manufacturing processes, the unit will be more reliable.
- As the use of standard parts the maintenance of the mechanism is Simple.
1.4 Methodology:

The methodology used for design and development of the mechanism is as shown in the flow chart shown below:

![Flow Chart](image)

Figure 1. Flow Chart

2. Design Stage

Listed below are the components for which detailed design & analysis have been done:

- Bracket thickness calculation
- Selection of Bearings
- Design of shaft
- Trolley base thickness
- Section selection
- Guiderail supports calculations
- Tolerances calculations

2.1 Assembly drawing

It contains overall view of the assembly. The parts of assembly are numbered and corresponding details of that part are shown in the BOM (Bill of Material).
2.2 Platform base

2.3 Gross design concepts and finalization:
2.3.1 Benefits of Automated loading Trolley for Missile and Canister (Figure 6) over the concepts shown in Figure 4 and Figure 5

- Mechanism selected is shown in Figure 6 it’s easy for serviceability and maintenance, while the concepts shown in Figure 4 and Figure 5 are not.
- The finalized Electro-Mechanical based project can be used on irregular surfaces while the other mechanisms shown can only be used
- Vertical mounting of actuator reduced centre to centre distance between guiderails.
- Missile Loading time is reduced due to Autonomous operation.
- Lesser workforce is required by using the mechanism shown in the Figure 6.
- Actuator is electromechanical and motor operated, So need of sump and oil reservoir is eliminated.
- Only two persons will be needed load the missile into the canister instead of many.
- The cost of the project is justified against its application.

2.3.2 Areas of improvements in this mechanism:

- This design can carry load upto 500Kg only. (it can be designed separately for higher loads).
- High precision required, even slight angular deflection between guiderails will cause interruptions in sliding motion of trolleys.
- Use of ribs and guiderail supporting blocks increases total weight of assembly.
- Can’t tolerate angular misalignment between two platforms i.e. missile and canister platform.
- The missile will be rotated about its central axis (axis along its length). So there will be friction between the semicircular support and missile base. This friction may cause damage to some critical parts.
3. Analysis and validation

We have used Ansys software for analysis and validation of the part strength and produced deflection due to loading. The critical components are mentioned as follows;

- Actuator mounting shackle of trolley1
- Actuator mounting shackle of trolley2
- Shaft
- Rectangular channel

3.1 Actuator supporting shackle of trolley 1

![Figure 7. Analysis for Deflection of trolley1 actuator mount](image)

![Figure 8. Analysis for induced stress on trolley1 actuator mount](image)

We applied 6000N load on actuator supporting shackle and evaluated maximum induced deflection and maximum induced stress. Maximum induced stress is 175.51 MPa, which is less than the permissible value of 248MPa and maximum induced deflection is 0.067mm. Hence the design is safe.
3.2 Actuator supporting shackle of trolley 2

![Figure 9. Analysis for induced stress on trolley2 actuator mount](image)

Figure 9. Analysis for induced stress on trolley2 actuator mount

![Figure 10. Analysis for Deflection of trolley2 actuator mount](image)

Figure 10. Analysis for Deflection of trolley2 actuator mount

We applied 6000N load on actuator supporting shackle and evaluated maximum induced deflection and maximum induced stress. Maximum induced stress is 162.9 MPa, which is less than the permissible value of 248MPa and maximum induced deflection is 0.013mm. Hence the design is safe.

3.3 Rectangular channels

![Figure 11. Analysis for induced stress on rectangular channel](image)

Figure 11. Analysis for induced stress on rectangular channel

© IEOM Society
We applied 3700N point load on each rectangular channel and found out maximum induced load and maximum induced deflection. Maximum induced stress is 52.217 MPa, which is less than the permissible value of 248 MPa and maximum induced deflection is 0.0045mm. Hence the design is safe.

We applied 2500N load on each end, 20N load of brake on square step and 5N load of key. Two ends are given fixed support. Maximum induced stress is 0.8 MPa, which is less than the permissible value of 248 MPa and maximum induced deflection is 0.000042mm. Hence the design is safe.
4. Manufacturing

Table 1. Manufacturing Processes Used

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Components</th>
<th>Manufacturing Processes</th>
<th>Tools Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Platform (Base Plate)</td>
<td>Milling, Drilling, Welding (MIG Welding).</td>
<td>Light duty plain milling cutter, Twist drill</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Shaft</td>
<td>Facing and chamfering, Turning, Milling, Slotting</td>
<td>Single point chamfering tool, Shoulder turning tool, light duty plain milling cutter, staggered teeth side milling cutter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Key</td>
<td>Milling</td>
<td>plain milling cutter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Trolleys</td>
<td>Milling, Welding, Drilling</td>
<td>plain milling cutter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Actuator mounting plate</td>
<td>Milling, Drilling</td>
<td>plain milling cutter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Shaft mounting plate</td>
<td>Milling, Drilling</td>
<td>Light duty plain milling cutter and plain side milling cutter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Shaft and brake mounting plate</td>
<td>Milling, Drilling</td>
<td>Parallel shank (stub series) twist drill</td>
</tr>
</tbody>
</table>

5. Future Scope

Our model satisfies the needs for an automatic sliding mechanism for heavy loads like that of a missile. But there is still scope for improvement in the model design. Also with the help of innovative techniques the model can be modified to a great extent. The field that might be improved to increase the efficiency and effectiveness of the model are as follow

- In this project the sliding motion of the missile into the canister is given more emphasis on. The axes alignment and angular alignment solutions can also be incorporated in the model to render it a capability to be sufficient for the whole loading operation.
- With the given constraints we have designed a crawling type of mechanism to slide the missile into the canister. A crawling mechanism is the one in which the forward stroke of the actuator is used to push the load trolley and the backward stroke is used to retrieve the trolley on which the rear end of the actuator is mounted. In this case a continuous motion type of solution can be thought of and realized for time reduction of the objective. But again the cost of such a project has to be given a thought.
- Our project supplies a good amount of automatic nature to the operation, but it still needs an operator to switch on and off the motor. Sensors can be used to make the system fully automatic and to fully avoid human interference. Reducing the probability of errors.
- The cost of the mechanism can be cut short to some lower value.
- The portion where actuator is mounted or the undersides of the trolleys have a bulky look to it. With some modifications there a simpler way can be found out.
- Instead of four support columns to the platform base we can use four hydraulic cylinders for adjusting the heights and to use the mechanism on irregular surfaces.
6. Conclusion

The end outputs in relation with the use of our mechanism are as follows;
- The missile loading time will be reduced.
- Service to Nation
- Lesser workforce is required.
- Accuracy in loading of fragile parts.
- Easier Automated operation for loading of missile into canister.
- Safer loading operation.
Bibliography
Kinematics and Dynamics of Machinery (English) 1st Edition

Biography

Mr. Syed Nazishuddin Quadri is currently pursuing Bachelor of Technology in Mechanical Engineering from College of Engineering Pune, Maharashtra, India. He has Completed Diploma in Automobile Engineering and Awarded with Gold Medal and Several Awards for outstanding performance in Automobile Engineering. His research focus is on knowledge-based intelligent and innovative design and its modelling, simulation and manufacturing.

Dr Mohan P. Khond , Associate Professor in Mechanical Engineering Department at College of Engineering Pune, Maharashtra, India, who acts as a guide for this project. He has more than 25 years of teaching experience and published more than 50 technical papers in various national and international journals and conferences. His area of interest is industrial Engineering.