Development of Storage System by Designing a Magazine for Forged Rings

Meet Karelia, Mehul Prajapati, and Vinayak Salian

Abstract A forged groove ring is one of the vital parts, widely used item in aerospace engineering. It is an essential step to store these rings carefully and keep them handy, when they are required. This paper helps the manufacturing shop to store these rings efficiently and keep it handy, whenever they are needed. By designing a magazine for storage system, stresses were calculated by selecting proper material and its availability. This provides machine shop safety as well as helps in efficiently handling the rings.

Keywords Forged groove rings · Shell segment

1 Introduction

The forged groove rings are used for connecting two shell segments in order to manufacture rocket launching vehicle. They have to be fixed with other in a proper full proof way that is convenient to assemble and dismantle at any given point of time. It is often found that it is difficult to roll a large shell of the entire length of the rocket. Hence, the connected shell segments with rings not only increase the convenience factor but also help in the strength and flexibility of the launch vehicle. When ring arrives into the shop, they are not stacked properly and do not have any specific space for storage. It was decided to develop a storage cum retrieval system to access these rings in the shop floor.

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H. Vasudevan et al. (eds.), *Proceedings of International Conference on Intelligent Manufacturing and Automation*, Lecture Notes in Mechanical Engineering,
https://doi.org/10.1007/978-981-15-4485-9_63

Fig. 1 Old storage system

2 Methodology

a. **Old method**

In Fig. 1 shown, the rings are left open with just wooden blocks separating them, and they are stacked one above each other. These rings are placed in an open unassigned area completely, where crane is used to pick the rings up and place them one over another. In old method, if the bottom rings are to be taken out from the magazine, the rings above are disturbed, an ineffective way to remove the rings which takes 10–15 min to handle.

b. **Modified method**

In this new and proposed method shown in Fig. 2, a new design has been created for storing and handling these forged rings. As mentioned, the previous method was inefficient and time consuming, whereas this method eliminates the handling issues and moreover reduces the risk of any accident that can be caused while stacking these rings [1]. The design which had been selected for rings is in horizontal position, and it can stack up to 10–11 rings.

3 Design

In this new and proposed method in Fig. 3, a new design has been created for storing and handling these forged rings; as mentioned above, the previous method was inefficient and time consuming, whereas this method eliminates the handling issues and moreover reduces the risk of any accident that can be caused while stacking these rings. The design which had been selected for rings was in horizontal position, and

Fig. 2 Modified storage system

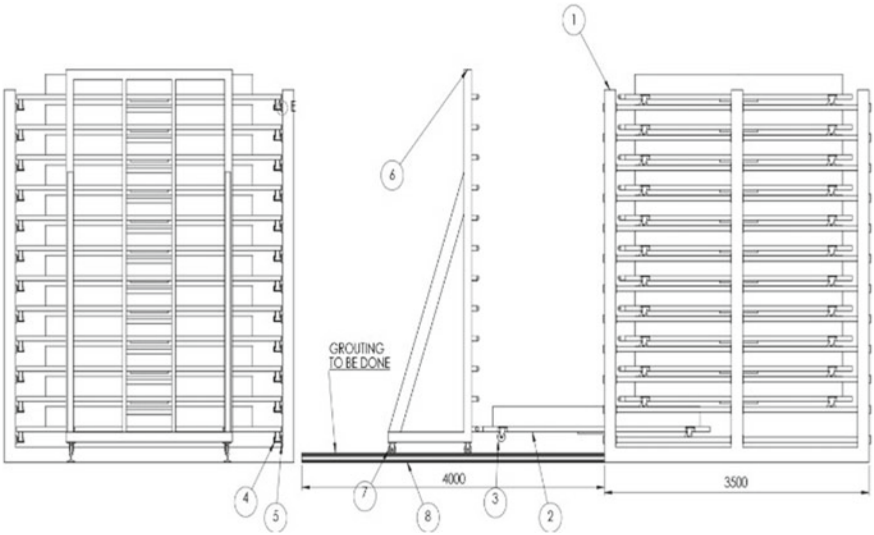

Fig. 3 Storage system design

Table 1 Design description

S. No.	Description
1	Storage rack
2	Trolley
3	Caster wheel
4	ISMC 100
5	Spacer plate
6	Moving trolley
7	Track wheel
8	Rail beam

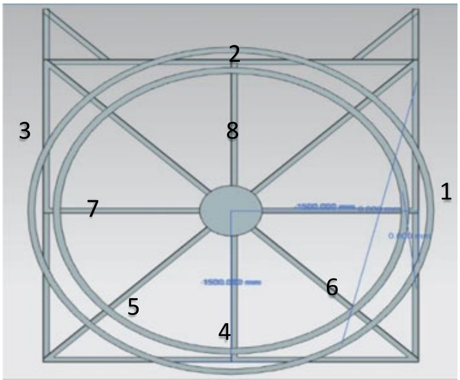

Fig. 4 Top view of 2 rings with frame

it can stack up to 10–11 rings [2]. Table 1 enlists the assembly components required for the rack design.

Material Specification

Inferring Fig. 3, the following are the detailed specifications with the beam cross section shown in Figs. 4 and 5) (Table 2).

3.1 *Stress and Deflection Calculations for Members 1 and 3 [3]*

$$\text{Max Weight acting on the frame considering both rings} = 400 \times 2 = 800\,\text{Kg}$$
$$= 8000\,\text{N}$$

Considering load factor, Total Load, $P = 16{,}000$ N
Load at centre of each beam (considering No. of beams $= 4$) $= \frac{16{,}000}{4} = 4000\,\text{N}$
Total load at centre (weight of rings + self-weight) (Fig. 6);

$$W = 4000 + \frac{(3200 \times 92)}{1000} = 4294.4\,\text{N}$$

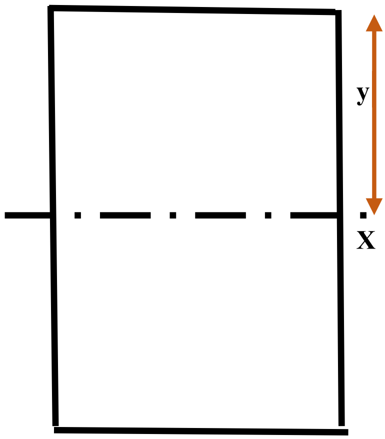

Fig. 5 Rectangular cross section of beam

Table 2 Material specification

Material	ISMC 100 Carbon steel
Self-weight	$w = 92$ N/m
y	50 mm
Moment of inertia for rectangular section	IXXX $= 186.7 \times 10^4$ mm^4
Yield stress	$\sigma_y = 247$ MPa
Factor of safety	FOS $= 1.8$
Allowable stress	$\sigma_{allowable} = 137.22$ MPa
Beam span along edge (2,4, 7 & 8)	$L = 3000$ mm
Beam span along edge (1 & 3)	$L = 3200$ mm
Beam span along diagonal (5 & 6)	$L = 4242$ mm
Young's modulus	$E = 210$ GPa
Weight of groove	400 kg
Load factor	2

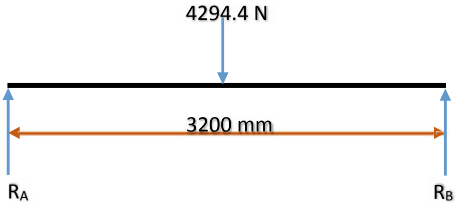

Fig. 6 Free body diagram for member 1 and 3

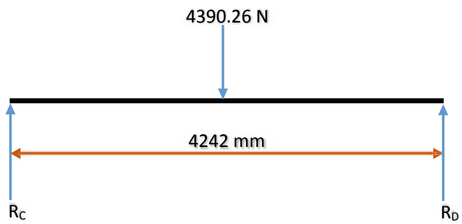

Fig. 7 Free body diagram for member 5 and 6

$$\text{Maximum Bending moment, } M_{\max} = \frac{W \times L}{4} = \frac{4294.4 \times 3200}{4} = 3{,}435{,}520\,\text{N mm}$$

Maximum Bending Stress, $\sigma_b = \frac{M \times y}{I} = \frac{3{,}435{,}520 \times 50}{186.7 \times 10^4} = 92.00643\,\text{MPa}$
$\sigma_b = 92.00643$ MPa < 137.22 MPa. Hence Safe
Max deflection, $\delta_{\max} = \frac{W \times L^3}{48 \times E \times I} = \frac{4294.4 \times 3200^3}{48 \times 2.1 \times 10^5 \times 186.7 \times 10^4} = 7.48\,\text{mm}$

3.2 Stress and Deflection Calculations for Members Diagonal Members 5 and 6

Max Weight acting on the frame considering both rings together $= 4000\,\text{N}$
Let, Load factor $= 2$ Therefore, Total Load, $P = 8000$ N
Load at centre(due to rings $= 2$ rings) $= \frac{8000}{2} = 4000\,\text{N}$
Total load at centre(rings + self − weight); (Fig. 7)

$$W = 4000 + \frac{(4242 \times 92)}{1000} = 4390.264\,\text{N}$$

$$\text{Maximum Bending moment, } M_{\max} = \frac{W \times L}{4} = \frac{4390.264 \times 4242}{4} = 4{,}655{,}874.972\,\text{N mm}$$

Maximum Bending Stress, $\sigma_b = \frac{M \times y}{I} = \frac{4{,}655{,}874.972 \times 50}{186.7 \times 10^4} = 124.69\,\text{MPa}$
$\sigma_b = 124.69$ MPa < 137.22 MPa. Hence Safe
Max deflection, $\delta_{\max} = \frac{W \times L^3}{48 \times E \times I} = \frac{4390.264 \times 4242^3}{48 \times 2.1 \times 10^5 \times 186.7 \times 10^4} = 17.81\,\text{mm}$

3.3 Stress and Deflection Calculations for Members 2, 4, 7 and 8

Max Weight acting on the frame considering both rings together $= 4000\,\text{N}$
Let, Load factor $= 2$ Therefore, Total Load, $P = 8000$ N
Load at centre(due to rings $= 2$ rings) $= \frac{8000}{2} = 4000\,\text{N}$

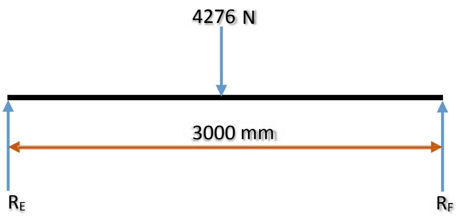

Fig. 8 Free body diagram for member 2, 4, 7 and 8

$$\text{Total load at centre(rings + self - weight); (Fig. 8)}$$

$$W = 4000 + \frac{(3000 \times 92)}{1000} = 4276\,\text{N}$$

Maximum Bending moment, $M_{max} = \frac{W \times L}{4} = \frac{4276 \times 3000}{4} = 3{,}207{,}000\ \text{N mm}$
Maximum Bending Stress, $\sigma_b = \frac{M \times y}{I} = \frac{3{,}207{,}000 \times 50}{186.7 \times 10^4} = 85.88\,\text{MPa}$
$\sigma_b = 85.88\ \text{MPa} < 137.22\ \text{MPa. Hence Safe}$
Max deflection, $\delta_{max} = \frac{W \times L^3}{48 \times E \times I} = \frac{4276 \times 3000^3}{48 \times 2.1 \times 10^5 \times 186.7 \times 10^4} = 6.135\,\text{mm}$

4 Result

Table 3 shows manpower cost where total manpower required for job is 3. Each worker's wage is Rs.48/hr, and time required to complete job was 90 shifts. Total manpower cost was Rs.1152 per shift, so the cost of product/shift and number of shift give total manpower cost which is Rs.103,680.

In Table 4, it shows comparison between material costs for C channel beams. Based on the criteria of whether to make the storage system from new material or from scrap material, the cost analysis for 3000 kg of material was required for beam. New material costs Rs.45/kg whereas for scrap material was Rs.28 /kg. So

Table 3 Manpower cost

Manpower required	Cost/h	No. of hrs. worked	Total cost (in Rs.)	No. of shifts manpower operated	Cost/shift	Total cost (in Rs.)
3	48	8	1152	90	1152	103,680

Table 4 Cost comparison of material categories

C channel beams	Material used (in kgs)	Cost/kg (in Rs.)	Total cost (in Rs.)
New material	3000	45	135,000
Scrap material	3000	28	84,000

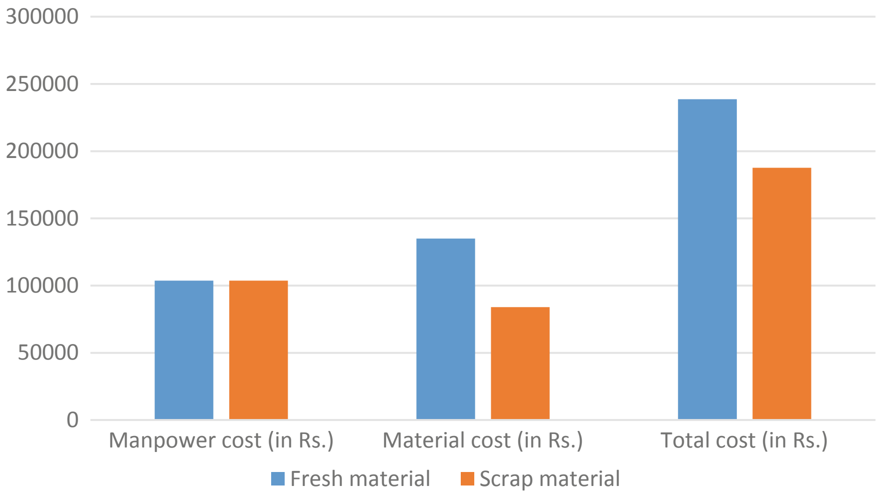

Fig. 9 Benefits of using scrap material

total cost for new material would have been Rs.135,000. The scrap material which was actually used cost Rs.84,000.

Figure 9 concludes Tables 1 and 2, which adds total cost, i.e. manpower cost and material cost for both fresh material as well as scrap material. When the cost is compared, it is found that fresh material expenditure is Rs.238,680, whereas scrap material usage expenditure is Rs.51,000 less than fresh material usage. Hence, scrap material usage helps in saving 21.36% cost.

5 Conclusion

Handling material in general is very expensive, and hence, with designing a storage system, materials can be efficiently and quickly moved with less cost per unit time.

Every time during material movement there is handling cost, and hence, effective use of storage system will reduce the same.

Health and safety of workers depend on the type of materials handling and storage systems employed, the equipment operated and the level of training among operators. A faulty system of poorly trained personnel working in the storage system can lead to serious accidents, and hence, a good storage system can eliminate all of these wastes. With storage system design, the storekeeper can easily access the stock of rings, and hence, inventory can be managed properly.

References

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