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DESIGN OF LIFTING TACKLE FOR ARMOR PLATE OF SINTER MACHINE

E.J. Reddy [1] **G.K. Reddy** [1] **D. Rajendra** [2]

1. Department of Mechanical Engineering, Sreenidhi Institute of Science and Technology, Hyderabad, Telangana, India, ejkiran@gmail.com, kondareddyg@sreenidhi.edu.in
2. Department of Mechanical Engineering, School of Engineering and Technology, Sri Padmavati Mahila Visvavidyalayam (Women's University), Tirupati, India, rajendra343@gmail.com

Abstract- Sintering is an important process to be done in the steel industries. In the process, the blast furnace is used and is required to undergo maintenance to improve the life of the armor plate as these plates need to sustain under very hot conditions. Because of the harsh working conditions on it like 900 °C hot sinter falls on the armor plate continuously. Due to high temperature and inertia, the armor plate suffers huge thermal stress as well as high impact forces. Because of these constant thermal loads on armor plates, they need to undergo maintenance frequently. This paper addresses the issue related to the maintenance of this armor plate by proposing a new setup with a new design for carrying out the maintenance. The new setup consists of a tackle for lifting the armor plate. In the new design, two alternatives were proposed and compared among them to know the best one to adopt for the industry. One among the alternative is with patch plates and the other is without patch plates.

Keywords: Armor Plates, Sinter Machine, Lifting Tackle, Patch Plates, Static Structural Analysis, Indian Standard Medium Weight Channel.

1. INTRODUCTION

The sintering process is the first step of the iron-making process and plays an important role to create iron ore that can be used in the blast furnace. The proper grain size of the iron ore required for a blast furnace is about 10 mm. Therefore, the sintering plant's function is to process these fine raw materials to a coarse iron ore ready to be charged to the blast furnace. Sintering is a process in which the fine particles of iron ore agglomerates to porous mass by just initiating the fusion caused by heat produced during the combustion of mass itself [1]. At the sinter plant, the fines of the iron ore, breeze and dolomite with recycled waste is converted into agglomerated mass. This mass is the 70 to 80% of the iron bearing charge in the blast furnace [1].

Sinter machines are classified into two types namely circular sinter machines and straight-line sinter machines. The circular sintering machine is shown in Figure 1 and is normally suitable for blast furnace with less volume and investment cost. Straight-line sinter machine is shown in Figure 2 and is normally used for the large volume of blast furnace and investment cost is high when compared [2]. Usually, straight-line sinter machines have a width from 2 to 5 m with sintering areas from 200 to 600 m^2. In comparison with straight-line machines, the capital investment cost of circular sintering machine is low and the construction periods are also short.

In the blast furnace, the armor plates often need to undergo maintenance because of the harsh working conditions on it like 900 °C hot sinter fall on the armor plate continuously. Due to high temperature and inertia, the armor plate suffers huge thermal stress as well as high impact forces. Because of this high impact, the armor plate hits the receiver plate and creates a huge noise. As a result of their thermal stress and impact force, the armor plate erodes continuously. The position of the armor plate along with the receiver plate is in the confined space and it is difficult to handle effectively [4]. Hence, it is very crucial to protect the armor plate to get continuous production and this task has become very critical for present-day manufacturers especially steel manufacturing plants.

Further, for maintenance of the armor plate, lifting tackles are used. The need for these tackles is for adjusting the armor plate. The main constraint of this task is the position of the armor plate as it has confined space and it is difficult to handle it effectively. The other constraint is the weight of the armor plate as it weighs about 8 ton; moreover, this armor plate is located at the elevation of the shop. So, safe and steady lifting of this armor plate is an important task as far as maintenance is concerned. On the other side, it is observed that in the underdeveloped countries, the lifting mechanism for the armor plate is almost unavailable because of its cost issues and moreover with the traditional cranes it will be difficult to handle this task. So, it is very much in need to address this issue for manufacturing plants especially the steel plants. So, to address this issue a new lifting tackle needs to be designed. For designing the tackle ISMC (Indian Standard Medium Weight channels) has given some guidelines. Hence the new design must adopt ISMC standards. Mostly, the material used in tackle manufacturing is structural steel.

Figure 1. Circular sinter machine [3]

Figure 2. Straight-line sinter machine [3]

2. LITERATURE REVIEW

In the process of enhancing the existing or developing a new tackle, many researchers proposed various guidelines. Girishkumar et al. [5] developed the lift device to lift a V engine of 300 kg for a manufacturing plant economically by following the safety standards. Similarly, Nayeem et al. [6] has designed and optimized roof lifting tackle arrangement for a car manufacturing company. To improvise the design, the tackle is redesigned for mass reduction. Additionally, strength characteristics were also improved. Xue et al. [7] designed the sandblasting lifting equipment for completing the pipework laying process cycles in the area of subsea pipelines. Similarly, Dale Lifting and Handling Inc. [8] worked on developing an automated design for heavy-duty lifting equipment. Likewise, various researchers tried to develop an automatic design system to obtain a better design. Among them, the design improvement of various mechanical components like Universal Coupling [9], Spur Gear [10, 11], Industrial battery Stack [12], IC Engine Connecting Rod [13, 14], different nuts, bolts and bearings [15, 16], were presented. In the same way, the generic process of improving the existing design is presented in various research papers [17-26].

Along these lines, many researchers tried to develop a mechanism for lifting the armor plate. At present, there is no such lifting tackle available for armor plates that can be used in the industry. Hence, in this paper, the authors tried to propose a new design for the lifting tackle for the armor plate for a steel manufacturing industry.

3. DESIGN AND MODELLING

For designing the lifting tackle for armor plate, the standards of ISMC are adopted. Additionally, the weight of the armor plate is considered as per the industry norm which is 8 tons. Furthermore, the other considered constraint as per the industry norm is the length of the tackle should not exceed 4500 mm. The proposed design for the lifting tackle is considered in two cases. One is with patch plates and another is without patch plates. The software used for developing these models is Creo and for testing their robustness CAE software called Ansys was used.

At first, the mainframe for the lifting tackle was developed by considering the ISMC standards. This mainframe can be seen in Figure 3 and its detailed dimensions can be seen in Figure 4. For the design of this mainframe, ISMC 200 was considered. The cross-section of the channel is shown in Figure 5 and which is chosen in such a way that section modulus and strength are higher. The developed C channel model can be seen in Figure 6. The complete assembly of the proposed framework without patch plates can be seen in Figure 7 and with patch plates is given in Figure 8. Figure 9 and Figure 10 show the detailed dimension of the proposed mainframe assembly without and with patch plates respectively. In these two assemblies, there are two subassemblies namely brackets 'A' and bracket 'B' which are shown in Figure 11 and Figure 12 respectively, and their detailed dimensions are shown in Figures 13 and 14, respectively.

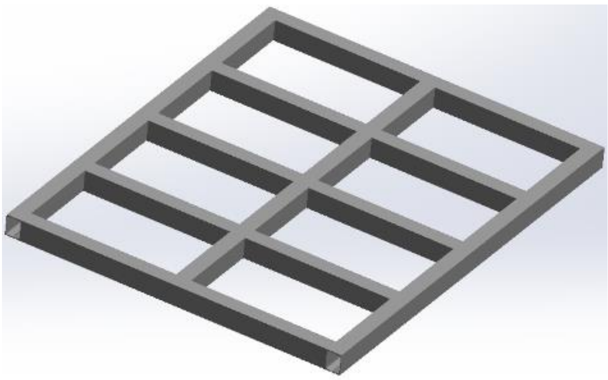

Figure 3. Proposed mainframe for lifting tackle

4. RESULTS AND DISCUSSION

The above-proposed mainframe for lifting tackle in both cases is analyzed for checking its robustness using Ansys 18.1 software by applying 8 tons as the load on it. In the case of the proposed lifting tackle without patch plates, Figures 15 to 18 shows the screenshots of the total deformation, equivalent stress, maximum principal stress, and maximum principal strain respectively. Similarly, in the case of the proposed lifting tackle with patch plates, Figure 19 to 22 shows screenshots of the total deformation, equivalent stress, maximum principal stress, and maximum principal strain respectively. The procedure for carrying out the simulation was adopted from various researchers through their published papers [6, 7, 21, 22, 24-26].

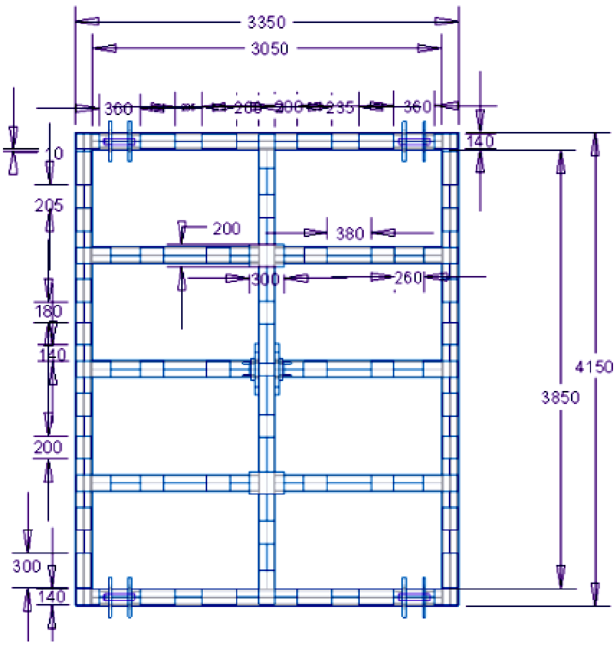

Figure 4. Detailed dimensions of the proposed mainframe

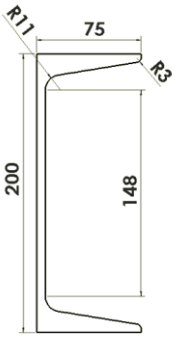

Figure 5. Cross-section of the channel used for the proposed mainframe

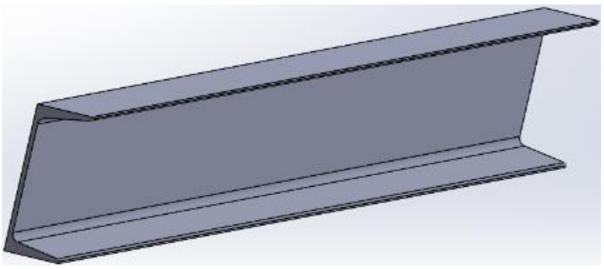

Figure 6. Developed a C channel model for the proposed mainframe

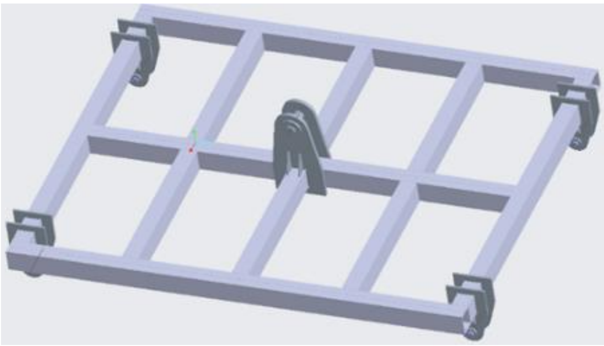

Figure 7. Assembly of proposed mainframe without patch plate

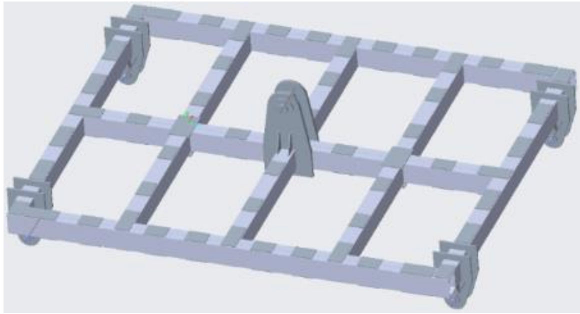

Figure 8. Assembly of the proposed mainframe with patch plates

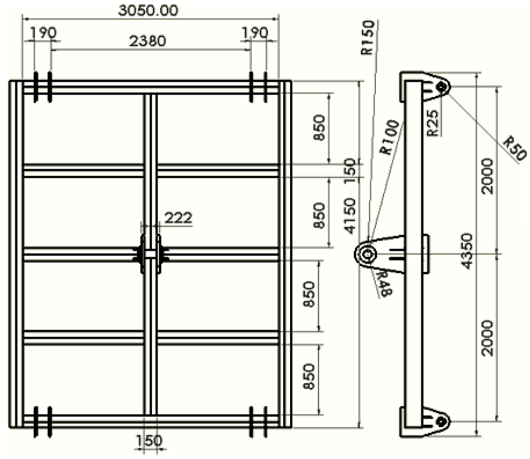

Figure 9. Detailed assembly of the proposed mainframe without patch plates

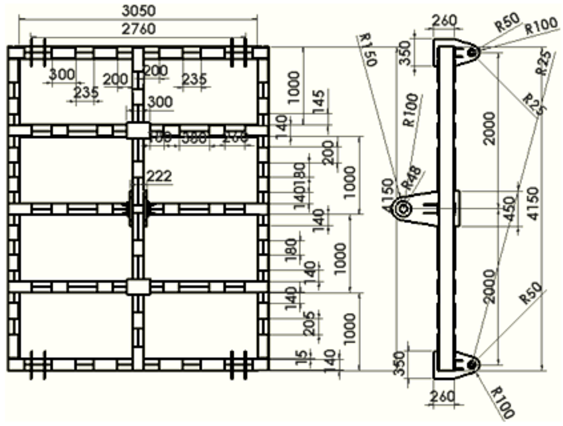

Figure 10. Detailed assembly of the proposed mainframe with patch plates

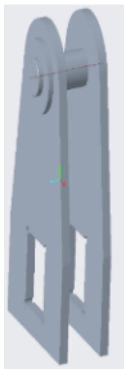

Figure 11. Bracket 'A'

Figure 12. Bracket 'B'

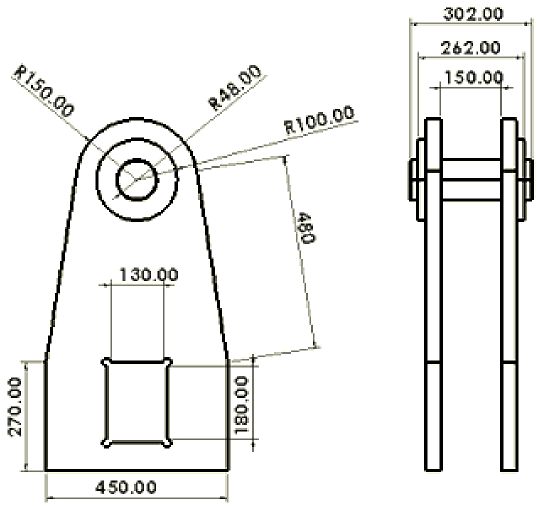

Figure 13. Detailed dimensions of bracket 'A'

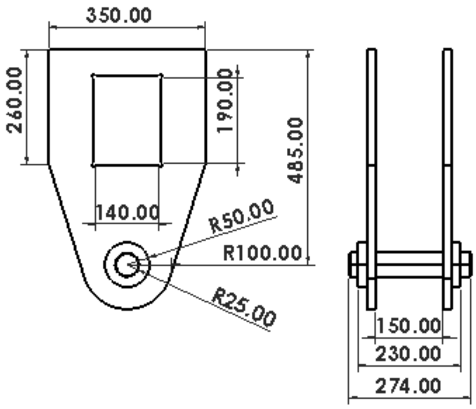

Figure 14. Detailed dimensions of the bracket 'B'

A detailed comparison of the total deformation, equivalent stress, maximum principal stress, and maximum principal strain in both cases is given in table 1. On comparing and observing the values of the above four characteristics, it can be concluded that lifting tackle with patch plates is providing better results than in the case of lifting tackle without patch plates. The reason for the better result is because of the extra strength provided by the patch plates. Hence, the lifting tackle with patch plates is suitable for lifting the armor plate of the blast furnace for carryout the maintenance activity.

4.1. Case 1: Static Structural Analysis without Patch Plates

Total deformation, equivalent stress, maximum principal stress and maximum principal strain without patch plates are shown in Figures 15-18.

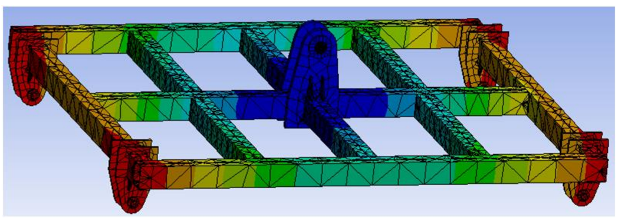

Figure 15. Total deformation without patch plates

Figure 16. Equivalent stress without patch plates

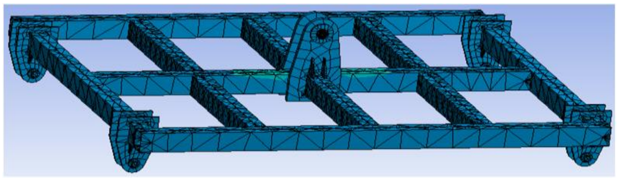

Figure 17. Maximum principal stress without patch plates

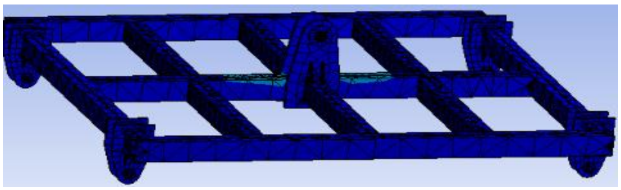

Figure 18. Maximum principal strain without patch plates

4.2. Case 2: Static Structural Analysis with Patch Plates

Total deformation, equivalent stress, maximum principal stress and maximum principal strain with patch plates are shown in Figures 15-18.

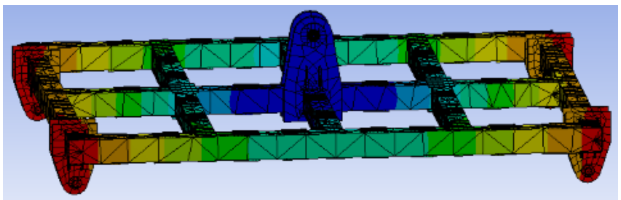

Figure 19. Total deformation with patch plates

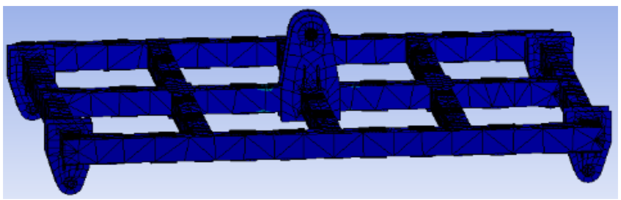

Figure 20. Equivalent stress with the patch plates

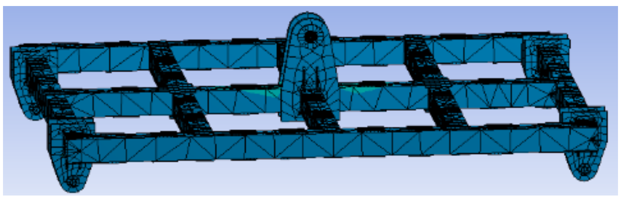

Figure 21. Maximum principal stress with patch plates

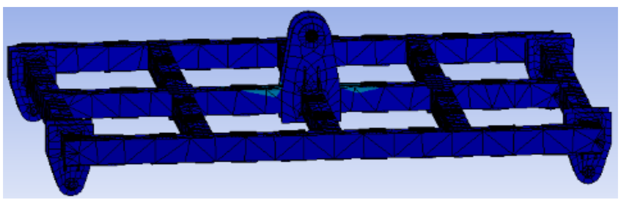

Figure 22. Maximum principal strain with patch plates

The analysis results of Lifting tackle without patch plates and with patch plates are compared in Table 1.

Table 1. Comparison of analysis results

Properties	Lifting tackle without patch plates	Lifting tackle with patch plates
Total Deformation	1.8525 mm	1.5317 mm
Equivalent Stress	248.29 Mpa	209.4 Mpa
Maximum Principal Stress	201.44 Mpa	168.67 Mpa
Maximum Principal Strain	9.7509 e-004	8.2109 e-004

5. CONCLUSION

On comparing the total deformation, equivalent stress, maximum principal stress, and maximum principal strain of the proposed lifting tackle in both cases (with patch plates and without patch plates), it is observed that the lifting tackle with patch plates is providing better results than the lifting tackle without patch plates as the patch plates are providing the extra strength to the mainframe. Additionally, as this proposed mainframe is following the ISMC guidelines, it may be concluded that the proposed mainframe is suitable to meet the industry requirements. Hence, on the whole, it can be concluded that the proposed lifting tackle with patch plates can provide the armor plate maintenance solution to the industry, especially for the steel manufacturing plants.

With the proposed mainframe structure, the advantage is it is simple in fabrication and use, but it has limitation though. While carrying out the maintenance of the armor plate with the proposed mainframe, the counter weight is required to balance the weight of the armor plate. Hence, the crane to operate the proposed mainframe must be capable to handle this extra weight too. This extra capacity may cost the industry.

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BIOGRAPHIES

Esanakula Jayakiran Reddy was born in Tirupati, India in 1982. He received the Bachelor of Technology degree from Sri Venkateswara University (Tirupati, India), Master of Technology degree from VIT University (Vellore, India) and the Ph.D. degree from Jawaharlal Nehru Technological University Ananthapuramu (Anantapur, India) all in Mechanical Engineering, in 2003, 2007 and 2019, respectively. Currently, he is an Assistant Professor of Mechanical Engineering at Sreenidhi Institute of Science and Technology (Hyderabad, India). His research interests are in the area of CAD/CAM, automated CAD modeling, parametric modelling, knowledge-based systems, expert systems, 3D printing, and rapid prototyping.

Gondi Konda Reddy was born in Khammam, India in 1969. He received the Bachelor of Technology degree from University of Mysore (Mysore, India), Master of Technology degree from Osmania university (Hyderabad, India) and the Ph.D. degree from Jawaharlal Nehru Technological University Hyderabad (Hyderabad, India) all in Mechanical Engineering. Currently, he is Associate Professor of Mechanical Engineering at Sreenidhi Institute of Science and Technology (Hyderabad, India). His research interests are in the area of composite materials, nonlinear vibration buckling, and welding.

Degala Rajendra was born in Kadapa, India in 1987. He received the Bachelor of Technology degree and Master of Technology degree from Jawaharlal Nehru Technological University (Kakinada, India) in Mechanical Engineering, in 2009 and 2012 respectively. Currently, he is Assistant Professor of Mechanical Engineering at Sri Padmavati Mahila Visvavidyalayam (Tirupati, India). His research interests are in the area of manufacturing and welding technology.