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Research Paper

DESIGN AND ANALYSIS OF METAL SHEET STORAGE SYSTEM

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Human needs are in increasing day-by-day, to satisfy those needs the small and medium scale industries are increasing. Most of small and medium scale industries uses traditional storage system i.e store the metal sheets horizontally on floor available within the industry. Such system has many drawback and safety factor is also less. Due to which most of the industries are searching for better and efficient storage system which can provide them better safety, better handling, compactness and low maintenances. Storage system should consume less space, more efficient, much safety with low maintenances. To design such system many of industrial sector come forward with hydraulic and pneumatic or mechatronics system but such systems are not compatible with small and medium scale industries due to maintenance cost and requirement of skilled labour for handling such system. So, here for storage of metal sheets a simple metal sheet storage system has been suggested. It is affordable and easy to handle in any type of small and medium scale industries.

Keywords: Storage System, Case, Cassette, Loader, Analysis

INTRODUCTION

Storage system is one of the most important and prime section in every industry, especially production industries needs very frequent and feasible storage system. As the supply of raw material in industries plays important role in fulfilling the demands and smooth working of industries, most of the raw material supply depends upon the storage capacity and reaching time to working area. The storage system must be durable and reliable by providing free pallet transfer system. The storage system should be integrated with processing in industry and also it should fit for all requirements to improve the efficiency and profitability of your material storage systems as a whole. An automated storage and retrieval system (AS/RS) consists of a variety of computer-controlled systems for automatically placing and retrieving loads from defined

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storage locations. Automated storage and retrieval systems (AS/RS) are typically used in applications where there is a very high volume of loads being moved into and out of storage also storage density is important because of space constraints no value adding content is present in this process accuracy is critical because of potential expensive damages to the load. AS/RS can be used with standard loads as well as non-standard loads.

AS/RS systems are designed for automated storage and retrieval of parts and items in manufacturing, distribution, retail, wholesale and institutions. They first originated in the 1960s, initially focussing on heavy pallet loads but with the evolution of the technology the handled loads have become smaller. The systems operate under computerized control, maintaining an inventory of stored items. Retrieval of items is accomplished by specifying the item type and quantity to be retrieved. The computer determines where in the storage area the item can be retrieved from and schedules the retrieval. It directs the proper automated storage and retrieval machine to the location where the item is stored and directs the machine to deposit the item at a location where it is to be picked up. A system of conveyors and or automated guided vehicles is sometimes part of the AS/RS system. These take loads into and out of the storage area and move them to the manufacturing floor or loading docks. To store items, the pallet or tray is placed at an input station for the system, the information for inventory is entered into a computer terminal and the AS/RS system moves the load to the storage area, determines a suitable location for the item, and stores the load. As items are stored into or retrieved from the racks, the computer updates its inventory accordingly. The benefits of an AS/RS system include reduced labour for transporting items into and out of inventory, reduced inventory levels, more accurate tracking of inventory, and space savings.

NEED

The small and medium scale industries are diverting towards low maintenances industrial equipment due to financial significances. This situation has generated much interest in economical storage and retrieval system, as more expensive storage system can drop the profit ratio of industries. It is, logical to expect development of such storage system that will be feasible, time saving and economically affordable for small and medium scale industries. So, in this dissertation with the help of virtual and analytical software we tried to provide solution for this critical problem.

CASE STUDY

The case study was undertaken at GUKKS industries located at Amravati M.I.D.C on 46000 sq ft of land. The industry started in 2006-2007 with the basic products related to sheets working. The products of these industries are Cotton Ginning and Handling Machines with spare parts as Belt Auto Feeders, Pre and Post Cleaners, Air Separators, Diverters, Dampers, Distribution Trolleys, Electrical Enclosures, Distribution Panels, Air Conditioning Ducts, Grills, Sound Attenuators, Acoustic Baffles, Machinery Covers, Guards and Consoles. The facilities available and operation performed at industry are CNC turret punch press, Bending Machine,

Sharing Machine, Power Press, Spot Welding, MIG welding, TIG welding. The turnover of the industry is 9 crore so, the industry lie in category of medium scale industry. The staffs at industry are 30 and workers are 70.

As the information provided about the industry gives idea that the maximum work in industry is related to metal sheets. The raw materials for this industry are rectangular metal steel sheets. The working in industry starts with punching or shearing of sheet after the bending or other operation are performed.

EXISTING STORAGE SYSTEM IN GUKKS

Traditional storage system: This kind of system are generally use in small scale industries for storage and stacking purpose of raw materials. In this system material unload directly and stored randomly, as we can see in above picture, sheet are placed in horizontal manner which occupy unnecessarily much more space and also no standardization or any particular manner of storage system. Due to such storage system the area available at industrial site is unnecessarily consumed.

Figure 1: Existing Sheets Storage System

PROBLEM WITH EXISTING STORAGE SYSTEM

- Lower sheet cannot be removed directly
- Time consuming
- Power loss during operation of stacker
- Space required is more due to horizontal storage
- Safety issues arise regarding to handling of material by workers
- Inventory controlling is difficult
- Due to several problems production will suffers

To avoid and overcome such problems cost effective advance technology is required, which will increase production and consume lesser time for sorting and reaching to work area.

TERMS AND CONDITION PROVIDED BY COMPANY FOR DESIGN OF STORAGE

System

Terms and conditions of Gukks Industries regarding design of storage system.

I. Current storage system is traditional which consume unnecessarily large space, which company needs to minimise anyhow.

II. Safety Crises for worker, where edges of sheets is in open condition, those are directly comes in contact with worker during movement, that company tends to secure.

III. Company needs to expand storage system in vertical direction instead of horizontal.

IV. A stacker available in company having lifting shifting capacity is 1500 kg, so within

capacity system should be able to work feasibly.

V. The height stacker can lift weight is 15 feet, so design should not exceed than stacker lifting limit unless design will be unusable.

VI. Inventory control must be easy and simpler in system.

VII. Hydraulic and pneumatic or mechatronics contains system are not affordable for stacking or storage purpose.

VIII. No skilled worker must be involved in working operation or no extra training have to provide to worker.

This all conditions are fulfilled and reached in advance metal sheet storage system.

PROPOSED STORAGE SYSTEM

The proposed storage system is very simple and it includes three components i.e Cassette, Case and Loader and Unloader. Cassette is rectangular pallet, total height is 17 cm in which the sheet storage height is of 15 cm and remaining 3 cm height is for support provide at bottom of cassette. The Case is vertical unit, it contains inverted L shape bar on which the cassette will slide in and it will be rested on that bar. The design of case is developed to limited height in which 15 cassettes can be store. The loader and unloader is design to transfer the sheets in cassette and remove sheets from the cassette.

COMPUTATIONAL MODEL

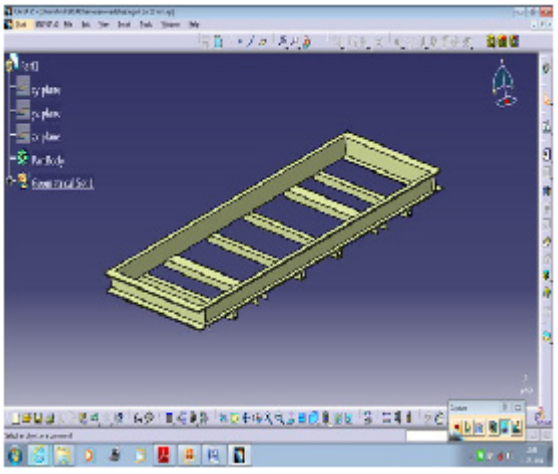
Introduction to CATIA

The design is developed with the help of catia software as CATIA is introduces (Computer Aided Three-dimensional Interactive Application in English is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA (Computer Aided Three-Dimensional Interactive Application) started as an in-house development in 1977 by French aircraft manufacturer Avions Marcel Dassault, at that time customer of the CAD/CAM CAD software[1] to develop Dassault's Mirage fighter jet. It was later adopted in the aerospace, automotive, shipbuilding, and other industries.

Modelling of Cassette in CATIA

The image show screen image of CATIA software while CASSETTE model is prepared in the part design tools of the CATIA software. This part is developed in several steps with the help of sketch option and various commands available in modelling option of CATIA. To find out the optimum design many changes is done step by step such as changing

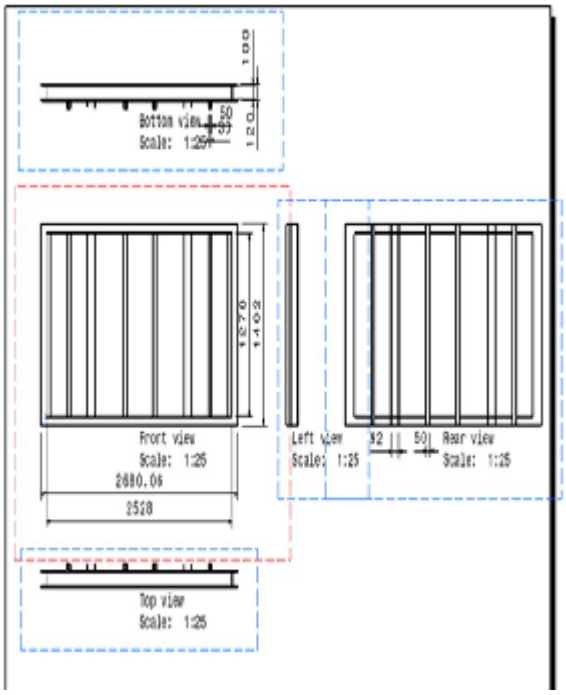
Figure 2: Modeling of Cassette



the support position, changing size of supports, changing thickness and area of contact of supports, also finding most suitable position for stacker arms to lift the cassette so that weight distribution must be in correct form on the cassette.

As the design was a finalized after several changes the photo image of complete cassette is shown in above figure. In the final cassette 4 square supports of 10 cm x 10 cm with thickness of 5 mm in all direction is provided the provision for stalker arms to lift the cassette is provided with the help of C channels .The C channels having width of 100 mm because the stalker arms width is 80 mm.

Figure 3: Drafting of Cassette

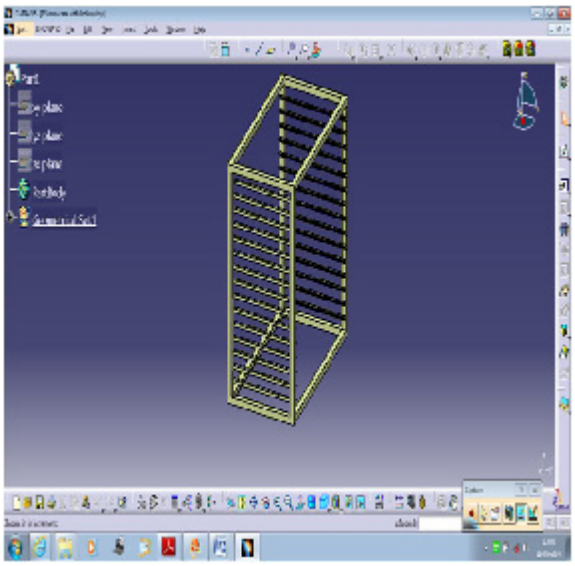


The CATIA software provide the tool drafting due to which the design can be easily understood by production engineer .Drafting gives the dimensional information of the part or designs which makes the geometry understanding and well define for the user. In this case the dimension plays important role due to which model can successfully work on the basis of its dimensional accuracy .If the cassette detention and case dimension does not match then the is maximum possibility of failure of this metal sheet storage system.

Modelling of Case in CATIA

The image shows the screen image of CATIA software while the CASE model is prepared in the part design tools of the CATIA software. This case contains 15 cassettes as the stalker height is limited upto 15 feet so within the limitation it has been design and accepted by the company. Case is base on rectangular frame and four pillar are provided so that the angles can be welded on the pillar .The upper frame is provided for the upper support of pillar to avoid them form buckling.

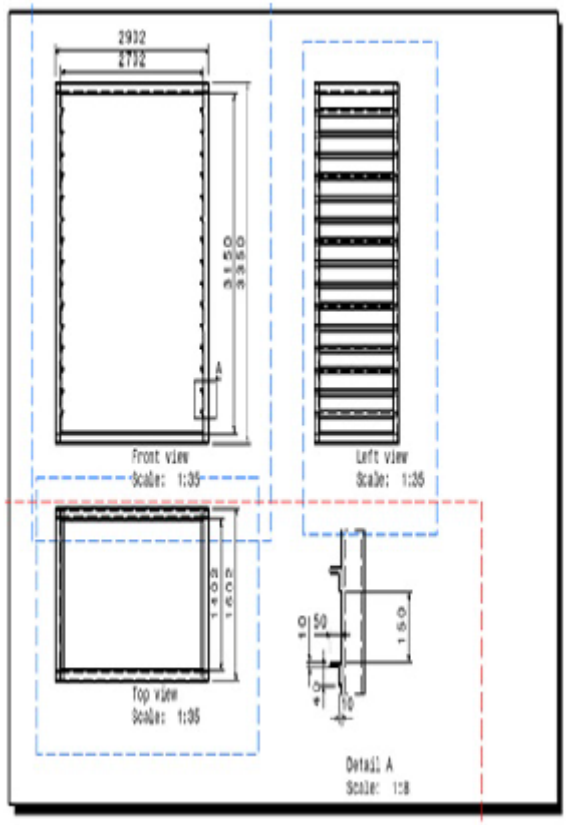
Figure 4: Modeling of Case



As the design was a finalized after several changes the photo image of complete case is shown in above figure. The case contains 15

cassettes and the gap between two cassettes is 200 mm as the total vertical length of cassette is 170 mm the 30 mm clearance is maintained for easy and safe working of case and cassette. The total load case has to sustains is 1400 kg multiplied by 15 i.e 21000 kg if this value is converted in force then it will be 205800 N. So, the case has to design to sustain 205800 N force with maintain the clearance gap within the cassette.

Figure 5: Drafting of Case

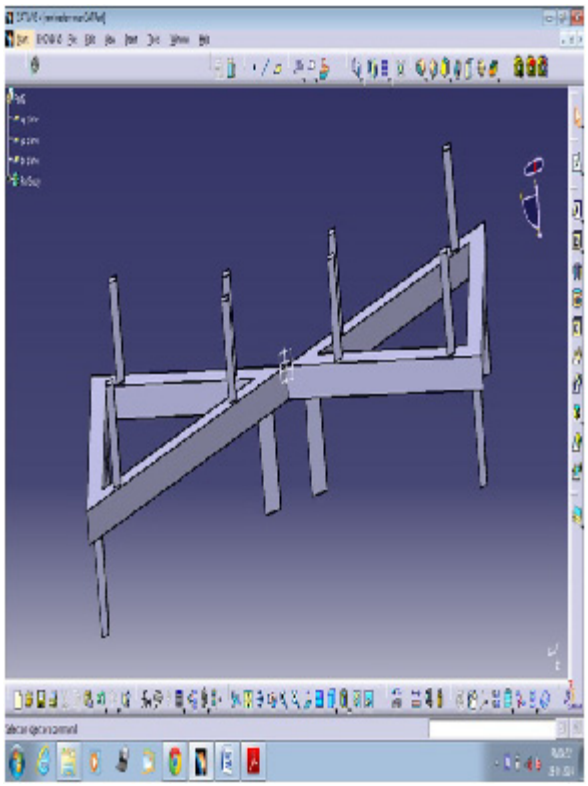


The CATIA software provide the tool drafting due to which the design can be easily understood by production engineer .Drafting gives the dimensional information of the part or designs which makes the geometry understanding and well define for the user.

Modelling of Loader and Unloader in CATIA

The image show the screen image of CATIA software while the loader and unloader model is prepared in the part design tools of the CATIA software. The working of loader and unloader is simple; the X section which is horizontal is exactly of the size of cassette. The cassette will rest on X section and the sheet bunch will be kept on bar's those are vertical welded on X section. This design can be change according to sheet weight varies or economical permissibility because it's working is limited to loading and unloading without any dynamic activity.

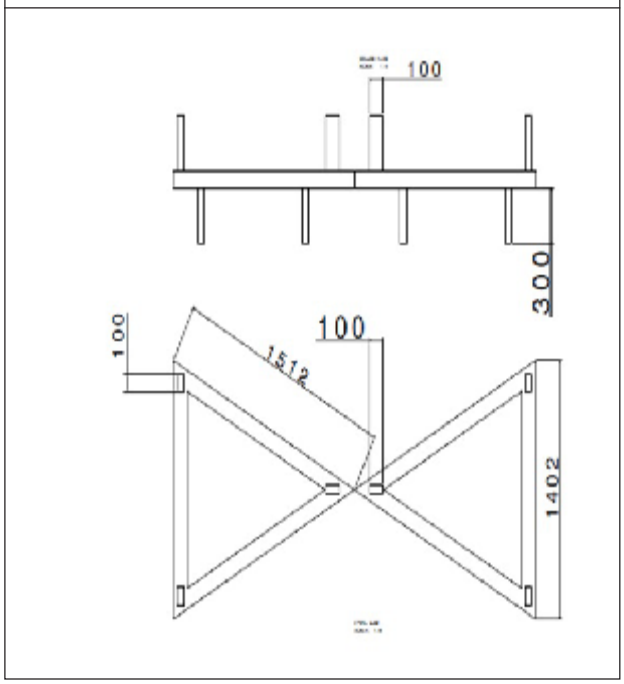
Figure 6: Loader and Unloader



As the design was a finalized after several changes, the photo image of complete loader and unloader is shown in above figure. The

design is permissible for 1400 kg and analysis is done with the help of ANSYS software .The design can be change according to economical condition and material use for loader and unloader because the heavy duty work is not found for the loader and unloader .The future advancement can be done by providing the wheels for loader and unloader for easy handling.

Figure 7: Drafting of Loader and Unloader



The CATIA software provide the tool drafting due to which the design can be easily understood by production engineer .Drafting gives the dimensional information of the part or designs which makes the geometry understanding and well define for the user. In this loader the dimension are not so important because it has no heavy duty work it is just use for loading the sheets in cassette and unloading the sheets. Failure of this component in storage system will not affect the storage or material. So, the company or designers can the change the dimension as per their requirement.

PERFORMANCES ANALYSIS

The design developed of storage system need to be analysed under working condition. It is necessary to find out the various stress and deformation after application of forces when material will be store in cassette and case. So, for optimization of design the software ANSYS is used. The ANSYS is recommend for finding the optimized design in most of the industries. Here, the ANSYS version 14.0 is used for the optimization of the metal sheet storage system.

Material used for Storage System

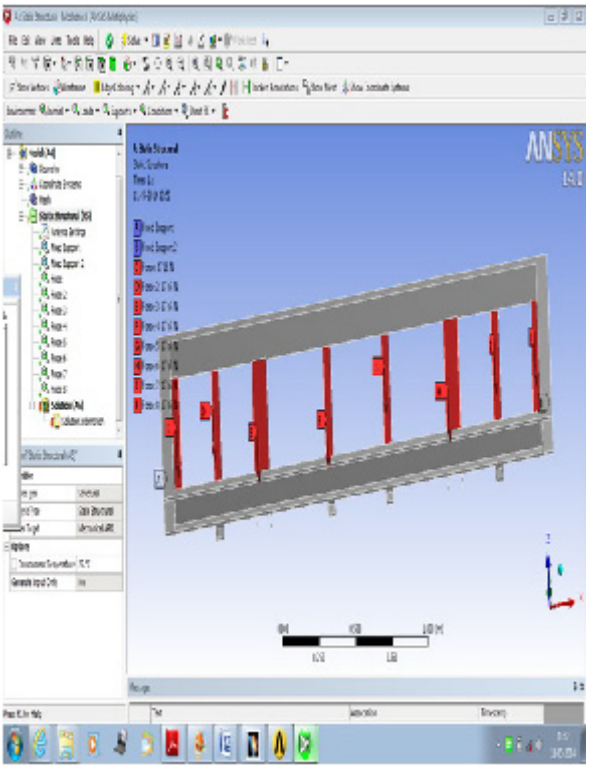
The material consider for the storage system was structural steel of IS 2062 grade. This helps to give correct output in result after the analysis is done. So we input the data as per the steel Material, structure steel grade IS 2026 having the properties as young's modulus:- 210 x 10e9 pa, poison ratio:- 0.3, modulus of rigidity:- 81 x 10e9 pa, tensile yield stress(maximum):- 240 x 10e6 pa, tensile yield stress(minimum):- 230 x 10e6 pa, ultimate tensile strength:- 410 x 10e6 pa. These total properties are necessary to be feed in the property section of ANSYS.

Applying Forces on Cassette

For the Cassette we consider 1400 kg load for analysis. This load was converted in Newton and was distributed according to supports available in cassette. In the mechanical [Multiphysical] window ANSYS provide major three option in which first is MODEL second is STATIC STRRUCTURAL and third is SOLUTION. The very first option provides

changes in geometry, coordinate systems, mesh. Then second option provides analysis setting in which the various forces and fixed support can be applied. The third option provided is solution, this include solution information and various solution which we required can be obtained such as normal stress, equivalent stress, max principal stress, min principal stress, total deformation, directional deformation etc.

Figure 8: Applying Forces on Cassette



ANSYS Report for Cassette

The report in the ANSYS can be obtained in tabular form with all required information. This software provide the range of maximum and minimum values of any operation performed on the design, thus it is very compatible to work with the ANSYS. So, solution to the applied load is as given in table.

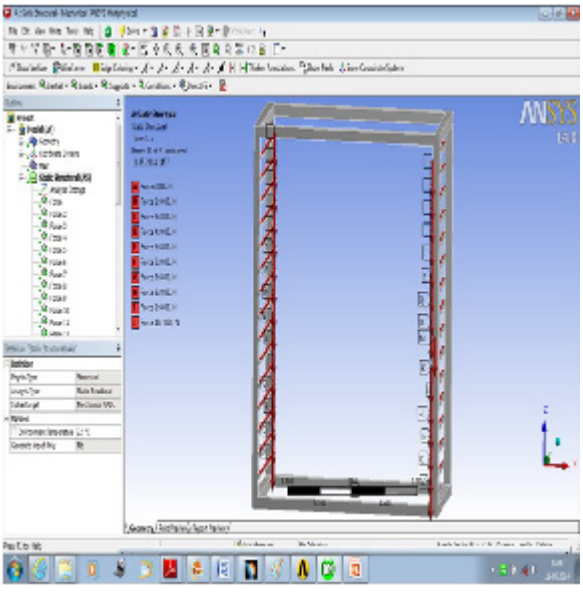
Figure 9: ANSYS Solution for Case

Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	Maximum Principal Stress	Minimum Principal Stress	Total Deformation	Equivalent Stress
State	Solved			
Scope				
Scoping Method	Geometry Selection			
Geometry	All Bodies			
Definition				
Type	Maximum Principal Stress	Minimum Principal Stress	Total Deformation	Equivalent (von-Mises) Stress
By	Time			
Display Time	Last			
Calculate Time History	Yes			
Identifier				
Suppressed	No			
Integration Point Results				
Display Option	Averaged			Averaged
Results				
Minimum	3.0332e+003 Pa	-1.8407e+007 Pa	0. m	21406 Pa
Maximum	4.0785e+007 Pa	5.2954e+006 Pa	1.0841e-003 m	3.5503e+007 Pa
Information				
Time	1. s			
Load Step	1			
Substep	1			
Iteration Number	1			

The case can be feed with 15 cassette so the total load will be 1400 x 15 kg. So, the structure of case should bear the weight of 206010 Newton. The forces are applied as per the they are distributed on each rod.

Figure 10: Application of Forces on Case



ANSYS Report for Case

The report in the ANSYS for case is obtained in tabular form with all required information. This software provide the range of maximum and minimum values of operation performed on the design, thus it is very compatible to work with the ANSYS.

Figure 11: ANSYS report for case

Model (A4) > Static Structural (A5) > Solution (A6) > Results

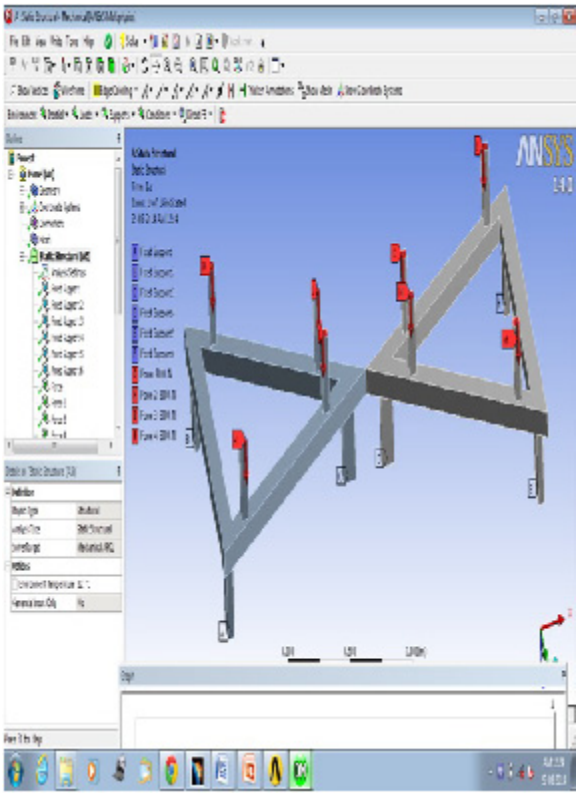
Object Name	Total Deformation	Equivalent Stress	Maximum Principal Stress	Normal Stress
State	Solved			
Scope				
Scoping Method	Geometry Selection			
Geometry	48 Bodies			
Definition				
Type	Total Deformation	Equivalent (von-Mises) Stress	Maximum Principal Stress	Normal Stress
By	Time			
Display Time	Last			
Calculate Time History	Yes			
Identifier				
Suppressed	No			
Orientation				X Axis
Coordinate System				Global Coordinate System
Results				
Minimum	0. m	0.73472 Pa	2.9652e+006 Pa	-1.3918e+007 Pa
Maximum	2.3779e-005 m	1.2545e+008 Pa	1.1715e+008 Pa	2.1953e+007 Pa
Information				
Time	1. s			
Load Step	1			
Substep	1			

ANSYS Solution for Loader and Unloader

The load of 1400 kg was applied to loader and unloader. The design can be change as per requirement because it has no heavy loading and any restricted dimension.

ANSYS Report for Loader and unloader

Figure 12: Application of forces

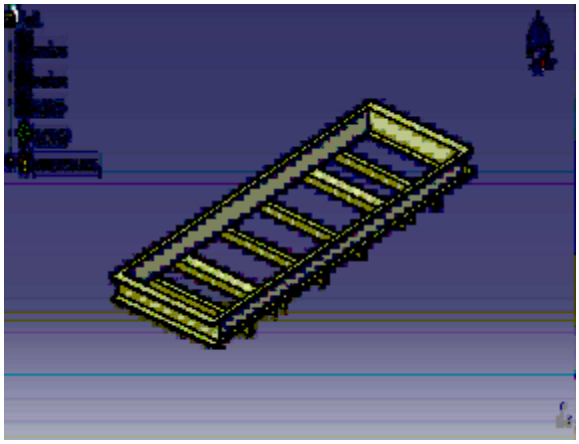


MATHEMATICAL ANALYSIS

Figure 13: Result Obtained by ANSYS for Loader and Unloader

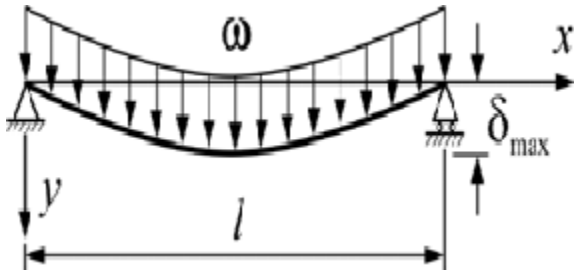
Part A: Cassette

Figure 14: Cassette



Considering UDL for Calculation

Figure 15: UDL



Design and Material Data

1. Area (A1)= 0.128 Sq. M..... for one Member of Cassette

   =0.128 X2 =0.256

   Area (A2)= 0.064 Sq. M..... for one Member of Cassette

   =0.064 X6 =0.384

   Hence, total area of load bearing members in cassette

   A=A1+A2

   =0.256+0.384

   =0.64 Sq. M

2. Working Load (W)=1400 kg

   =1400X9.81

   =13734 N

3. Pressure (Normal Stress σ)= 13734/0.64

   =21459.37 N/Sq M

4. Pressure on each specimen of cassette

   = 21459.37 / 8 =2682.42 Pa

5. τ^{max} (Max shear stress = P/2A

   Here, on axis system for normal stress, óx=0 Pa σy= 21459.37 Pa

6. Max. Principal stress=

$$\sigma = \left(\frac{\sigma x + \sigma y}{2}\right) + \sqrt{\left(\frac{\sigma x + \sigma y}{2}\right)^2 + \tau xy^2}$$

$$\sigma \max = \left(\frac{0 + 21459.3}{2}\right) + \sqrt{\left(\frac{0 - 21459.3}{2}\right)^2 + 10729.68^2}$$

   = 25903.6877 Pa

   Hence,

7. Factor of safety = $\frac{Max\ principal\ stress}{Normal\ stress}$

$$= \frac{25903.68}{21459}$$

$$=1.207$$

8. Max deformation =

$$= \frac{wl^3}{48EL}$$

$$= 0.33 \text{ mm}$$

Table 1: Calculation of Cassette		
Estimated Quantity	**Figures**	**Status**
Normal Stress σ	21459.37 N/m²	Safe
Max shear stress σ	10729.68 N/m²	Safe
Max. Principal stress	25903.6877 Pa	Safe
Factor of safety	1.207	Safe
Max deformation at centre	0.33 mm	Safe

Part B: Reactions

Calculations at both end of casset as shown in diagram

$\Sigma f(x)=0, \quad Ha=0$ ...(1)

$\Sigma f(z)=Va+Vb \times 2.538 - \frac{wl^2}{2}$ ...(2)

$\Sigma f=Va+Vb - wl$ ...(3)

Here, Va = 0

$$Vb = \frac{wl^2}{2} \times \frac{1}{2.538}$$

$$= \frac{(1400 \times 9.81)}{2} \times \frac{1}{2.538}$$

= 17428.446 Nm ...(A)

Va = wl - Vb

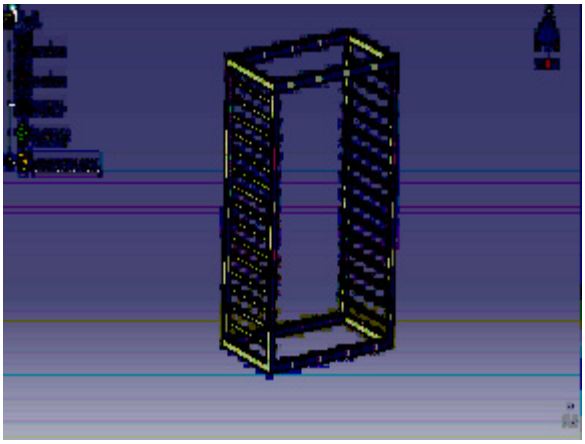
= (1400 x 9.81)(2.538) – (17428.446)

= 17428.89 N ...(B)

Part B: Calculation for Case

The angles shape (L) is attached between the rigid column the span between two column next to each other is more so angles is assumes to be simply supported and calculation is done considering uniform distributed load.

Figure 16: Case



Here, reaction Va and Vb are directly acting load on case bars,

hence, for analysis of case bars, reactions are consider as Uniformly distributed load, as shown in figure,

Design Parameters:

1. $I = \frac{bh}{12} = \frac{50 \times 10^3}{12} = \frac{50000}{12} = 4166.66 mm^4$
2. $I = \frac{bh}{12} = \frac{50 \times 10^3}{12} = \frac{50000}{12} = 4166.66 mm^4$
3. E = 210 x 10^9
4. Area (A1)=1.602 X0.05 =0.0801 m sq.
5. Working Load (W)=10705.15 N/mm.
6. Pressure (Normal Stress σ)= 10705.15/ 0.0801=133647 pa
7. $\tau^{max}(Max\ Shear\ Stress) = \frac{P}{2A} = \frac{10705.15}{2 \times 0.0801} = 66822.72\ pa$

Here, on axis system for normal stress, σx=0 Pa σy= 133647 Pa

Max. Principal stress =

$$\sigma = \left(\frac{\sigma x + \sigma y}{2}\right) + \sqrt{\left(\frac{\sigma x + \sigma y}{2}\right)^2 + \tau xy^2}$$

So, with above Eq we get

σmax =182563.5 Pa

Hence,

Factor of safety =

$$\frac{Max\ Principal\ Stress}{Normal\ Stress} = \frac{182563.5}{66822.72}$$

= 2.7

Now, Total defection

$$\delta c = \frac{\left(5 \times W \times L^3\right)}{\left(384 \times EI\right)}$$

$$\delta c = \frac{\left(5 \times 10705.15 \times 1.602^3\right)}{\left(384 \times 210 \times 10^3 \times 4.16 \times 10^{-9}\right)}$$

δc=0.0001 m

Hence, Deflection at centre of case bar (load bearing member) is 0.0001m.

JUSTIFICATION FOR DIFFERENCE

The mathematical and ANSYS result show that there is an acceptable correlation. There is slight difference between both methods this is due to different approach i.e ANSYS follow Finite Element Analysis approach while mathematical use simple Uniform Load Distribution consideration. This difference are within the permissible limit of material used for structure of storage system. Hence, the design is safe.

CONCLUSION

The result obtained by analysis of metal sheet storage system show's that stress on the cassette and case are within the safe limit under stacking and static condition.

- As the load is applied the deformation is found 0.33 to 2 mm This deformation is permissible for the developed design.
- The factor of safety by mathematical calculation is 1.2 for cassette and 2.7 for case at maximum load of 1400 kg for cassette and 21000 kg for case.
- The amounts of floor space required for traditionally store method is 46.87 meter square and for propose vertical system is 4.64 meter square. So there is 42.22 meter square space saving.
- The human labor required for existing storage system are three, for proposed system it reduces to 2.
- In the proposed system time can be saved as the lower sheet can be directly removed which is not possible in the existing system.
- The approximate value of the propose storage system lies between 1.33 to 1.45 lakh .
- Many advancement in the system can be done using hydraulic and pneumatic system there by, retrieval time can be reduce.

REFERENCES

1. Alessandra Fraschini (2012), "Storage System", Vol. 1, October, pp. 3-4.
2. Behbahanifard R1, Grondin G Y2 and Elwi A E2 (2004), "Analysis of steel plate shear walls using explicit finite element

method" August 16, Published in 13th World Conference on Earthquake Engineering Vancouver, BC and Canada.

3. Bose B, Sarkar S and Bahrami M (1991), "Finite Element Analysis of unstiffened extended end plate connections", *Structural Engineering Review*, Vol. 3, pp. 211-224.
4. Chem Clear (2010), "Handling and Storage", Vol. 1, pp. 1-6.
5. Danobatgroup (2012), "Efficiency and Productivity in Sheet Metal", Vol. 1, pp. 3-7.
6. Feare Tom (2001), "Staging/Storing: Up, Down, and All Around", *Modern Materials Handling*, February.
7. Groover (2002), "Automated Material Handling and Storage Systems", Vol. 2, Published.
8. Health and Safety Executive (2004), "Safety in the storage and handling of steel and other metal stock", Version of HSG246 Published in 2004, pp. 10-20.
9. Jim Butterworth Constructional Research Unit, School of Science and Technology, University of Teesside, UK." Finite Element Analysis of Structural Steelwork Beam to Column Bolted Connections" 2011 published online.
10. Kemper storatec "www.kemper-storatec.eugermany.online site.
11. MIKLOS Imre Zsolt, MIKLOS Cristina Carmen, ALIC Carmen Inge" Beam structures static and dynamic analysis with finite element method in algor program" year 2008 published in Journal of engineering annals of faculty of engineering huhedoara.
12. OSHA (2002), "Material and Storage System Book", Vol. 1, Online Publication pp. 1-10.
13. SSAB Leading Global (2011), "The Steel Book", Vol. 2, Online Publication, pp. 4-10.