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Design of Dolomite Brick Palletizer in RINL – Cost Reduction Design Process

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Abstract: Now a day's all the material handling process are being automated for ease of work and accountability purpose. In order to reduce stress on worker and smooth work flow automated or semi-automated machines are to be introduced. In this present scenario palletizing of dolomite brick is becoming very great danger to the employee who is stacking the bricks manually, as the bricks releasing dense fumes of coal tar pitch which is a one of the carcinogenic material and the weight of the brick is high. In our present work a machine is designed which is used for palletizing the dolomite bricks. The cheap design process of palletizing machine and its advantages have been discussed in detail inside this paper.
Objective: to design a simple machine for palletizing of dolomite brick in order to reduce hazardous exposure along with stress on worker and also reduces investment and maintenance cost. The machine is confined to the one work only not for multi-tasking.
Key words: dolomite brick, material handling, coal tar pitch, palletization, carcinogenic, robotic arm, structural steel, creo, ansys

I. INTRODUCTION

Material handling is the process of combination of transporting, protection, storing, and control of materials and products. Different types of material handling process are of following types 1) manual 2) semi-automated and 3) fully automated, they support the logistic and make the supply chain work. In this paper we are going to design cheap and best suitable equipment for palletizing of dolomite bricks.

Coal tar pitch is the material which contains mostly Anthracene, Phenanthrene, Pyrene, Carbazol, Benzo (a) Pyrene which are carcinogen agent's cause's cancer during human exposure to that product. In order to avoid the direct exposure of human to that environment some machine is to be replaced for the purpose of Palletization. The second reason is that the weight of the brick is 35 kg's which is very difficult to place them in stacking position repeatedly so for reducing stress on the employee there is a need to implement a machine in place of humans.

At present industries automated robotic arm is being used as material handling for palletizing purpose but the initial cost (3 to 6 crores) and maintenance is high. To reduce the initial cost and maintenance cost a new machine with simple structure and confined to a particular work has been designed. This is best suitable for dolomite brick Palletization with low cost around 6 to 10 lakhs along with machining and shipping of elements cost too which is approximately 80 times cheaper.

For the design of simple machine best technique is to use simple angles and plates. The materials used for this project are mostly structural steel and rubber. Some of the tools like CREO and ANSYS software used for modeling and analysis purpose. A 4 pole synchronized servo motor along with gear box, pneumatic cylinders and hydraulic cylinders are used for the various translation operations and as gripping mechanisms.

II. METHODOLOGY

As there are many solutions which can decrease the fumes generated by the bricks which include as follows:

Using chemical sprays which can reduce the generation of fumes (it is a costly process and not includes any designing process).

Fully automating the palletizing area (which is not suggestible due to high cost and maintenance issue).

We replace a human with a machine in order to reduce stress on the worker and also reduce the direct contact with the fumes which are carcinogenic material (suggestible and suitable to any work environment).

A. Static Analysis

For designing a machine the following tools and material are used

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

B. Materials

1) Structural steel
2) rubber

IS: 2062 Specification of Structural Steel for Fabrication

Chemical Composition

Grade	C %	Mn %	S %	P %	Si	C. E. %
	Max.	Max.	Max.	Max.	Max.	Max.
A	0.23	1.5	0.05	0.05	-	0.42
B	0.22	1.5	0.045	0.045	0.04	0.41
C	0.2	1.5	0.04	0.04	0.4	0.39

Mechanical Properties

Grade	UTS (MPA)	Y.S.(MPA) Min.	EI. % Min	Bend
A	Min.	< 20 mm 20-40 mm > 40 mm	5.65 So	Test
B	410	250 240 230	23	3T
C	410	250 240 230	23	2T & 3T*
	410	250 240 230	23	2T

*2T-Lessthan25mm.
*3T - More than 25 mm.

C. Software used

By using CREO the model has been made, and by the use of ANSYS workbench (finite element package) the above stated analysis are carried out to find the induced displacements, stresses and strain at static condition.

C. Process

First Hydraulic cylinders are selected on the basis of the force required to lift the whole body Force exerted by the machine on elevating to a certain height is given as follows:
Force = mass * acceleration due to gravity
(As the machine is lifted up and down)
Force = factor of safety * original mass * g (g=9.81m/sec^2)
Force = 2 * 1000 * 9.81 = 19620 N = 19.6 KN ≈ 20 KN
The hydraulic cylinder is selected as specified by STARCYL CYLINDERS on basis of ANSI standards from catalogue page no – 34 cap square flange mountain style ST6F6 (NFPA style MF6).
The rack and pinion is selected from the ATLANTA catalogue. As already specified that the module of the pinion and rack should be 4 then based on the standard specifications in the catalogue

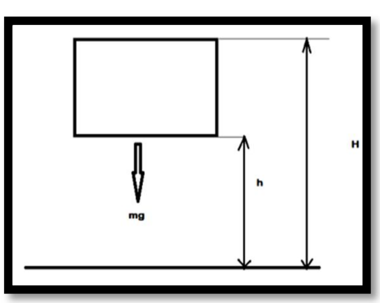

Figure -1 LIFTING FORCE

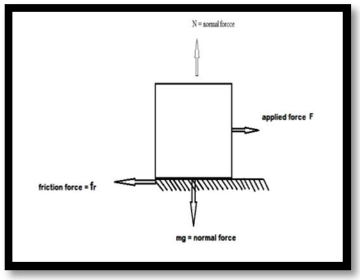

Figure -2 MOVING FORCE

Pressure angle = $\alpha = 20^0$

Torque = Mt = (60 * 10^6 * power in kw) / (2 * ∏ * N)

Mt = (60 * 10^6 * 0.6) / (2 * ∏ * 70)

Mt = 81851.1 N-mm Mt = 81.85 KN –mm ≈ 82 KN-mm

Tangential force Pt = (2 * Mt)/ d'p

Pt = 2 * 82000 / 72 = 2277.78N

Pr = Pt * tanα = 2277.78 * tan 20 = 829N

Normal force Pn = Pt / cosα = 2277.78/cos20 = 2424N

D. Beam strength of the gear tooth:

The analysis of bending stresses in gear tooth was done by Wilfred Lewis in this project

Bending moment = Mb = Pt * h (where h = height of the tooth)= 2277.78 * 9

= 20.50 KN-mm

Bending stress = σb = Mb * y / I = [(20500 * 3.1415) / (40 *6.283^3 / 12)]

= 20500 * 3.1415 / (826.76)

= 77.89 ≈ 78 N/mm²

Beam strength = Sb = m * b * σb * Y (where Y = Lewis form factor for Z= 18 Y = 0.308)

= 4 * 40 * 78 * 0.308

= 3843.84 N = 3.844 KN

In order to avoid the breaking the condition to be satisfied is Sb ≥ Peff

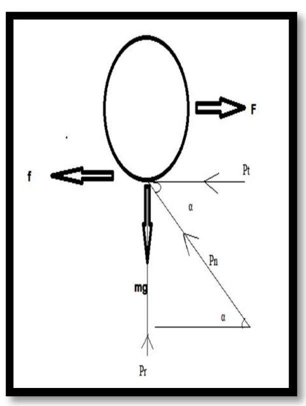

Figure -3 PINION FORCE

Where Sb = bending stress

Peff = effective load on gear tooth = (Cs * Pt) / Cv

Cs = service factor = (maximum torque / rated torque) = 1.50 for a light shock

For ordinary and commercially cut gears Cv = velocity factor = (3) / (3 + v)

V = pitch line velocity = (π * d'p * n) / (60) = π * 0.072 * 70 / 60 = 0.264

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$C_v = 0.92$

$P_{eff} = 1.50 * 2277.78 / 0.92 = 3717.34$ N = 3.7KN

Therefore 3843.84 ≥ 3717.34 which states that the beam strength is greater than the effective load on the beam hence the condition satisfied

$$S_b \geq P_{eff}$$

Permissible bending stress = Sut = 3 * σb = 3 * 78 = 234 N/ mm²

Wear strength of the gear tooth = Sw = b * Q * d'p * K = Peff * factor of saftey

Where b = half width of deformation

$b = [\{2P (1 - \mu^2) * ((E_g + E_p) / (E_p.E_g))\}/ \{\pi l ((1/D1) + (1/D2))\}]^{0.5}$

For rack the diameter is infinity

Eg and Ep are the young's modulus of the rack and pinion material

P = force applied on rack by pinion

l= length of the pinion

μ = Poisson's ratio

BHN = Brainell hardness number K = contact stress = 0.16 * (BHN / 100)²

Q = ratio factors for internal gears = 2Zg / (Zg - Zp)

Where Zg and Zp are no teeth on rack and pinion

And factor of safety is 4

Sw = 3717.3 * 4 = 14869.2 = 14.9KN

Hence all the conditions are satisfied for the rack and pinion of module 4.

Selection of Pneumatic cylinders for gripping:

Pneumatic grippers are selected on the basis of the force required to lift a brick to certain height which is shown as follows

Strength of the brick = 300kg/cm² = 29.43 N/mm²

And cold crushing strength = 4000kg/cm² = 39.24 N/mm²

Pressure applied by the pneumatic cylinder on the brick = 0.1 MPa = 0.1 N/mm²

Condition to be satisfied for selecting the pneumatic cylinder as a gripper is

Pressure applied by the pneumatic cylinder ≪ strength of the brick

So that the brick does not break on the working condition

Friction force

Friction force acts twice on the brick as the body is supported sidewise and the grippers acted on the both sides

The friction force acting is given as follows;

F (friction) = μ* N = 0.1 * 5600N = 560 N   Where

μ= coefficient of friction and

N = normal reaction acted on the brick from the gripper

N = Pressure * area of the gripper = 0.1 * 400 * 140 = 5600N.

The net force acting on the brick is as shown as following:

Net force = Mg – 2F

= (factor of safety * weight of the brick * acceleration due to gravity) – (2 * friction)

= (2 * 35 * 9.81) – (2*560)

Net force = - 433.3 N

Where – ve sign indicates the direction of force acting in

Based on the above calculations the required / suitable pneumatic cylinder is selected from the AIR CYLINDER STANDARD TYPE K1 Series and their specifications and the design specifications are stated as follows. These are the standard details obtained from the company catalogue.

E. Selection of motor and gear box

Selection of motor and gear box is taken from the siemen motor catalogue

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Motor type – servo motor

Rated rotational speed (Rpm)	1500	Size	100
Shaft height (Sh)	100	Motor type	1FT6 10
Rated output(kw)	13	Brake type	EBD 4 B
Rated torque (Nm)	83	Holding torque (Nm)	80
Rated current (I)	31	D current(A)	1.4
Stand still torque (Mo)	90	Opening time with varistor(ms)	180
Order no	1FT6108-8SB71--SB0	Closing time with varistor (ms)	20
Pole pair no	4	Moment of inertia (10^-4 kgm²)	32
Rotor moment of inertia(10^-4 kgm²)	260	Max switched energy per brake (J)	2150
Weight (kg)	61.5	Stand still current (Io)	30
Power connector size	1.5	Motor cable area (mm²)	4.6

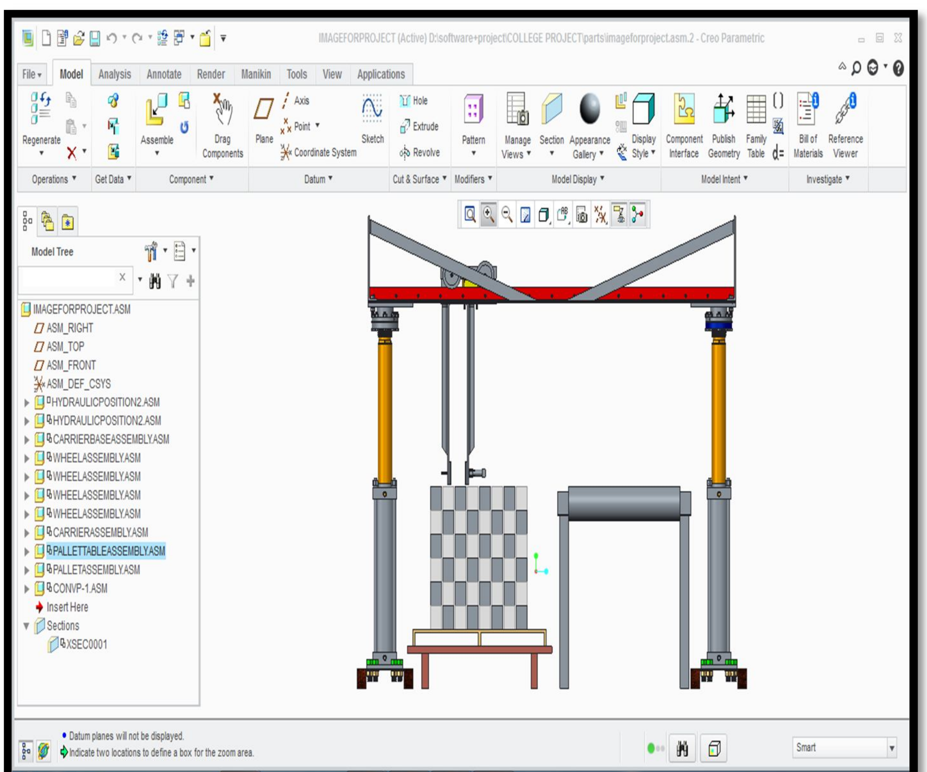
F. Design of gear box

Gear box type – helical gear type

Acceleration torque M2B = 23 - 8000 Nm

Ratio i = 2 - 276

Backlash Δϕ 10 - 20 arcmin



Volume 5 Issue VI, June 2017
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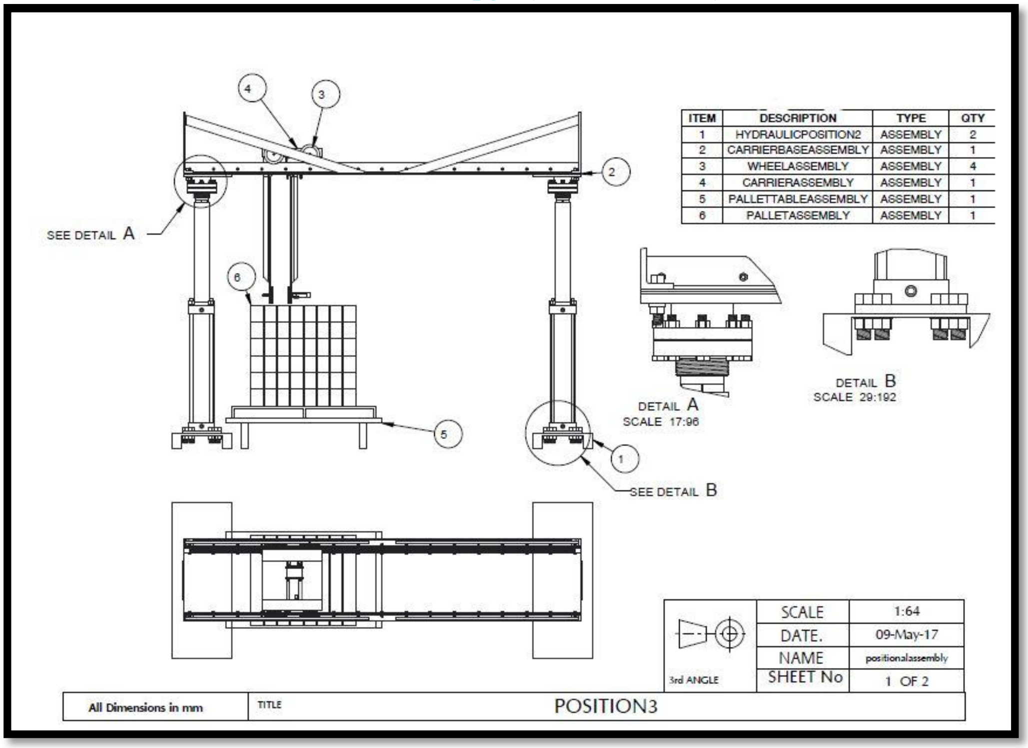
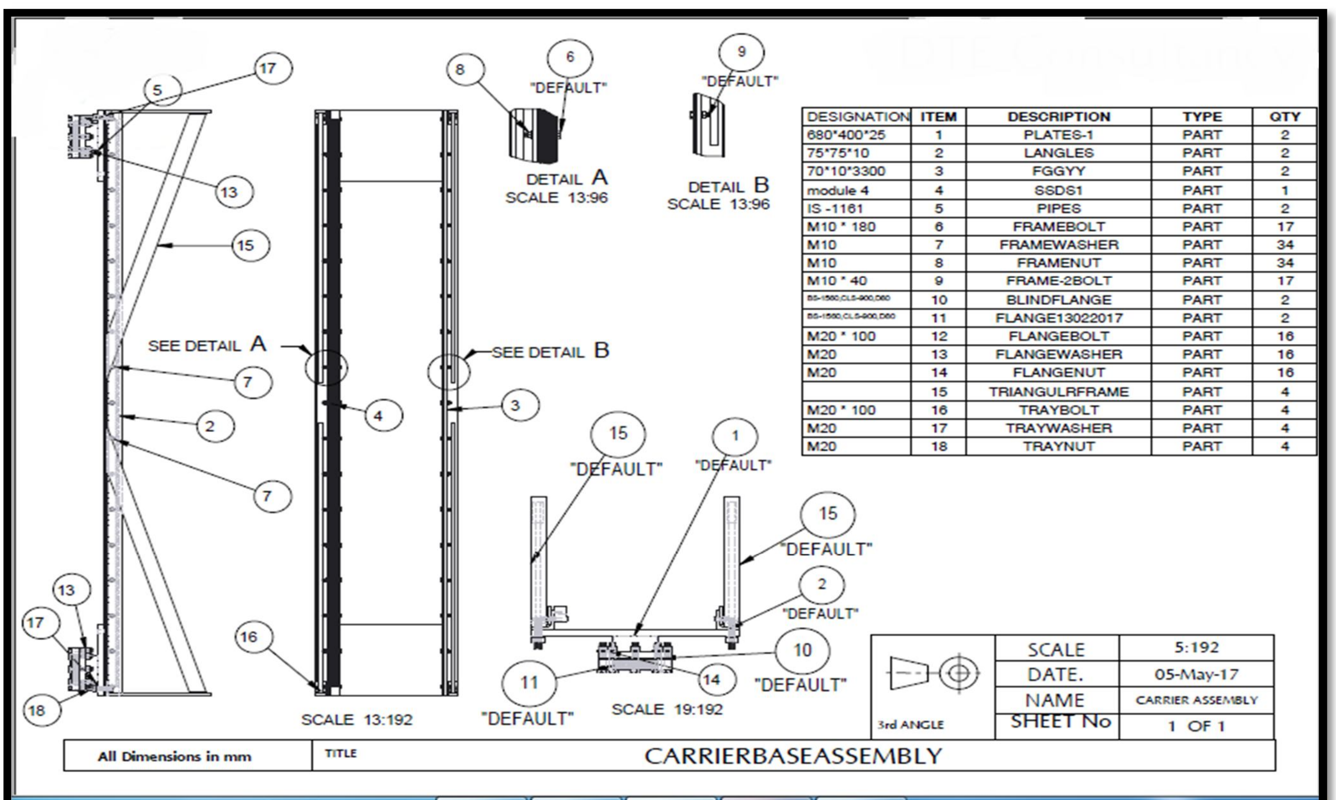


Figure -4 representing the final assembly model in creo

Remaining parts are designed as per the requirement, based on the satisfactory conditions which are obtained as above. The remaining parts are kept in assembly drawing as below



Volume 5 Issue VI, June 2017
ISSN: 2321-9653

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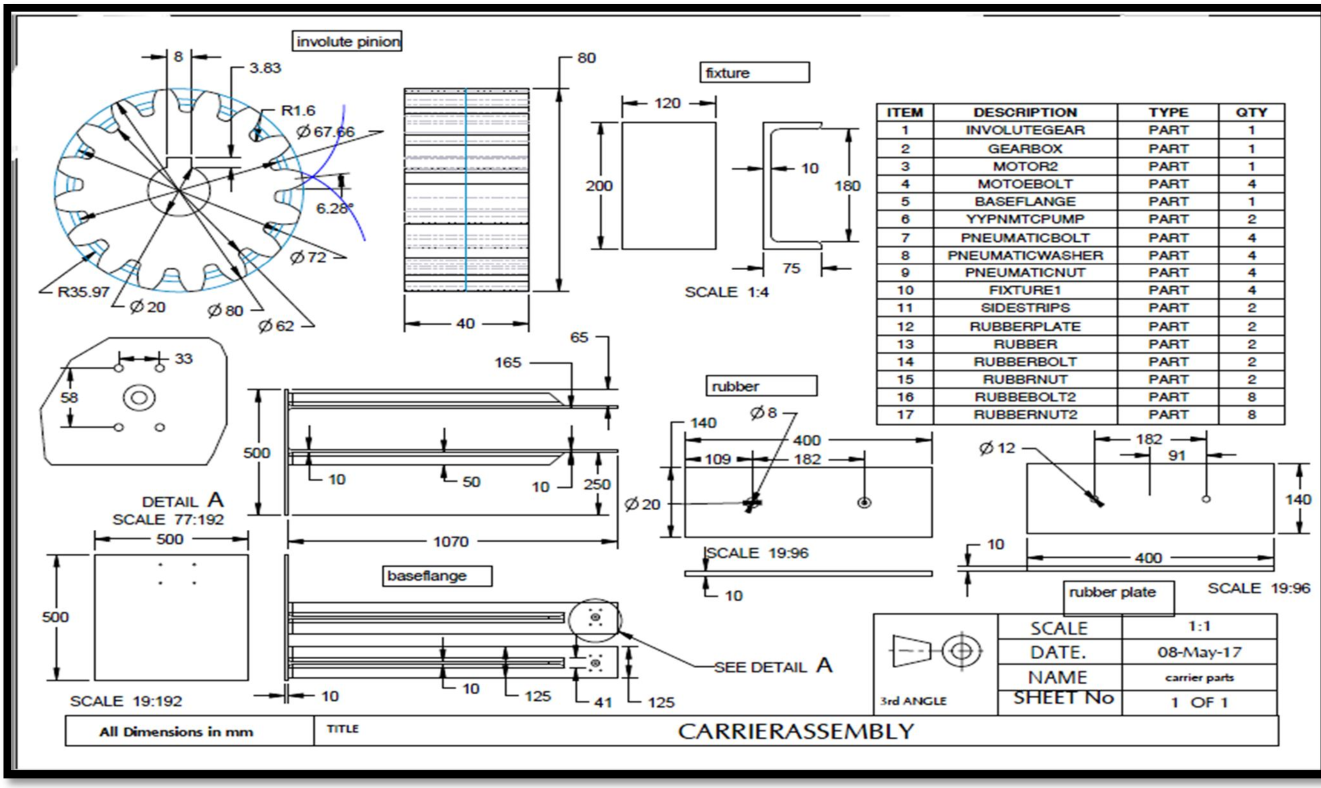

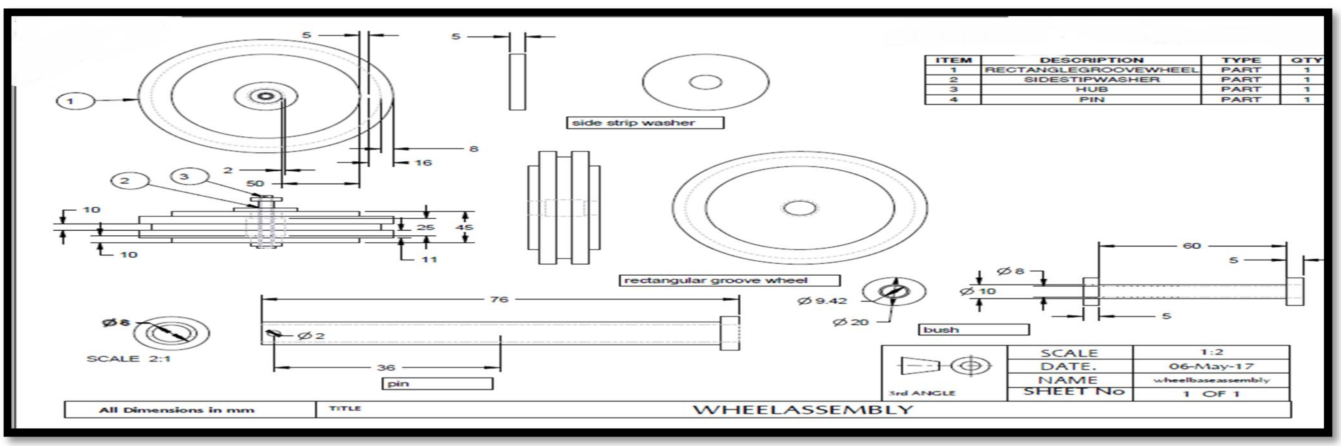

Figure -5 part drawings of the carrier base with carrier

Their dimensions are taken from standard catalogues so mentioned in their designations in the assembly drawing.

III. ANALYSIS

The design is analyzed in ANSYS 16 software using static condition. Only the frame along with carrier is analyzed in this paper as the deflection of the structure is considered only for the newly designed elements/ assembly. The remaining hydraulic cylinder, pneumatic cylinder, motor, are taken directly from the industries as per the required output which are already tested in both simulated and the analytical manner so no need of wasting time on already known items.

Process of analysis is select the analysis workbench in structural static option – enter the engineering data – import the assembly into the geometry – apply the boundary conditions and material properties to the individual elements – apply meshing – apply load conditions as follow 1) apply fixed boundary condition on both the flanges surface 2) apply bearing load on the centre of the wheels with 150N on each wheel – apply solutions to be evaluated 1) Total Deformation 2) Von-Mises stress 3) Von-Mises strain 4) fatigue analysis conditions – life time cycles and factor of safety – apply solve the solution – evaluate the solutions.

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

RESULTS:

The obtained results are as follows

s.no	Result name	Obtained value	Acceptable value	Conclusion
1	Total deformation	7.8524e -02 mm	3.3 mm	The deformation is within the allowable range
2	Equivalent strain	Min – 6.439e-16 Max – 1.26e-4	- -	Very less strain and allowable
3	Equivalent stress	Min – 1.621e-11 Mpa Max – 24.495 Mpa	- -	Low stress and allowable
4	Life time	Min - 1.e+006 cycles	-	It is the minimum number of life cycles and obtained for rubber material so for structural steel it is even more lifecycles
5	Factor of safety	Min -2.9325 Max - 15	- -	As the considered factor of safety is varied for different material the minimum and maximum are obtained in the ANSYS software

IV. CONCLUSIONS

Based on the above results one can conclude that the new design can withstand the load. The deflection in the structure under static condition is within the limitations.

It is a best optimization process for the following:

A. Time management
B. Economical wise
C. Design wise
D. Health and safety wise etc

As the above results are obtained in a satisfactory level then this design is the best technique for implementing for palletization of dolomite bricks in an economical manner.

E. Extensional Thoughts

Automation can be done by inserting sensors and micro processor chip so that the process can be fully automated.

It can be added one more degree of freedom if the brick size varies as in the above scenario the brick considered is standard of fixed dimension.

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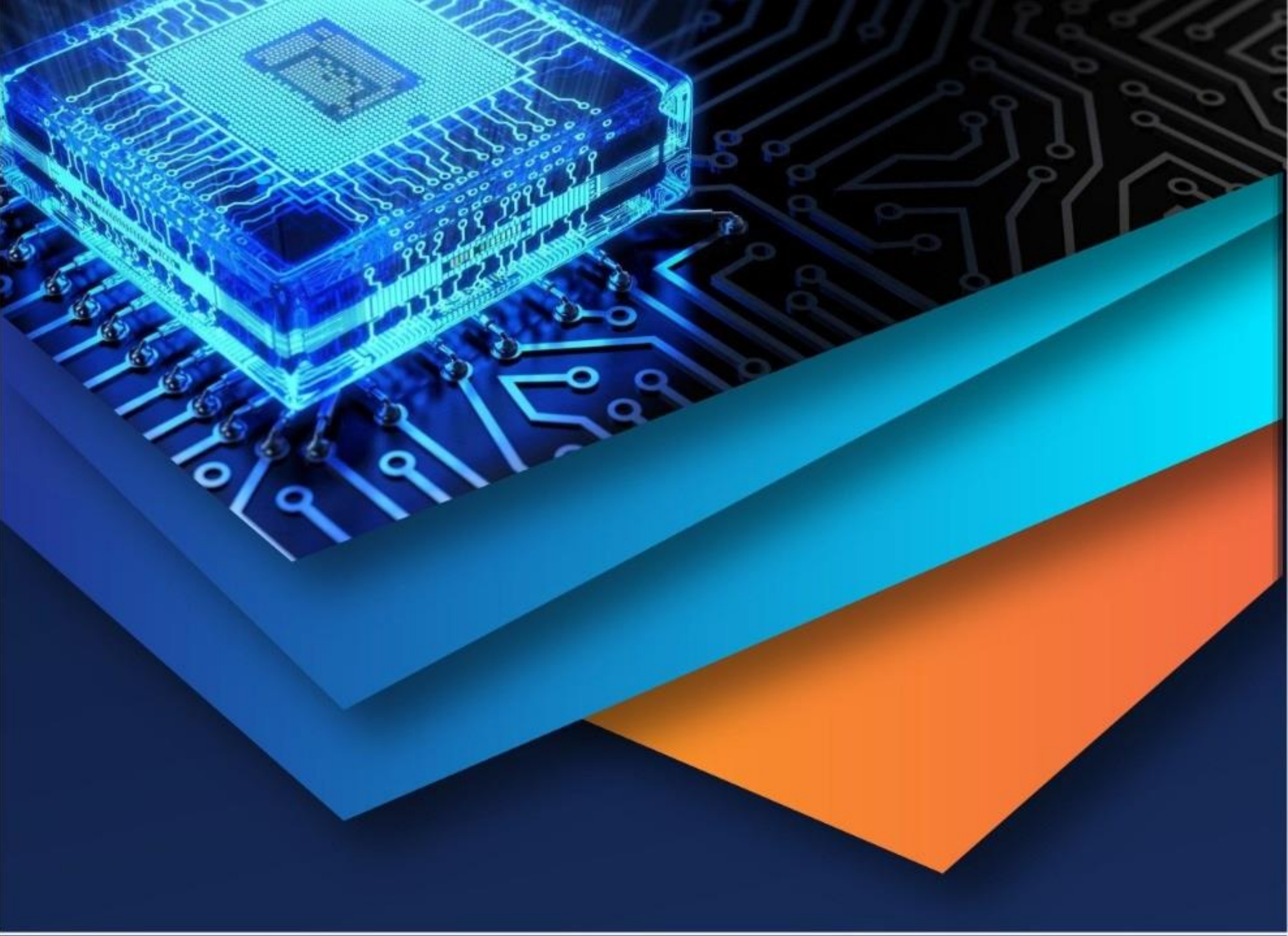

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