Design and analysis of Matarial Handling System

Waghmare Santosh R.[1], Tolmare Ashish M.[2], Praveen K Mali[3]

1. B.E. student, Department of Mechanical Engineering, G. H. Raisoni College of Engineering, Ahmednagar, India.

2. B.E. student, Department of Mechanical Engineering, G. H. Raisoni College of Engineering, Ahmednagar,India.

3. Assistant. Professor, Department of Mechanical Engineering, G. H. Raisoni College of Engineering, Ahmednagar

---***---

Abstract- In today's rapid growth of industrialization need to meet the goal of each and every industry. Material handling system design has a direct influence on the overall cost. Any industry look for its profit higher the production more will be the profit. Design and analysis of material handling system(chain conveyors) is discuss in this paper to improve the effectiveness of organization with reduced cost.

Keyword- Ansys, Catia, FEA, Theoretical analysis of material handling system, cost reduction, automated system

1. Introduction

Material handling system can be defined as loading, unloading of material, storage and controlling of material through manufacturing unit. The main purpose of using material handling system is to reach the material to destination in correct amount to minimize the cost of part produced. Any human activity involving materials need materials handling. However, in the field of engineering and technology, the term materials handling is used with reference to industrial activity. In any industry, be it big or small, manufacturing or construction work, material have to be handled as raw material, intermediate goods or finished product from the point of receipt and storage of raw materials, through production processes and up to finished goods storage and dispatch points. In many cases, mechanical handling reduces the cost of manual handling of materials, where such material handling is highly desirable. All these facts indicate that types and extent of use of material handling should be carefully designed to suit the application and which become cost effective.

Chain conveyors are ideally suited for cycled transport of products. Available with different drive variants, they are often used for setting up complex interlinked solutions. Typical applications are transfer of pallets in two-strand applications for high loads at moderate speeds. For high speeds or positioning tasks, low maintenance, and low-noise timing belt conveyors are used. Various chains, in conjunction with our robust and solidly designed wear strips, permit an optimally matched sustainable function. Chain conveyors are extremely robust and low maintenance.

The essential requirements of a good materials handling system may be summarized as:

i. Efficient and safe movement of materials to the desired place.
ii. Timely movement of material when needed.
iii. Supply of material at desired rate.

Storing of materials utilizing minimum space

Fig.1 chain conveyor

Objective of material handling system:-

The primary objective of a material handling system is to reduce the unit cost of production. The other subordinate objectives are:

1. Reduce manufacturing cycle time
2. Reduce delays, and damage
3. Promote safety and improve working conditions
4. Maintain or improve product quality
5. Promote productivity

i. Material should flow in a straight line
ii. Material should move as short a distance as possible
iii. Use gravity
iv. Move more material at one time
v. Automate material handling

6. Promote increased use of facilities

   i. Promote the use of building cube
   ii. Purchase versatile equipment
   iii. Develop a preventive maintenance program
   iv. Maximize the equipment utilization etc.

7. Reduce tare weight

8. Control inventory

2. Problem Statement:-

The concept behind design of the system should be as per customer requirements. The customer requirements are as follows:

TABLE I

Customer Requirements

Sr. No.	Description	Specifications/Requirements
	Critical inputs for design	
1	Basic Component details	Hex rod A/F=22/25mm & length from 0.9 to 9m. Min wt=3kg to Max 30 kg.
2	Min Component in buffer for machining	40 nos.
3	Load & Unload of the two component	Individually powered
4	Cycle time	5 min per cycle for loading & unloading parallel operation per side.
5	Component to be loaded at a time	02 nos.
6	Conveyor pitch	Equal or in Multiple to fixture pitch - 16 inches

Objective of the work:-

The objective of this project is:

- To reduce the manufacturing lead time.
- Reduce product development cost.
- Increase the productivity.

Aim and Scope of the work:-

The objective of the present work is to design, analyse and propose a method of handling the material in any organisation.

This is done to achieve the following-

- This design helps in the precision handling of material without any disturbance to production unit with less care.
- Ability to transport unit loads as well as bulky and heavy loads over large distances.
- Large conveying capacities at desired speeds.

3. LITERATURE REVIEW:

- J. S. Noble and C. M. Klein, A. Mid ha [1] have examined several aspects of the integrated material flow system design problem. ; However, as problem complexity has increased the ability to obtain solutions to the more integrated problem formulations has become more difficult. They present a model which integrates material handling equipment selection and specification (including interface equipment between different types of equipment), and path/load dependent unit load size and variable unit load size. The formulation is solved using the meta-heuristic procedure of tabu search to find a "good" solution to a more integrated formulation.
- Ramazan YAMAN [2] develop a knowledge-based system for material handling equipment selection and pre-design of these 111equipments in the facility layout is discussed. The study comprises two sections. In first section author explained the selection of material handling equipment for related product requirements and in second section decision making for equipment between departments.
- J. D. Tew, S. Manivannan, D. A. Sadowski, and A. F. Seila [4] were illustrate the simulation methodologies used in the design of Automated Material Handling Systems (AMHS) at Intel wafer fabs for semiconductor manufacturing. The models used in AMHS design has categorized as AMHS models and production models. The AMHS models support the design of Interbay and Intrabay systems. The Inter bay systems handle the material flow between different bays (production centers). Prasad Karande and Shankar Chakraborty[5] have carried out the selection method for suitable MH equipment . They had proceed with multicriteria decision-making (MCDM) problem. As wide range of MH equipment is available today, for this complicated task they applied a multicriteria decision-making (MCDM) tool to select the most suitable MH equipment. They implement weighted utility additive (WUTA) method to solve an MH equipment selection problem

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 05 | May-2016 www.irjet.net p-ISSN: 2395-0072

4. Work methodology

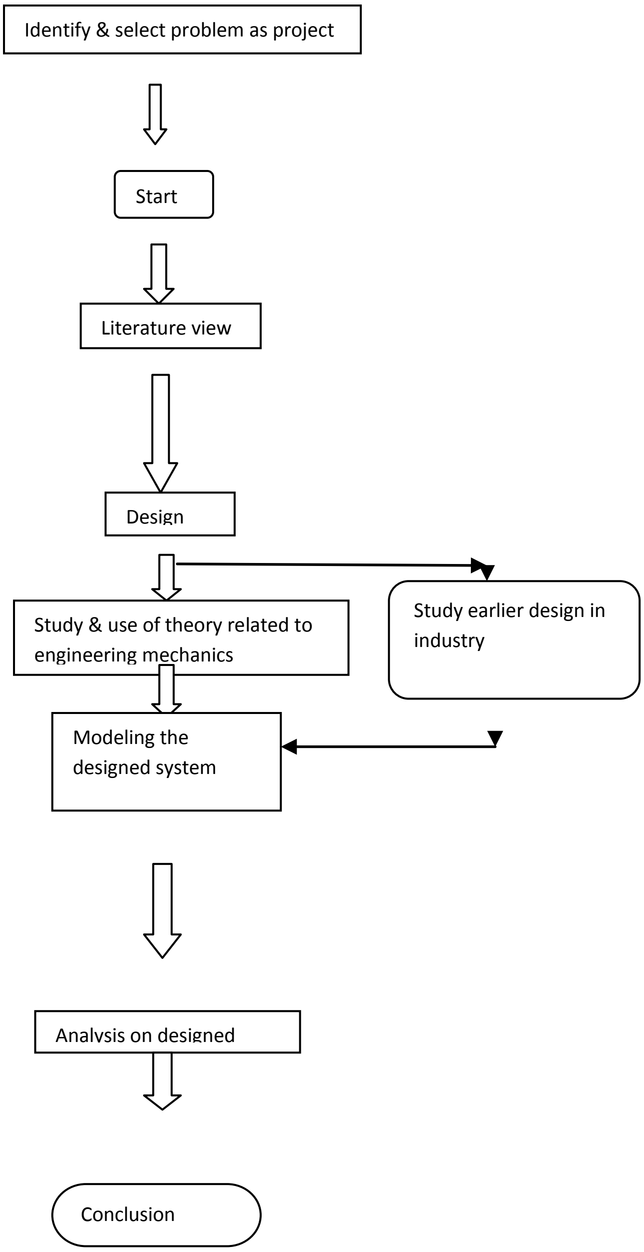


Fig No 2. Work methodology

5.Detailed design procedure:

Chain selection steps

Selection of chain is depend on following factor:

1. Type of conveyor
2. Total load to be carried
3. Type of attachment

4. Operating condition
5. Lubrication
6. Chain breaking load.

6 .Chain design

We have used the simplex roller chain to convey rod. We have used 2 simplex chain instead of duplex chain for cost reduction and stability of attachment.

Advantage of using 2 chains :

1. Uniform speed
2. Less lateral improvement

Calculating chain pull

Chain is that force required removing the chain, the connected mechanical parts and load to be conveyed.

The chain pull required for a particulars application is dependent on following factor:

1 .Weight of material carried.
2. Weight of chains and support element(slats, swing trays, cross bar etc.)
3. Coefficient of friction.
4. Service factor
5. Gearing factor

Coefficient of friction (fr)

Table for coefficient

Bodies in contact	Fr dry surface	Frlubr. Surface
Steel chains on hardwood tracks	0.44	0.29
Steel chains on steel tracks	0.30	0.20
Steel chains on rough or rusty tracks	0.35	0.25
Steel chains on tracks of high density very high molecular weight	0.18	0.05

Service factor=Fs

Operating condition	
Load position centred	1

not centred	1.2
Load characteristics uniform extent of overloading less than 5% with minor variation extent of overloading 5 to 20 % with major variation extent of overloading 20 to 40%	 1 1.2 1.5
Frequency of loaded starting/stopping -less than 5 per day -from 5per day to 2 per hour -more than 2 per hour	 1 1.2 1.5
Working environment -relatively clean -quite dusty or dirty -humid, very dirty or corrosive	 1 1.2 1.3

6. Determining the type of chain to use

1)Type of chain is depend on max chain pull, the maximum stress that chain components will be considered.

2) It is generally accepted that a chain, working at 65% of the breaking load will be stressed beyond the 'elastic limit' of the side plate material.

3) In order to provide sufficient margin of safety, the chain breaking load should therefore be at least 8 times the maximum working load.

Calculation of bearing pressure

a) Roller loading=w/L. Dr kgf/mm^2
b) Pin pressure=T/Lb. Db kgf/mm^2

Where,

W= load supported by each roller.

T=chain pull [kgf]

L=distance through roller bore [mm]

Lb= total bush length [mm]

Dr= diameter of roller bore [mm]

Dp=external diameter of pin [mm]

Material in contact		Max. Spec. Press. (kgf/mm^2)
Bush	Pin	
Case-hardened steel	Case-hardened steel	2.5
Case-hardened steel	Hardened-tempered steel	2.1
Cast iron	Case-hardened steel	1.75
Stainless steel	Stainless steel	1.2
Bronze	Case-hardened steel	1

Material in contact ROLLER	BUSH	Max. Spec. Press. K g f/mm^2
Case hardened steel	Case hardened steel	1
Hardened tempered steel	Case hardened steel	1
Cast iron	Case hardened steel	0.70
Bronze	Case hardened steel	0.60
Polyethylene A.D.	Case hardened steel	0.1
Stainless steel	Stainless steel	0.40
Cast iron	Bronze	0.28

Calculation and selection

	Pitch of chain	
According to customer I/p, max velocity permitted and cycle time requirement		
The pitch selected is p=	25 .4	mm
Minimum no. Of rods (NI)=	45	

Number of links between two successive rods=		3	
Length of upper span of chain		3429	mm
	Number of teeth of sprocket		
Assumed D=	250		mm
Z=	Pi*D/p		30.905 51 =31

Customer requirement: Min.40 rods to be transmitted

Assuming max. Load of 45 rods of 9m length

Weight of material (rods)= 45X30= 1350 kg

Velocity of conveyor V= L x T= 10 m/min

N= v/Pi*D= 12.73885 RPM

From catalogue weight of chain = 2.71 Kg/m

Weight of chain for total length= 18.58518 Kg

4 simplex chains, 4*weight of each chain=74.34072

Final weight of chain= 89 Final weight of chain

Total chain weight = 1440 kg

Fr = 0.2

Therefore, fs=1.2*1.5*1.5*1*1.2= 3.24

Total Chain Pull (F)			
F=fs*(1+fr)*F1*9.81 /No. Of chains		13730.860 8	N
		13.730860 8	KN
Torque (T)			
T=	F*D/2=	1761.239	Nm
P=	2*Pi*N*T/60 =	2.34950500416	Kw

Calculation of bearing pressure

A] roller loading = p\L+Dr [kgf\mm^2]

B] pin pressure = T\Lb[kgf\mm^2]

Where

P = load (kgf supported) by each other

T = chain pull (kgf)

L = distance through roller bearing (mm)

Lb = total brush length (mm)

Dr = diameter of roller bore(mm)

Dp = external diameter of pin (mm)

7. FINITE ELEMENT ANALYSIS

(1) Total deformation during conveying

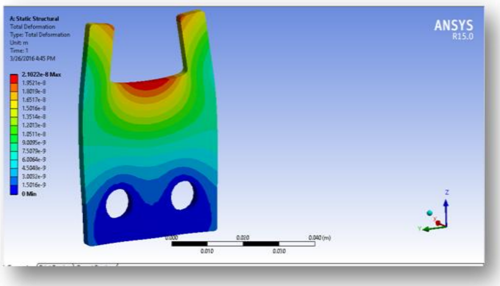


Fig no 1. total deformation during loading

The total deformation is = 2.1022e^-8 mm.

(2)Equivalent stress during conveying

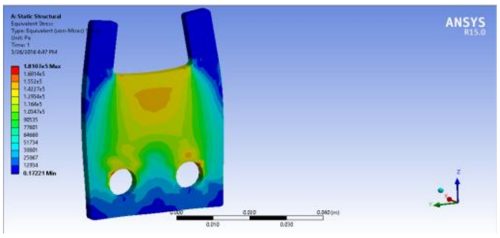


Fig no 2. Equivalent stress during conveying

The Max Equivalent stress = 9.7547 e^6 Mpa.

(3)Total deformation during unloading

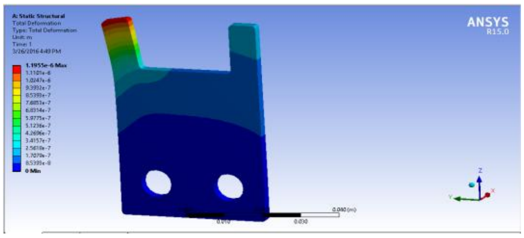


Fig no 3. Total deformation during unloading

The max deformation during unloading process is 1.8107eˆ5 mm..

(4) Equivalent stress during unloading

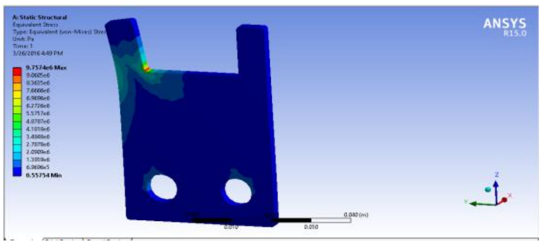


Fig no 4. Equivalent stress during unloading

The equivalent stress during unloading process is 1.1955eˆ-5 Mpa.

8. SPROCKET DESIGN:

Sprocket Drawing

Fig no 5..Isometric View Of Sprocket

Sprocket calculation:

Using trial and error method we assumed the pitch circle diameter (PCD) of the sprocket to be 250 mm. The no of Teeth of the sprocket are given by:

V = PxZxN/1000

Where,

V = Linear velocity of chain (m/s)

P = pitch of the chain (mm)

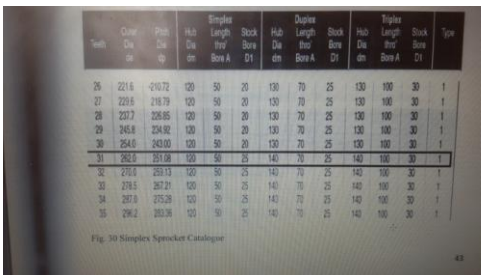
Z = No of teeth of sprocket

N = RPM of chain

Thus we got the no of teeth as 31.

Also, we have used 2 simplex chain side by side & therefore we have selected the following duplex sprocket.

Simplex sprocket catalogue:



Teeth	Outer Dia de	Pitch Dia dp	Simplex Hub Dia dm	Simplex Length thro' Bore A	Simplex Stock Bore D1	Duplex Hub Dia dm	Duplex Length thro' Bore A	Duplex Stock Bore D1	Triplex Hub Dia dm	Triplex Length thro' Bore A	Triplex Stock Bore D1	Type
26	221.6	210.72	120	50	20	130	70	25	130	100	30	1
27	229.6	218.79	120	50	20	130	70	25	130	100	30	1
28	237.7	226.85	120	50	20	130	70	25	130	100	30	1
29	245.8	234.92	120	50	20	130	70	25	130	100	30	1
30	254.0	243.00	120	50	20	130	70	25	130	100	30	1
31	262.0	251.08	120	50	25	140	70	25	140	100	30	1
32	270.0	259.13	120	50	25	140	70	25	140	100	30	1
33	278.5	267.21	120	50	25	140	70	25	140	100	30	1
34	287.0	275.28	120	50	25	140	70	25	140	100	30	1
35	296.2	283.36	120	50	25	140	70	25	140	100	30	1

Fig. 30 Simplex Sprocket Catalogue

43

9. Design of shaft :

Shaft design on the basis of torsional rigidity

Ør = (Mt * L)/(L*G)

Where,

Ør =torsional deflection per m length in radiance

Mt =torsional moment

L = length of the shaft

J = polar moment of inertia

J = (π* dˆ4)/32

G = modulus of rigidity

After subtracting formula for j for circular shaft and converting angle to radians,

The formula become as follow

Ør = (584 * Mt*L)/(G*dˆ4)

the bore of the sprocket is Ø =25 mm.

transmission shaft are made of low or medium carbon steel.

Shaft diameter (Ø) = 25 mm,

Shaft length (L) = 1000 mm (assumed)

G for steel = 1764 Nm

Mt. = 0.0793 N/M^2

Subtracting values in above formula

Ør = 0.033256627 rad/ mL

= 1.906430875 Degree m length

For line shaft torsional deflection Ør should be < 3deg per m length

As the selected shaft has Ør within permissible limits it is safe

10. KEY DESIGN

We are selected sun key with rectangular cross section made pf plane carbon steel of 50C4.

For 25 mm diameter the key are as follow

B*h = 8*7

Taper of 1:100 on one side

Cheacking for stresses

Syt for key = 260 N/mm^2

Fs= 3

$\sigma c=\sigma t$ =153.34 N/mm^2

Ʈ=(0.5*Syt)/fs = 76.67 N/mm^2

Mt = 1761239 Nmm

D = 25mm

L =

Ʈ= ((2*Mt))/((d*b*L))

= 17612.31 N/mm^2

11. COUPLING DESIGN:

We have selected the muff coupling due to its following advantages

- ***It is rigid coupling***
- It is simplest coupling with 2 parts sleeve and key.

Length of the sleeve

L=3.5d=87.5mm

Diameter of sleeve

D= (2d+13)mm =63mm

Allowable shear stress

Ʈ = 16*Mt/3.14d^3

=574.07N/mm^2

Calculated shear stress

Ʈ=Mt*r/J

J = 3.14*(D^4-d^4)/32

=1.508*10^6 mm^4

Ʈ= 14.599 N/mm^2

calculated shear stress is less than allowable value. The design is safe.

10. MOTOR AND GEAR BOX SELECTION

INPUT DATA FOR MOTOR SELECTION

N = 12.73 RPM

T = 1762 Nm

P= 2.35 KW

From input data we are selected KII112M.

Rated torque can be calculated as follow,

T = Rated power*60/(2π*rpm)

= 24.37952998 Nm.

Therefore at required rpm 12.73, the torque is given by,

T1N1 = T2N2

= 2776.929966 Nm

Shaft diameter for motor 28 mm

Gross weight = 52 Kg.

11. Gearbox Selection

Gear reduction ratio G = 1440/12.73

= 113.118

This ratio can be achieved using two or three stage gearbox. But the design of gear pairs using this no of stages would lead to larger gear size & hence large gearbox.

The selected gear box contains single groove deep ball bearing. They have high load carrying capacity at moderate thrust carrying capacity

11. FRAME DESIGN

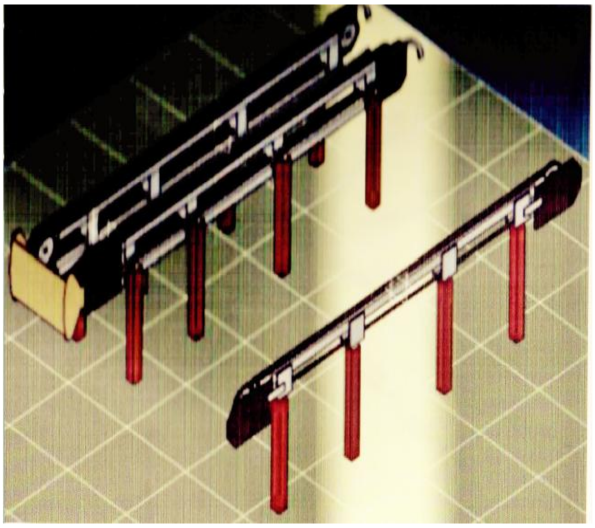
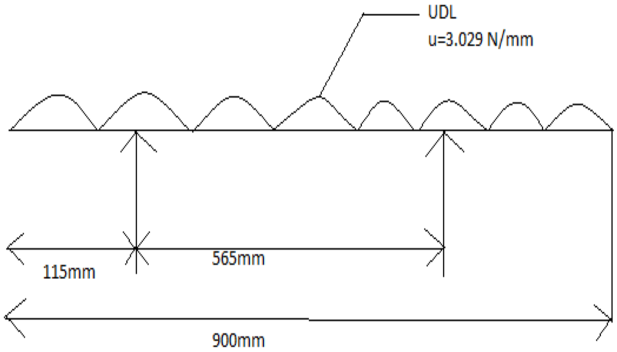


Fig No 6. Frame Design



Loading on the small length

Sel load (N)	=	26.487
Udl N/mm	=	0.02943
Reaction at A (N)	=	10.78232
Reaction at B (N)	=	15.70468

Bending moment at A N/mm = -194.606

Bending moment at C N/mm = 720.943

Bending momentat B N-m = -712.206

Bending stress calculation for two support:

CALCULATION

IXX 14081.63

SaLL 0

S 0.563172

INPUT DATA			
Max bending moment	BM	720.943	N/mm
Distance from neutral axis	Y	11	mm
Moment of inertia about x-axis	Ixx	14081.6 3	mm^4
Allowable bending stress	SaLL	0	N/mm^2
Length of side of hex C/S	S	12.7	Mm
yield strength of rod material	Sut		n/mm

Three supports:

For rods of length grater than 2000 mm, an additional support is required as overhang on non machining side is very large because of which the rod will fail from the conveyor. This support is provided by another chain conveyor.

Range Of Lengths(Mm)	Position Of Third Support From Fixed Overhang End(mm)
900-2000	Not Required
2000-3000	1700
3000-4000	2250
4000-5000	3150

5000-6000	3500
6000-7000	5350
7000-8000	5350
8000-9000	6500

.12. CONCLUSION

- The main challenge while designing the system was to accommodate rods having large variation in length and weight with a stable configuration.
- After the designing and selection of all components is done the system can be summaries as follows
- • The final system consist of chain conveyor with an additional support as the when needed. The location of third support varies with lengths of rods.
- • The system capacity is to carry 45 rods in one batch in 10 m/min speed.
- • An attachment is designed to meet the functional requirements and assembled with chain separately.
- • The attachment designed was proved safe on the basis of finite
- Element analysis.
- • Accordingly other components were selected compatible with the system
- • The support frame was designed for men conveyor as well as third support.
- • The third support can be moved to different location according to the lengths of the rods being conveyed.

The system was fabricated as per designed an dispatched to sandvik. It is presently working there efficiently and satisfactorily

REFERENCES

[1] J. S. Noble and C. M. Klein, A. Mid ha [1] have examined several aspects of the integrated material flow system design problem. ; However, as problem complexity has increased the ability to obtain solutions to the more integrated problem formulations has become more difficult. They present a model which integrates material handling equipment selection and specification (including interface equipment between different types of equipment), and path/load dependent unit load size and variable unit load size. The formulation is solved using the meta-heuristic procedure of tabu search to find a "good" solution to a more integrated formulation.

[2] Ramazan YAMAN develop a knowledge-based system for material handling equipment selection and pre-design of these 111equipments in the facility layout is discussed. The study comprises two sections. In first section author

explained the selection of material handling equipment for related product requirements and in second section decision making for equipment between departments.

[3]. Hollingworth N.E and Hills D.A, "Forces in Heavy-duty drive chain during articulation", Proe Instn Mech, Vol-200 No.C5, 1985.

[4]. Srdan M Bosnjaka, Miodrag A Arsic, Nenad. Zernic,Zoran D Odanovic, Milos. Dordevic, "Failure analysis of the stacker crawler chain link", Elsevier, 2011.

[5]. Tushar S. Shahane1, Prof.Ameet M. Umbrajkaar2, "Design and analysis of chain outer link by using composite material" (ISOR-JMCE), e-ISSN: 2278-1684, p-ISSN: 2320-334X, Vol-12, Issue 1 ver. II Jan –Feb 2015)

[6]. Jagtap M.D., Gaikwad B.D.,Pawar P.M., "Study of roller convey chain strip under tensile loading", IJMER, ISSN: 2249-6645, Vol. 4, Issue 5, May 2014.