DESIGN AND ANALYSIS OF BELT CONVEYOR FOR WEIGHT REDUCTION IN FOUNDRY

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Abstract –

The Foundry sector is having very wide use of Belt Conveyor. Belt conveyor is used to transport material from one location to another. Belt Conveyor is a widely used continuous transport device, it has a high performance, wide conveying capability and it can be done at various distances, various transport of materials. The task of transportation within the conveyor belt systems can be defined as a process aimed at the transportation of the determined quantity of handled material within a defined period of time between the specified loading and unloading locations. It is significant to reduce the energy consumption or energy cost of material handling sector. This task accordingly depends on the improvement of the energy efficiency of belt conveyors, as these are the main energy consuming components of material handling systems. In this project the solution on more weight and power consumption is given. Hence in this project we are going to design and optimise the critical parts of roller belt conveyor used in Foundry, i.e., roller, bracket, bearing, and frame of conveyor.

Key Words— *Foundry, Belt Conveyor, Optimize, Energy Consumption.*

1.INTRODUCTION

In any industry there are various departments on which industry work smoothly, namely, purchase, machine shop, quality, material handling department, etc. Material handling is an important part of the industry and work for transporting a workpiece from one workstation to another workstation. This is the modern technology and used to decrease the lead time in production. It increases the total productivity of industry. The use of Belt Conveyor in the Foundry is to transport the Sand from one work station to another. Also the Sand is having more weight and hence there are many problems in belt conveyor. The Current system in the Foundry is heavy and having the problem of wear in belt due to weight and improper roller supports. Also the overall weight of the system is more than required. This project is sponsored by a Vijay Engineers and fabricators, Kolhapur and deals with optimization of the System to achieve the weight reduction.

2 LITERATURE REVIEW

Pranav Deshmukh et. al [1]

The aim of this paper focuses on choosing the right belt conveyor and suitable components in the system. It was a sponsored project carried out in Yash Enterprises, Khamgaon, Buldhana. The problems of various components in the system was carried out and the proper solution was given to make larger life of components. The final aim was to create a modified design to achieve larger scale production of idler which enhance the efficiency and productivity. The remedies on various problems was given in this paper.

Miroslav Bajda and Robert Krol [2]

The aim of this paper was to reduce the energy consumption of belt conveyor by reducing the resistance of conveyor. The various resistances are belt rolling conveyor, sliding resistance of conveyor, bending resistance, idlers turning resistance, flexure resistance of bulk materials. The biggest savings of energy is expected in belts and idlers selection, and in some cases in unconventional solutions of the route. The test rig was used to test various resistances of the idlers and belt. By decreasing this resistance 34 % energy conservation was achieved. The belt conveyor used in mining was took in study.

Mr. Amol Kharage et. al[3]

The main objective of this paper was to analysis the gravity Roller Conveyor, the detail study of existing gravity roller and optimizing its parts by using composite material, so weight reduction of system is achieved. A finite element model was generated of existing system by using Pro-E software. In this paper only roller is optimized by using composite material.

Shirong Zhang, Xiaohua Xia [4]

The aim of tis paper focuses on the saving energy of the belt conveyor system through improvement of the operation efficiency, thus optimization is employed here. We begin with the energy model of belt conveyors which is the base of optimization. The existing energy models are reviewed and then an analytic model, lumping all the parameters into four coefficients, was proposed. The four coefficients of the new model can be derived from the design parameters or be estimated through field experiments. The latter guarantees an improved accuracy of the model, consequently, the practicability of the energy optimization of belt conveyors. Off-line parameter estimation, based on least square (LSQ), and on-line parameter estimation, based on recursive least square (RLSQ), proposed to the identification of this energy model respectively. Off-line parameter estimation is applicable for the belt conveyors without permanent instruments for electrical power of motor, for belt speed and for feed rate. On the other hand, if a belt conveyor is equipped with permanent instruments, on-line parameter estimate is adopted to update the coefficients of the energy model automatically. Simulation results are presented to show the applicability of the proposed off-line and on-line parameter estimation of the energy model.

Tabello Mathaba and Xiaohua Xia [5]

The aim of this paper was to propose a generic energy model based on belt resistance for long belt conveyor. Here they have used two parameter power equation and also partial differential equation through the belt for calculating the variability of the material mass per unit length on the belt in order to give a more accurate representation of the transported bulk material throughout the belt. Here they have achieved with the error of less than 4 % the power consumption calculation of newly proposed simpler model are consistent with those of known non-linear model.

Yogesh Padwal and Satish Rajmane [6]

The aim of this paper was to convert the material handling from fork lift to belt conveyor of 30 m distance. The optimization in some parts like roller and frame was done in this paper. To develop the FEA model for engineering problem, solving requirements like static, dynamic, and nonlinear behavior; MSC/PATRAN software is used. The analysis was carried out by using MSC/NASTRAN software.

Imran S.Khan *, Prof. Ravindra Gandhe [7]

In this paper the study and analysis of roller is carried out. In industries, it is essential to move the workpiece from one workstation to the other for decreasing the workers involvement. In this paper design of conveyor which can be used in industries is done. The main objective of this study is to explore the analysis of a roller. This has entailed performing a detailed static analysis. The study deals with static analysis. A proper Finite Element Model is developed using Cad software Pro/E Wildfire 4.0.

Rohini Sangolkar et. al., [8]

In this paper the study of structural analysis was done. The modelling is done by using Creo Software and the FEA is performed to obtain variation of stress at critical location of system using the ANSYS software and applying the boundary conditions to evaluate the total deformation, equivalent stress and shear stress. ASTM A-36 hot rolled steel bar and nylon 66 materials was studied for rollers in system and belt respectively.

Findings from Literature review:

From all above papers, it is found that very less work is carried out on the belt conveyors of Foundry. It is also found that, they have used the conveyor system and worked on energy conservation of conveyor and weight reduction of single component in system. In my project work I mainly concentrate on the weight reduction technique on all critical components of conveyor system using Modelling and analysis software.

Scope:

Presently in Industry there is a high weight belt conveyor that causes various problems for workers such as buckling of belt, belt wear due to improper distance between two rollers, back and muscle strain during maintenance due to heavy weight of system and technical issues such as maintenance difficulty of critical components.

The detail study of current belt conveyor system with its design and specifications and finding suitable method for optimization of current design, and later wards results of redesign compile as modelling will be done using SOLIDWORKS software and analysis of components will done using ANSYS software. Results of Linear static, Model and Transient analysis of existing design and optimized design are compared to prove design is safe. Optimization leads to give an appropriate optimum design for carrying the same load while saving the material of system, weight reduction and power conservation of the system.

Problem defination:

The current design for belt conveyor is heavy weight that includes the critical parts like roller, belt, roller shaft, supporting brackets, C channel base frame which directly affects on excess use of material with increase in costs, so that power consumption and also the maintenance is more due to heavy weight system. To overcome these problem redesign of existing system and analysis with optimization will be done.

Objectives of Project

1. To study the current system in detail with its specification and all required considerations.
2. To design, optimize the existing material for the existing belt conveyor system to minimize the overall weight of the roller belt conveyor system, to save substantial quantity of material, to save material so to reduce energy consumption.
3. The modelling of new design with help of modelling software.

4. To analysis of the redesigned new components to study the stress on the system.

Proposed Work:

1. Data collection of Roller belt conveyor in Foundry.

The specification and related data collection on existing roller belt conveyor in Foundry is collected. The important data like material, quantity of components, measurements, etc. of components like roller, bracket, frame, etc. was collected. The system consist of following components

Table no. 1: List of components in Foundry

Sr. no.	Name of Component	Material	Quantity
1	Roller	MS	18
2	Roller Shaft	MS	18
3	Support bracket	MS	18
4	Bearings	STD	36
5	Base Frame	MS	1

Table no. 2: Specifications of Belt Conveyor in Foundry

Sr. No.	Name Of Element	Specifications
1	Roller	Outer diameter, D1 = 76 mm Inner diameter, D2 = 68 mm Length of roller, L = 650 mm
2	Roller Shaft	Diameter of shaft, d = 22 mm length-730
3	Support bracket	Length 142 mm. Width 50mm Thickness 10 mm
4	Base Frame	C channel 100X50 Thickness of C Channel = 5 mm

2. Calculations on existing conveyor

Calculation on existing system consist of its critical parts on which load is more, will be designed. This critical parts are roller, support bracket, base frame.

3. 2D and 3D modelling and analysis

Modelling of the existing belt conveyor system will be by using SOLIDWORKS software and after proper modelling the analysis of system will be done using ANSYS software.

4. Design of system for optimization

After study of existing system, design of that system for optimization will be started. The critical load bearing components like roller, bracket and C Channel Frame will be designed by iterative method. Optimization of system will be according to one of the following cases:

5. Modelling and analysis of optimized design

3. DESIGN OF EXISTING SYSTEM

1. ROLLERS

Material - MS
Consider the Standard Mechanical properties of MS.
Considering uniformly distributed load & FOS as 3
We have to calculate actual FOS for optimised roller.
Allowable Stress (σall) = 196.67 Mpa.
Maximum Stress Calculation for given condition
W= 200 kg
D1= Outer diameter of roller = 76 mm
D2= Inner diameter of roller = 68 mm
L= Length of roller = 650 mm.
y = Distance from neutral axis = 76/2
= 38 mm
Considering Uniformly Distributed load
The weight of the sand on the belt conveyour is nearly having weight of 200 kg per m3. Hence we will take weight on single roller as 200 kg.
Maximum moment (Mmax) = $W \times L^2 / 8$
= 113.4036 N-m.
Moment of Inertia (I) = 7.6741×10-7m4.
Maximum Bending Stress
(σb) = Mmax x Y / I
σb = 5.7 Mpa.
Checking Factor of Safety for design.
FOS= (σall) / (σb)
FOS= 34.1263
As calculated factor of safety (FOS) is greater than assume factor of safety,
So selected material can be considered as a safe.
Maximum deformation
(Ymax)= $5 \times W \times L^3 / 384 \times E \times I$
(Ymax) = 0.0435 mm.
Comparison with length 650 mm deformation obtained 0.0435 mm is very negligible. Hence selected material can be considered as safe for the same material.
Weight of Rollers = Cross section area x width x mass density x numbers of rollers
= 106 Kg.
The weight of each roller is 6 kg. Thus this weight should be reduced.

Thus the Analysis was done and results are as follow,

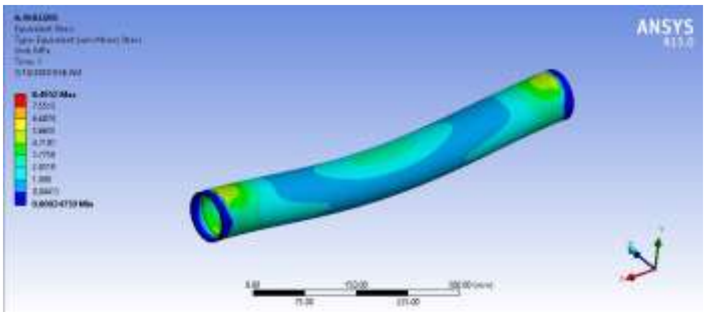

Fig 1: Stress of Existing Guide Roller

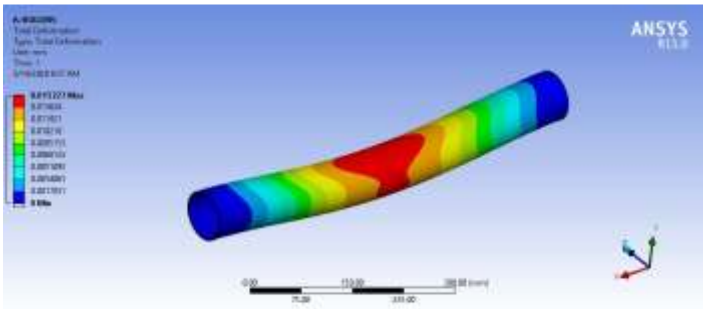

Fig 2: Total Deformation of Existing Guide Roller

2. SUPPORTING BRACKET

Material - MS
For given material we have to select standard properties of that material. Considering uniformly distributed load & FOS as 2.We have to calculate actual FOS for existing roller.

Allowable Stress (σall) = Syt / Fs

= 295 Mpa.

Maximum Stress Calculation for given condition, we have selected load of 200 Kg per m3. Each broller is having 2 supporting brackets and hence this 200 kg will be divide on two brackets and hence the load on each supporting bracket will be 100 Kg.

The Specifications of supporting bracket is as follows,

W= 100 kg
h = Depth of Section.
t = Thickness of Section= 10mm
L = 142 mm. h= 60 mm
y = Distance from neutral axis = 5 mm.
Ixx= 1.0198~~2.73~~×10-5~~6~~ mm^4
Considering simply supported beam with load act at centre
Maximum moment (Mmax) = W x L /4
= 34.825~~56.867~~ MPa

Maximum Bending Stress (σb) = Mmax ×Y/ I
σb = 17.074~~12.57~~ Mpa.
Checking Factor of Safety for design.
FOS= (σall) / (σb)
FOS= 18
As calculated factor of safety (FOS) is greater than assume factor of safety, hence selected material can be considered as a safe.
Maximum deformation (Ymax) = W x L^3/48 x E x I
(Ymax) = 0.00210~~520~~ mm.
Weight of Support Bracket = ~~Cross section area x length~~Volume x mass density x numbers of bracket
= 29.39 Kg
Thus the analysis of above system was done and results are as follow

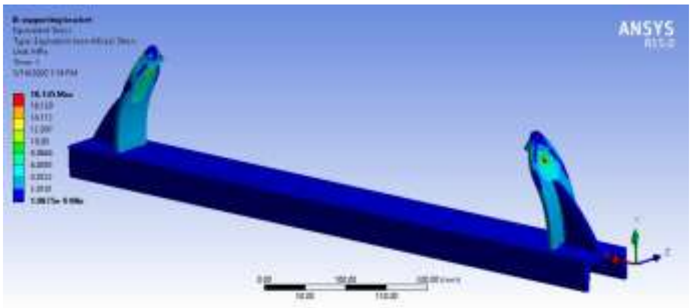

Fig 3: Stress of Existing Supporting bracket

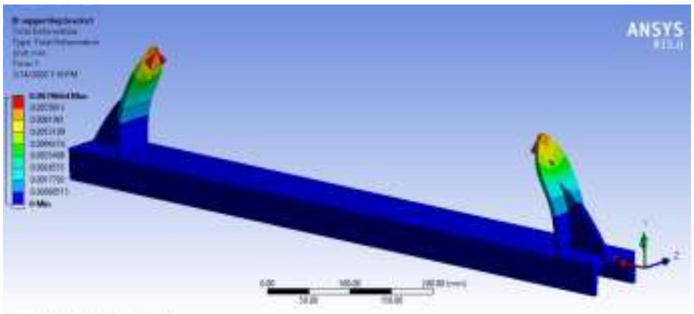

Fig 4: Total Deformation of Existing Supporting bracket

The maximum stress is 18.14 Mpa and maximum deformation is 0.0079 mm.

4. DESIGN OF OPTIMISATION

1. Roller
The existing material of the Rollers is Mild Steel, hence the mechanical properties of mild steel are as follow,
For given material we have to select standard mechanical properties of that material.
Considering uniformly distributed load & FOS as 2
We have to calculate actual FOS for optimised roller.
Allowable Stress (σall) = Syt / Fs
= 590/2
= 295 Mpa.

Iteration (1)

D1= Outer diameter of roller = 63.5 mm
D2= Inner diameter of roller = 60 mm
L= Length of roller = 650 mm.
y = Distance from neutral axis = 63.5/2
= 31.75 mm
Considering Uniformly Distributed load
Maximum moment (Mmax) = W×L2 /8
= (200×9.81× 0.652) / 8
= 103.6181 N-m.
Moment of Inertia (I) = π (D14 - D24) / 64
= π (0.064 – 0.0554) / 64
= 1.86×10-7m4.
Maximum Bending Stress
(σb) = Mmax x Y / I
= 103.6181 x 0.03 / (1.86×10-7)
σb = 16.71 Mpa.

Checking Factor of Safety for design.

FOS= (σall) / (σb)
= 196.67 / 16.71
FOS= 12

As calculated factor of safety (FOS) is greater than assume factor of safety,
So selected material can be considered as a safe.
Maximum deformation

(Ymax)= 5 x W x L3/384 x E x I
(Ymax) = 0.2755 mm.

Weight of Rollers = Cross section area x width x mass density x numbers of rollers

= π /4 (D12 - D22) x w x ρ x 18

= 41.53 Kg.

Same like above the following iterations was carried out.

Table 3: Iterations carried out for various dimensions

Sr No	OD	ID	Bending stress (pa)	Deformation (mm)	Actual weight (kg)	Weight reduction (kg)
1	0.06	0.055	31.55	0.2755	41.5	64
2	0.06	0.056	38.45	0.2260	33.5	72
3	0.06	0.057	49.99	0.1739	25.4	81
4	0.06	0.058	73.13	0.1189	17.0	89
5	0.06	0.059	142.2	0.0609	8.6	97
6	0.0761	0.0741	35.78	0.2451	21.7	84
7	0.0761	0.072	18.83	0.4820	43.9	62
8	0.0761	0.0715	16.23	0.5354	49.0	57
9	0.0761	0.0705	13.62	0.6389	59.3	47
10	0.0761	0.0695	11.57	0.7381	69.4	37
11	0.089	0.085	11.4	0.7624	50.3	56
12	0.089	0.0845	10.2	0.8504	56.4	50
13	0.089	0.0835	8.5	1.0219	68.5	37
14	0.089	0.0825	7.3	1.1873	80.5	25

By studying above iterations, the roller with OD=76mm and ID= 74 mm was selected as a best solution which is having good weight reduction. If we compare the weight reduction with existing one then it is 79%.

The Analysis of the best solution was done and it is as follow

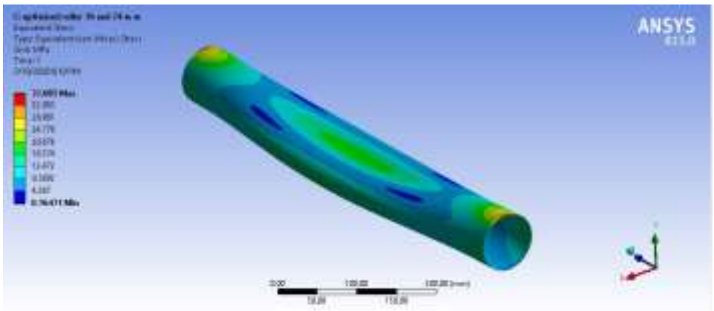

Fig 5: Stress of Optimized Guide Roller

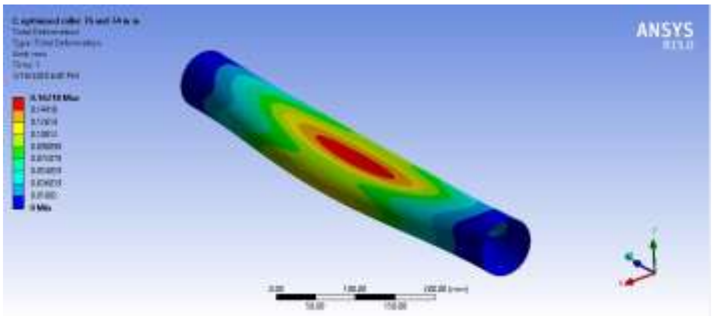

Fig 6: Total Deformation of optimized Guide Roller

2. Design of optimized supporting bracket

We are desiging the supporting bracket by changing dimensions and keeping material same.
Iteration (1)
Material - MS
For given material we have to select standard Mechanical properties of material, and considering uniformly distributed load & FOS as 2
We have to calculate actual FOS for existing roller.
Allowable Stress (σall) = Syt / Fs
= 295 Mpa.
Maximum Stress Calculation for given condition, we are selecting the maximum load conditions on roller i.e 200 Kg of material per meter and thus this load is acting half on each roller i.e 100 Kg.

Iteration 1:

W= 100 kg
h = Depth of Section.
t = Thickness of Section=8mm
L = 140 mm. h= 50 mm
y = Distance from neutral axis = 4 mm.
Ixx= 4.57×10-5 mm4
Considering simply supported beam with load act at centre
Maximum moment (Mmax) = W x L /4
= (25×9.81)× 0.112/4
= 34.33 MPa
Maximum Bending Stress (σb) = Mmax ×Y/ I
σb = 3.756 Mpa.

Checking Factor of Safety for design.

FOS= (σall) / (σb)

= 295 / 3.756

FOS= 78.54

As calculated factor of safety (FOS) is greater than assume factor of safety, hence selected material can be considered as a safe.

Maximum deformation (Ymax) = W x L3/48 x E x I

= (100 x 9.81x 0.0) / (48 x 2.10×105 x 2.73 × 10-6)

(Ymax) = 0.00584 mm.

Weight of Support Bracket = Cross section area x length x mass density x numbers of bracket

=83.058×7860×36

= 23.50 Kg

Same like above, some Iterations was carried out, they ar as follows

Table 4: Iterations carried out for various dimensions of supporting bracket

h	L	t	Bending Stress	Weight	Weight Reduction
60	142	8	26.8	19.28	10.1
		6	20.1	14.46	14.9
		5	16.7	12.05	17.3
		4	13.4	9.64	19.7
		3	10.07	7.23	22.2
50	140	8	47.0	15.84	13.5
		6	35.3	11.88	17.5
		5	29.4	9.9	19.5
		4	23.5	7.92	21.5
		3	17.6	5.94	23.4
40	140	8	91.9	12.67	16.7
		6	68.9	9.50	19.9
		5	57.4	7.92	21.5
		4	45.9	6.33	23.1
		3	12.0	13.58	15.8

Thus after studying the above iterations the Bracket having following specifications is selected as best.

h = 40 mm, L= 140 mm, t=4 mm

The Analysis of supporting bracket is as below

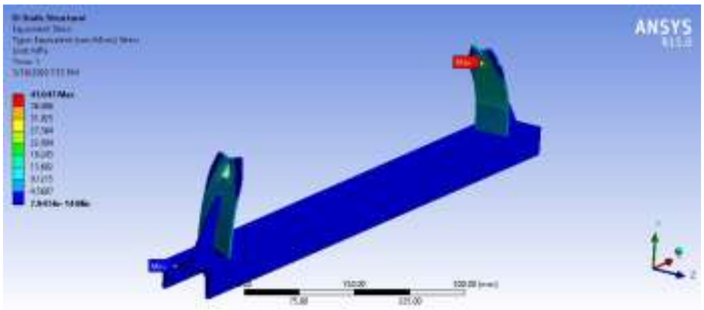

Fig 7: Stress of Existing Optimized Supporting bracket

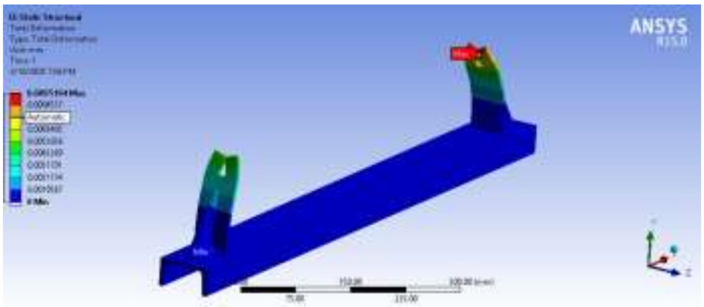

Fig 8: Total Deformation of Optimized Supporting bracket

5. RESULT AND DISCUSSION

The weight of Roller reduced by 79 %, this is a good weight optimization. The material was kept same as of existing System.

The saving of material is shown in table below:

Design of system	Materialrequired compare to existing system in %	Material save compare to existing system in %
Existing	100	-
Optimized	20.76%	79.24 %

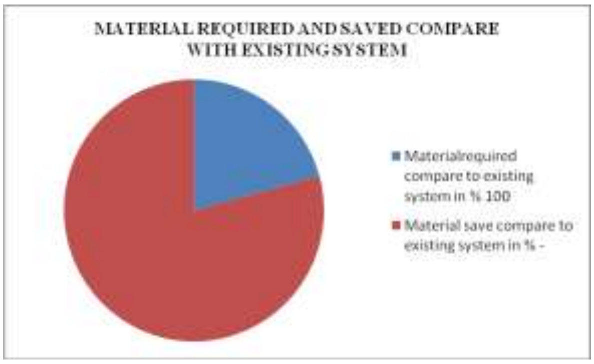

Fig 9: Comparision of Material of optimized system with existing system

Table 5: Comparision of Results

Dimensions	Design calculations Results		Ansys Results	
GUIDE ROLLERS				
OD= 76 mm ID= 74 mm	Deformation	Stress	Deformation	Stress
	0.2457 mm	35.78 Mpa	0.16218 mm	37.085 Mpa
SUPPORTING BRACKETS				
Length= 140 mm Width= 40 mm, t= 4 mm	Deformation	Stress	Deformation	Stress
	0.002769 mm	45.9 MPa	0.0095104 mm	41.047 MPa

The above table shows the results of designed and analysis, and they are between 10% and hence it is acceptable for our project.

6. CONCLUSIONS:

- The material saving of optimized roller system with existing system is 79%
- Material saved in Supporting bracket is nearly 23 kg compare with Existing SUpppoerting bracket.
- The overall weight reduction of system was 75 % in average without any failure.
- The existing system was heavy and labours was also having various problems like maintenance. By using this system it will be useful for them.

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