Force Variation on Beater shaft of Double Roller Gin

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Presented by

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INTRODUCTION

- Ginning: Separation of fibre from cottonseed
- Roller gin preserves fibre attributes
- DR gin performance depends on : Machine settings and moisture content
- Improper settings and moisture contents affects: fibre quality, productivity, loads on machine components

Objective

- To study the effect of knife clearances and moisture content on gin productivity, fibre quality and energy consumptions of DR gin
- Analysis of forces and stresses on beater shaft under different working conditions.

METHODOLOGY

- Moisture content: 4-20%.
- Knife Clearances : 1.0 mm, 1.2 mm and 1.4 mm
- Determination of lint productivity, fibre quality, energy consumptions of DR gin (54")
- Forces Analysis on beater shaft using finite element method

Instruments used:

- Delmhorst C-2000 Cotton Moisture Meter and Oven Dryer for moisture measurement
- Clamp on power meter (Yokogawa Electric Corporation; Model CW240, Japan, Accuracy ±0.5% of reading) for measuring electrical parameters

Moisture measurement

Power analyzer

DR gin attached with Power Analyzer

Results and Discussion

Effect of moisture content and knife clearances on Productivity

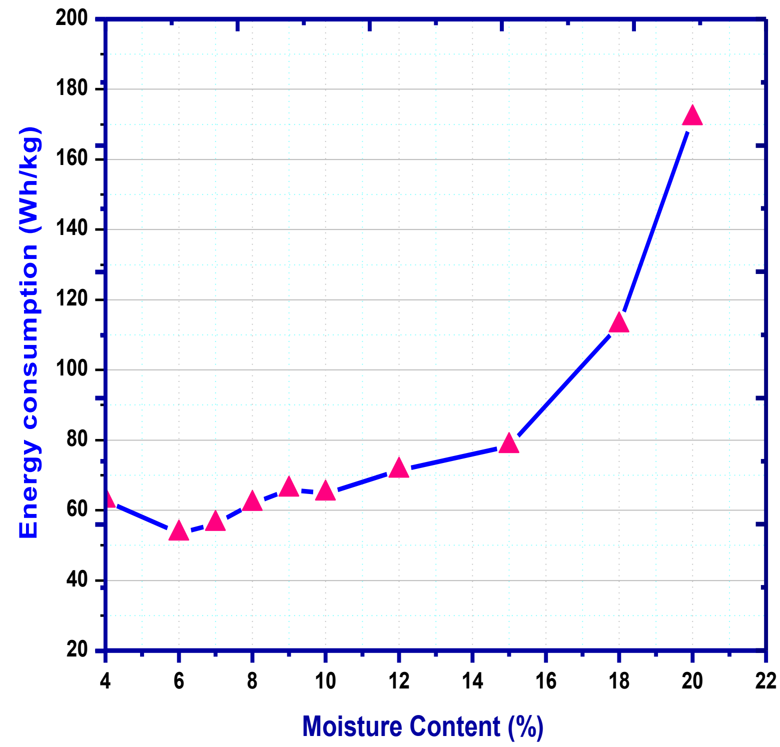
Moisture Content (%)	Lint Productivity (kg/h) with different clearances			% Increased/ Decreased w.r.t. 1.2 mm Clearance	
	1.0 mm	1.2 mm	1.4 mm	1.0 mm	1.4 mm
4	55.00	68.00	57.00	-19.11	-16.17
6	67.80	81.00	60.60	-16.29	-25.18
7	69.00	81.60	73.00	-15.44	-10.53
8	74.00	84.00	71.40	-11.90	-15.00
9	71.40	78.00	68.80	-08.46	-11.79
10	63.30	76.70	64.70	-17.47	-15.64
12	60.30	70.80	60.50	-14.83	-14.54
15	59.20	60.00	51.30	-01.33	-14.50
18	43.40	39.00	31.70	11.28	-18.71
20	30.80	22.00	21.00	40.00	-4.54

- Productivity increases at all clearances with increasing moisture content upto 8% moisture content.
- Highest productivity obtained at clearance 1.2 mm and 8% moisture content compared to 1.0 and 1.4 mm clearance where productivity reduced by 11.90% and 15% respectively.
- Productivity reduces with increase or decrease in the clearances from 1.2 mm

Effect of moisture content and clearances on energy consumptions

Moisture Content (%)	Energy consumption (kWh) with different clearances		
	1.0 mm	1.2 mm	1.4 mm
4	4.360	4.266	4
6	4.450	4.326	4.064
7	4.530	4.578	4.505
8	**4.630**	**5.196**	**4.655**
9	4.650	5.142	4.592
10	4.980	4.970	4.844
12	5.130	5.050	5.040
15	4.730	4.700	4.629
18	4.458	4.395	3.982
20	4.482	3.780	3.804

Energy consumptions per unit lint production



- **Energy consumption increases with moisture content up to 8% for all clearances.**
- **The Energy consumption per unit lint production is lowest at 8% moisture content.**

Effect of moisture content and machine clearances on fibre parameters

M.C. (%)	2.5% S.L. (mm)	UR (%)	MIC (µg/inch)	Ten (g/Tex)	EL (%)	SFI (%)	Colour Grades		
							Rd (%)	b+ (%)	CG
4	29.7	47.0	4.0	22.8	4.6	7.6	87.2	7.1	11-1
6	30.0	48.0	4.1	23.8	4.6	6.4	86.1	7.2	11-1
7	30.4	48.5	4.3	23.6	4.7	6.3	85.6	7.3	11-1
8	**30.7**	**47.6**	**4.3**	**23.4**	**4.8**	**6.5**	**85.9**	**7.4**	**11-1**
9	30.5	49.2	4.2	23.7	4.7	6.4	86.0	7.3	11-1
10	30.3	49.6	4.2	25.7	4.9	5.2	84.5	7.3	11-1
12	31.7	49.0	4.2	25.8	4.8	5.3	78.1	8.4	31-1
15	31.1	49.2	4.2	25.9	5.4	4.7	69.2	8.1	42-2
18	31.2	49.0	4.3	23.5	5.3	4.6	68.8	8.2	42-2
20	**31.43**	**47.6**	**4.2**	**23.6**	**5.6**	**5.2**	**67.8**	**8.2**	**42-2**

- **2.5 % span length and strength increases with increase in moisture content**
- **For moisture range 7-10 %, average 2.5 % span length of cotton was found as 30.5 mm for clearance 1.2 mm**
- **Colour grades reduces at higher moisture content from 11-1 to lower values i.e. 31-1, 31-2, 42-2 etc.**
- **There was significant deterioration in fibre length (i.e > 0.5 mm) at 4 % moisture content**

Steps involved in finite element method (FEM) for force analysis

- Development of a 3D model of DR gin
- Mesh generation and assigning material properties to machine components
- Development of simulation model of DR gin
- Mathematical modelling for force calculations on beater shaft.
- Trained and solved the model
- The simulation values of forces, stresses and strain

Finite Element Method (FEM)

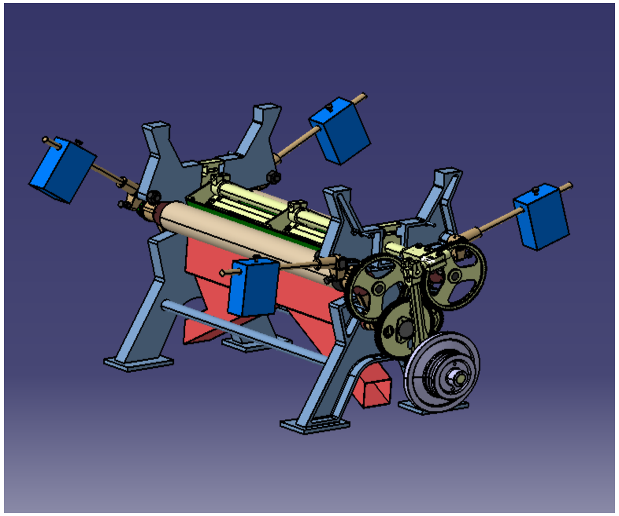
- FEM is a Numerical method to solve complex engineering problem and FEA is application of FEM.
- It is a method of dividing the part in to smaller elements and analyzing by the way of calculating the stiffnesses.

Different software, used for Finite Element Analysis (FEA)

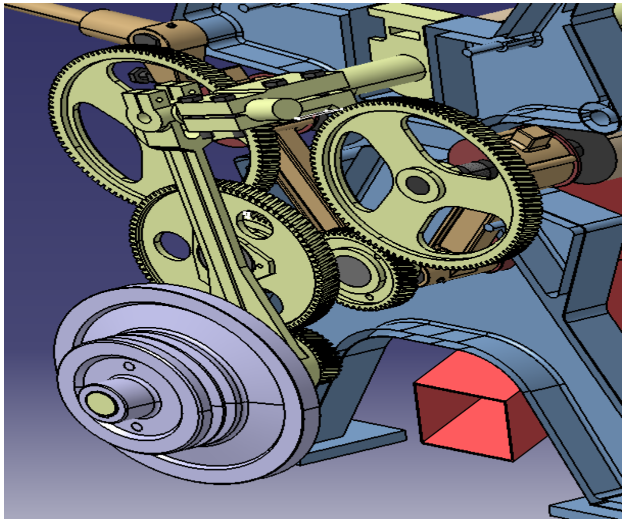
- **CATIA V5R17** software for 3D modelling
- **Alters Hyper works** for FEA: it is assembly of all software

- **Hyper mesh-** Mesh generation
- **MotionSolve-** MBD analysis (simulate mechanical system to predict forces, kinematics and dynamics of motion).
- **OptiStruct-** Analysis Part (It is a structural analysis solver used to solve problems under static and dynamic loadings).
- **Hyper view-** Visualization of the results (A complete post-processing and visualization environment for FEA).

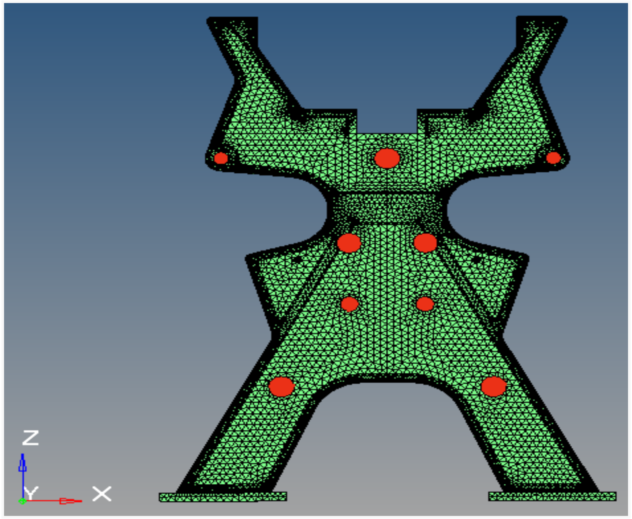
3D Modelling and Mesh Generation



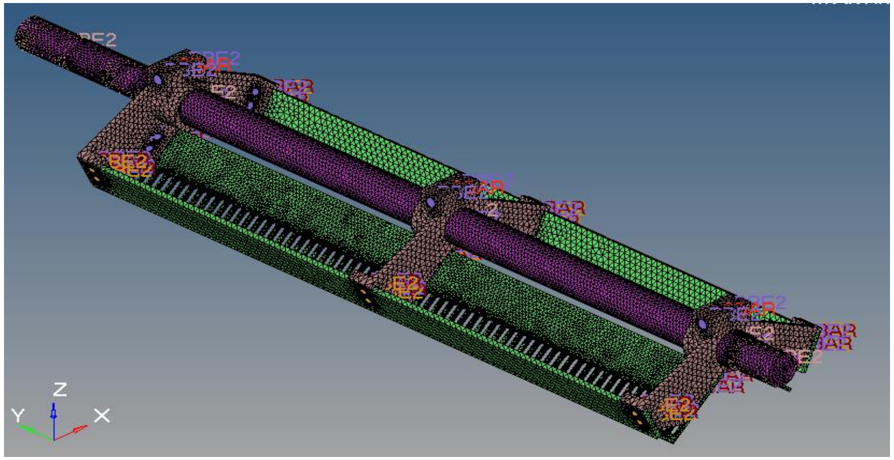
Isometric View



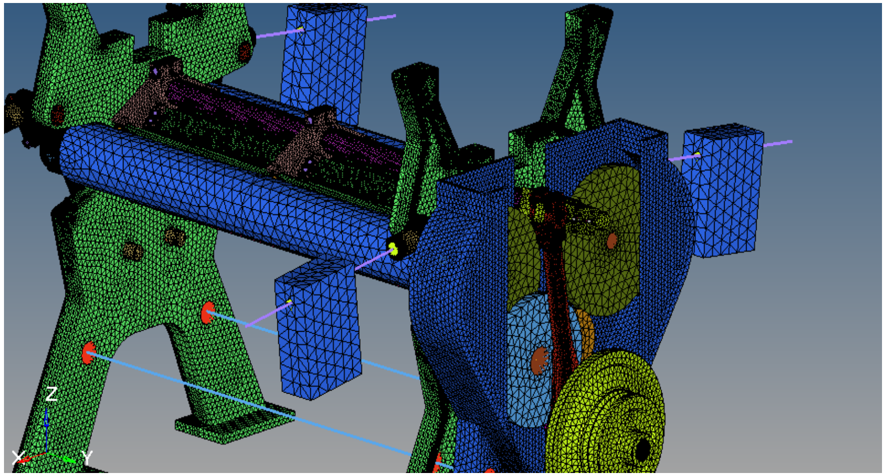
Gear Assembly



Body frame



Beater Assembly



TOTAL ASSEMBLY

Mathematical modelling for force calculation (clearance 1.2 mm)

M. C. %	Productivity one side (kg/hr)	Productivity (g/s)	Cotton ginned in 1rotation (mg)	Cotton ginned from 8mm length of roller(mg)	Cotton ginned in 8*8mm^2 area of the roller (mg)	Breaking load (Kg)	Shearing force(Kg)
6	40.50	11.25	6980.0	40.71	1.92	3.05	1.74
7	40.80	11.33	7025.0	40.97	1.93	3.04	1.73
8	42.00	11.67	7240.0	42.23	1.99	3.10	1.80
9	39.00	10.83	6714.6	39.16	1.84	2.90	1.65
10	38.35	10.65	6603.0	38.51	1.81	3.10	1.77
11	36.50	10.14	6286.8	36.67	1.73	2.80	1.60
12	35.40	9.83	6095.0	35.55	1.67	2.90	1.65
14	32.10	8.92	5530.4	32.26	1.52	2.56	1.50

Note: Time of one rotation of roller- 0.62 second, Roller length 1371.6mm, Average length of a single seed- 8mm,

Load Value at various moisture level

M.C. (%)	Fiber- seed attachment force cN.cm/mg	Load applied by seed cotton (N)
6	64.1	5200.0
8	70.0	5636.4
10	76.86	6148.8
12	83.3	6760.2

Mathematical modelling for load calculations on beater shaft(for 8% moisture content)

Avg weight of fibre (per seed)= 0.05 gram

Fibre seed attachement force= 64.1 cN.cm/mg

= 64.1 * 0.05 cN*cm*g/mg
Torque = 0.32 N.m

As cutoff (distance travelled by beater) = 10.5 mm

Force applied by cotton on beater= Torque/distance

= 0.32 * 1000/10.5
= 30.5 N

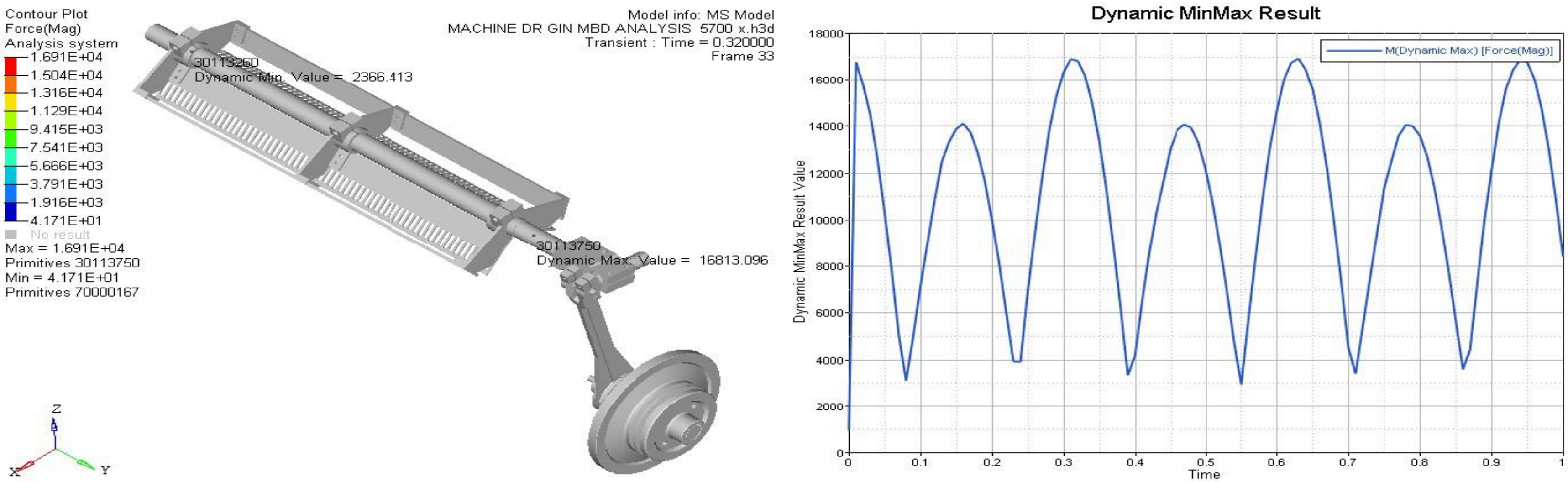
As Avg. no. of seeds in contact= 168
Therefore total load applied by seed cotton= 5200 N

Results

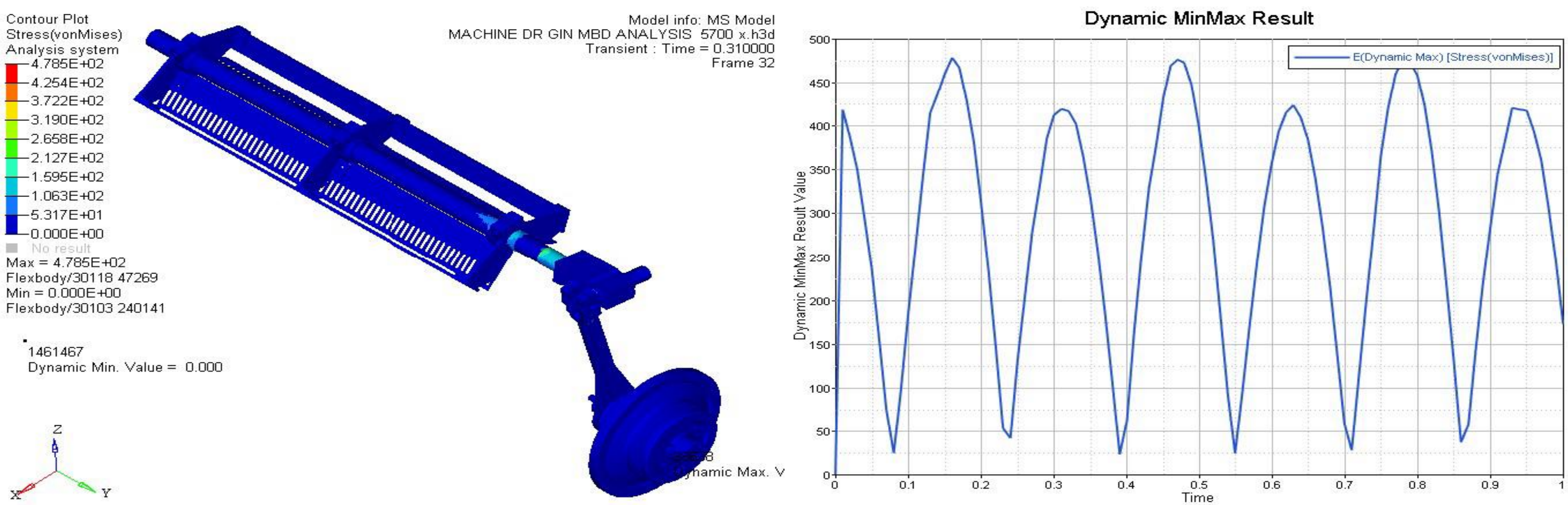
S.N0	CASE	LOAD APPLIED ON BLADE	FORCE ON BEATER SHAFT (N)	STRESS N/mm^2	STRAIN
1	Idle Running	0	133.1	7.397	3.053×10^{-05}
2	**8% M.C.**	**5700**	**16910**	$\mathbf{4.790 \times 10^{2}}$	$\mathbf{1.975 \times 10^{-03}}$
3	**12 % M.C.**	6800	20160	$\mathbf{5.762 \times 10^{2}}$	2.378×10^{-03}
4	30% of 5700	7410	22060	6.288×10^{2}	2.595×10^{-03}
5	60% of 5700	9120	27140	7.765×10^{2}	3.204×10^{-03}
7	90% OF 5700	10830	31910	9.323×10^{2}	3.848×10^{-03}

- **At optimized condition, total force and stress on beater shaft was found as 16910 N and 4.790×10^{2} N/mm^2**
- **Force on beater shaft increases with increase in moisture content of cotton**
- **Above 12% moisture content, the stress value goes beyond to tensile strength of the material i.e. 345 – 580 N/mm^2 .**

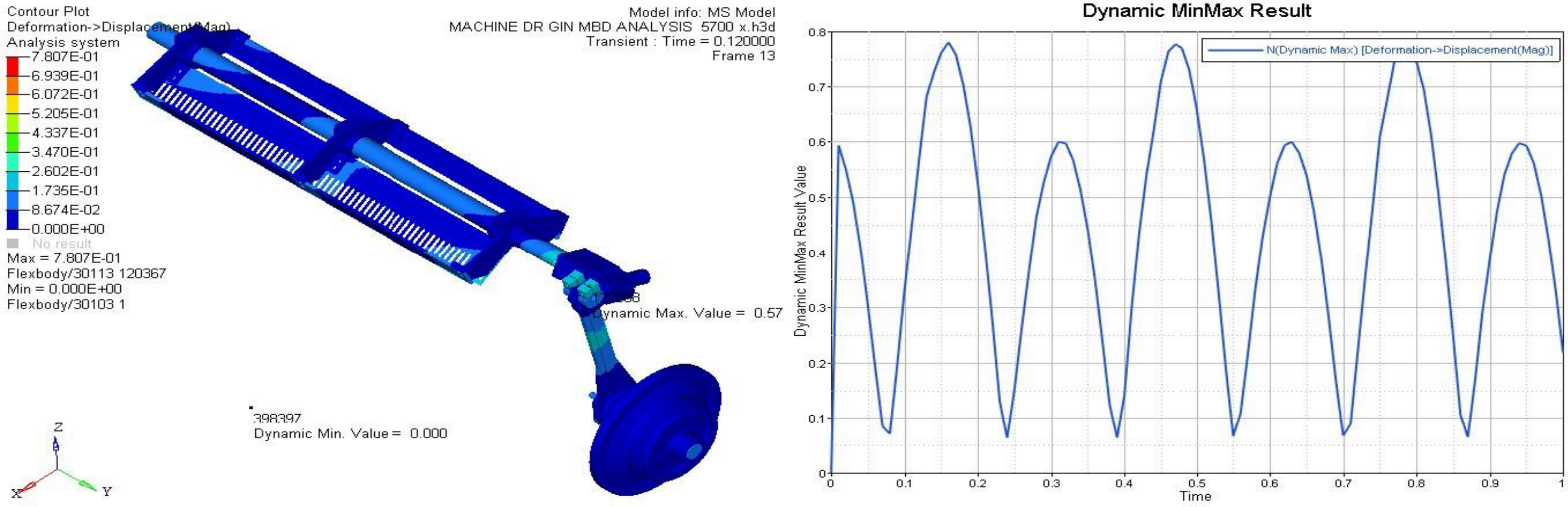
Moisture content 8%, load on single blade =5700 N



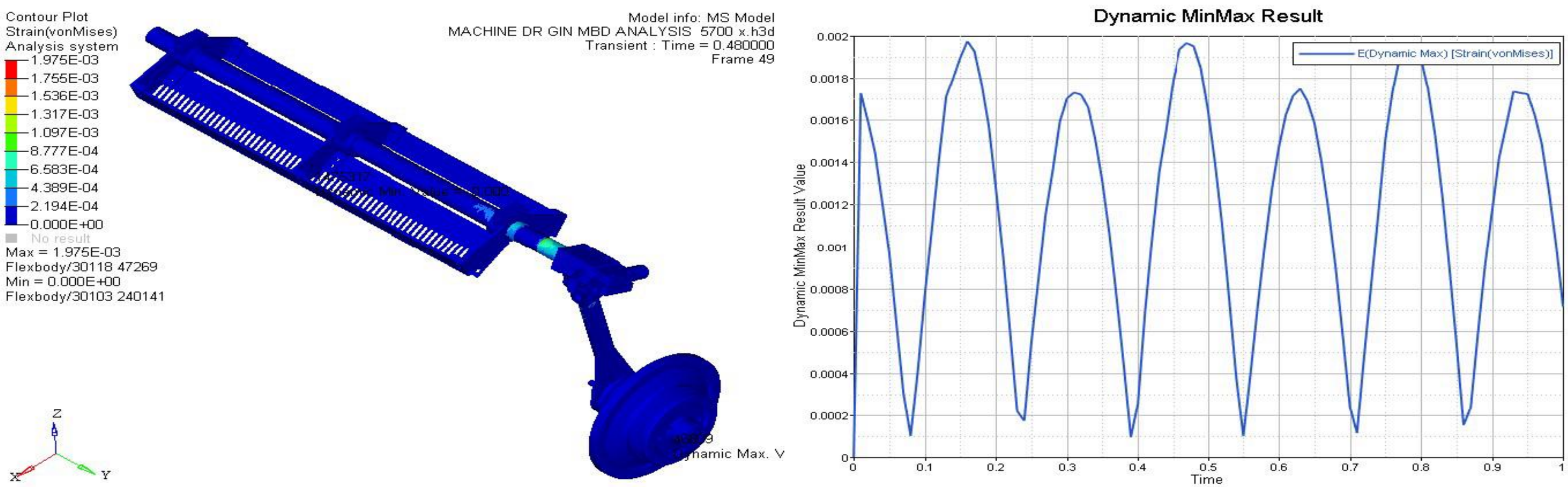
Force on beater shaft at 8% moisture content



Stress on beater shaft at 8% moisture content



Displacement on beater shaft at 8% moisture content



Strain on beater shaft at 8% moisture content

Conclusion

- **The optimum setting were found as 8 % moisture content, 1.2 mm clearance, 1/3rd of the staple length for cutoff and 85 mm fixed knife position.**

- **Lowest energy consumption at optimized condition.**

- **Maximum values of force, stress and strain at optimized condition were found as 1.691×10^{4} N, 4.79×10^{2} and 1.975×10^{-3} respectively.**

- **Improper settings and high moisture may lead to earlier failure of beater shaft compare to normal life.**

THANK YOU

Effects of Moisture content on productivity and energy consumptions

- Lower yield at low moisture content.
- Productivity decreases after reaching to a maximum level at around 8% moisture content
- Energy consumption increases with the moisture content and after reaching to maximum level starts decreasing.
- Energy consumptions is directly proportional to lint productivity