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Force Analysis of Geneva Wheel and Face Cam Used In Automat

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ABSTRACT
Glazerol Automat is a dedicated machine used in the Insulator pre assembly line. This automat is driven using single motor for different operations. Here the focus is on two main parts they are Geneva wheel and Face cam which are used for their respective operations. Geneva Wheel is used to index the drum which consists of 96 spindles. Due to this Geneva mechanism each of the spindles will hold the ceramic body when the drum is being indexed. Due to which there is a force which is generated in the Geneva wheel in maximum and minimum position. Face cam which is used while indexing the work piece carrier There are 2 tangential forces which are acting, one at the indexing side and the other at the driving side /cam side. The effective resultant force which is acting on the face cam while indexing work piece carrier is calculated. And these forces are analyzed using ansys and their respective Von Mises stresses and displacement plots are obtained for both the conditions based on boundary and loading conditions.
Keywords: Automat ,Geneva Wheel ,Face Cam , Catia V5 , Hypermesh , Ansys

I. INTRODUCTION

1.1Automat

Automat is dedicated machine for particular product or variants which will be operated using single power source. The type of automat which we are using here is electrical automat.

1.2 Glazerol Automat

The Glazerol Automat is dedicated machine used in spark plug manufacturing. This contains vertical rotary magazine for carrying the spark plug body (ceramic) called as insulator. This automat is driven using single motor for different operations Number of cams, gears and chain drives are used for power take off (PTO) for performing different operations. In this machine, we observe three processes. They are

- Inscription of Bosch emblem to the insulator
- Ring rolling for type identification
- Glaze liquid application

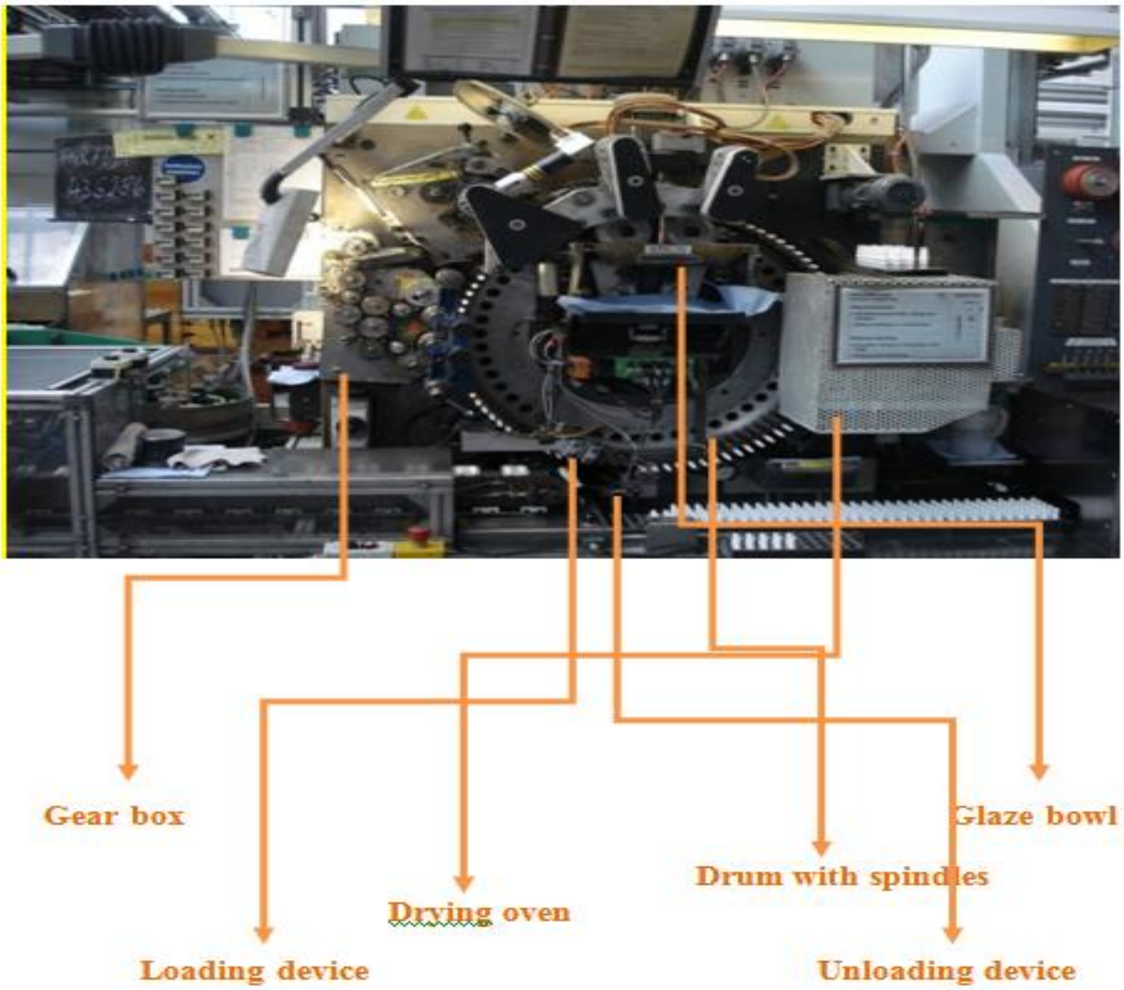


Fig 1.2(a)

The above fig represents the front portion of the machine where it consists of a drum with 96 spindles across the circumference/periphery of the drum.When this insulator part is first subjected to inscription process, BOSCH logo will be printed by a chain drive system.

After the inscription process, the next process it will undergo will be the ring rolling. A drive gear is used for ring rolling which applies 2 similar sorts of rings on insulator body.To give a proper finish to the insulator body glaze is used. This glaze liquid is applied by the help of rubber coated rollers whose movement is controlled by a face cam. A stirrer motor is provided in the glaze bowl so as to prevent the glaze to get hardened. Even after the machine is switched off, this stirrer motor will be continuously rotating to keep the glaze in normal condition without getting hardened.After the completion of glaze applying process, it goes to a drying oven where it will be heated to a temperature of 400 ˚c. The main function of the drying oven is to dry the glaze liquid which is applied on the insulator body. Once it comes out of the drying oven, it will be unloaded from the spindle to work piece carrier (WPC).

Dual cam mechanism is used for unloading of the components to the work piece carrier. Three cams are used for unloading mechanism which is controlled by a chain drive whose reduction ratio is 1:5.

There are 3 movements which we observe during the unloading i.e.,

1. Up and down movement

The position of the picking point and the dropping points are at different levels. Once the insulator body is removed from the spindle it swings down to the unloading position.

2. To and Fro movement

Due to this to and fro movement the insulator body moves from the spindle to the front end to the work piece carrier. Refer to the WPC layout, the Insulators are unloaded to 5 different slots in consecutive cycles. This progressive movement is achieved by special design on the cam profile.

3. Flipping movement

This is the unloading movement which can be seen. When the insulator body comes near work piece carrier, it flips 90 degree from horizontal to the vertical .

Clamping and unclamping are done with pneumatic grippers, Which is not in the scope of project.

As we said all these 3 movements are controlled by 3 different cams which is placed in the bottom most portion of machine.

The following processes such as the inscription ,ring rolling and glaze applying is driven by single motor which controls all the motions of cams, linkages ,gear drives, chain drives, belt drives etc.

Fig 1.2 (b)

II. Methodology and Objective

- Literature Review [1],[2],[3]
- CAD modeling of Geneva Wheel and Face Cam using Catia V 5.
- Meshing of Geneva Wheel and Face Cam using Hypermesh V 10.0.
- Vonmises stress analysis of Geneva Wheel and Face Cam under required loading and boundary condition.
- Displacement plot is obtained for Geneva Wheel and Face Cam under required loading and boundary conditions.
- Variation of stress and displacement for Geneva wheel and Face Cam is shown.
- Conclusion

III. 3 Experimental Details

CASE 1

3.1 FORCE ANALYSIS OF GENEVA WHEEL WHILE INDEXING THE DRUM

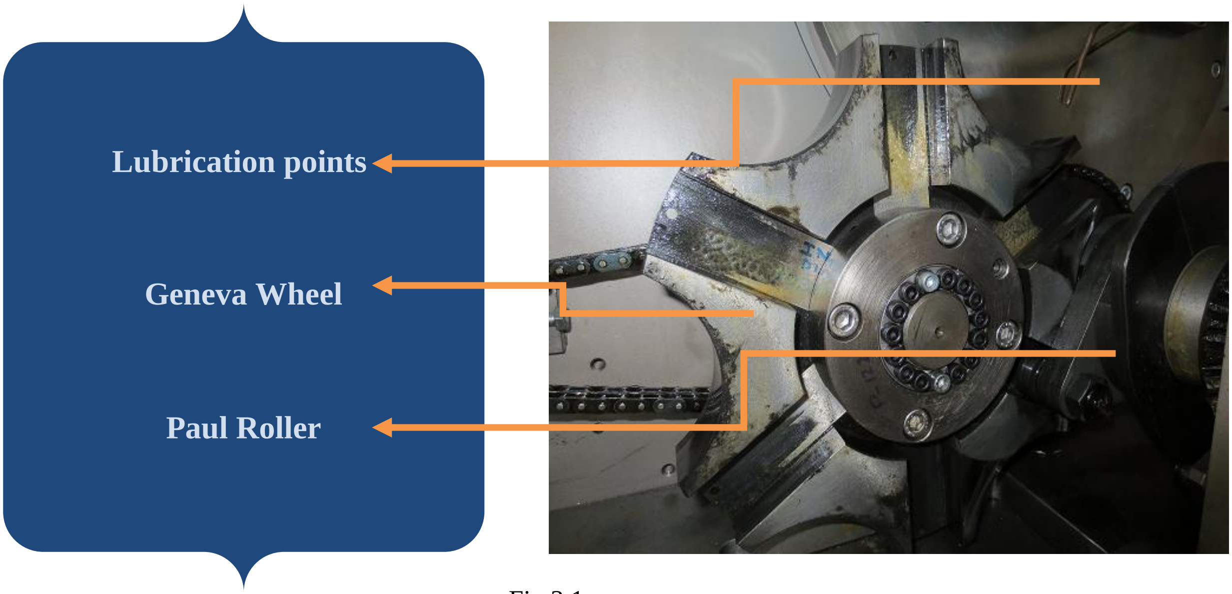


Fig 3.1

3.1(a) Input data					
1	**Drum**				
1.1	Radius of drum	400	mm	0.4	m
1.2	Weight of drum	22	Kg	215.82	N
2	**Spindle**				
2.1	Number of Spindles	96	nos		
2.2	Volume (V)	55707	mm^3		
2.3	Density (ρ)	7.8	g/cc		
2.4	Mass M=ρ×V	0.434514	Kg		
		4.26	N		
3	**Gear**				
3.1	Pitch circle diameter (PCD)	600	mm	0.6	m
3.2	Weight of Gear	33	Kg	323.73	N

4	**Geneva Wheel**		
4.1	Radius	160	mm
4.2	Angular displacement	60	degree
		1.04	Radians
5	**Clutch**		
5.1	Torque (T')	11	Nm
D	**Moment of Inertia I=1/2× M×R^2**		
	I = I1 + I2+ I3 + I4		
(i)	M I of Drum I1=(1/2×215.82×0.4^2)	17.26	Nm^2
(ii)	M I of Spindle I2=(1/2×4.26×0.4^2)×96	32.71	Nm^2
(iii)	M I of Gear I3=(1/2×323.73×0.3^2)	14.56	Nm^2
(iv)	M I of Geneva Wheel I4=(1/2×215.82×0.4^2)	17.26	Nm^2
	Total MI	81.79	**Nm^2**

E	**Angular Acceleration α=(2×s)/t^2**		
(i)	Initial velocity (u)	0	m/s
(ii)	Cycle time (t')	1.1	sec
(iii)	No of stations (n) in geneva wheel	6	nos
(iv)	Total time t=2t'/n=2×1.1/6	0.3666	sec
(v)	Angular displacement (s) of drum	0.1308	Radians
(vi)	Gear ratio	1:08	
	Angular Acceleration α=(2×0.1308)/0.3666^2	1.946	**Rad/sec^2**

F	**Total Torque Required T=(I × α) + T'**		
(i)	Torque of Entire System T=I×α =100.48×1.946	159.16334	Nm
(ii)	Torque of Starting Clutch	11	Nm
	Total Torque	170.16334	**Nm**

G	**Tangential Force Required to run the Geneva Wheel considering min and**				
max positions					
F = T / R					
(i)	Min position (R)	81	mm	0.081	m
(ii)	Total travel	60	degree		
(iii)	Max position (R') R'=81+60	141	mm	0.141	m

Tangential Force at min position F^t1=T/R		
=170.2/0.081	2101.27	**N**

Tangential Force at max position F't2=T/R'			
=170.2/0.141		1207.09	**N**

Table 3.1(a)

CASE 2
3.2 FORCE ANALYSIS OF FACE CAM WHILE INDEXING WORK PIECE CARRIER (WPC)

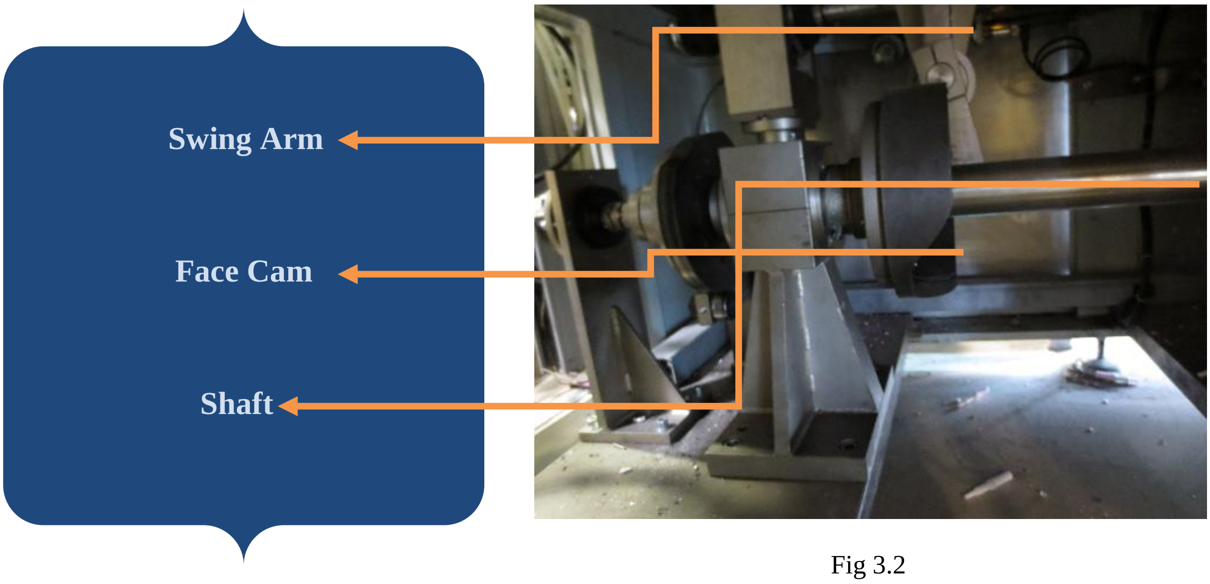


Fig 3.2

3.2(a) INPUT DATA					
1	**WPC**				
1.1	No of WPC (n)	5	nos		
1.2	Wt of each WPC (w)	3.5	Kg	cad value	
1.3	Sliding Friction (μ_s) Al to steel	0.6	from data hand book table 14.1		
2	**Components**				
2.1	No of Components (n')	50 nos/WPC ×5		250	nos
2.2	Weight of the component (w')	0.02	Kg		
3	**Indexing Shaft**				
3.1	Length (l)	1190	mm	1.19	m
3.2	Diameter (d)	43	mm	0.043	m
3.3	Rolling Friction (μ_r) steel to steel	0.08	from data hand book table 14.2		
4	**Spring**				
4.1	Type of Spring	Helical/ Extension			
4.2	No of Springs (n")	4	nos		
4.3	Mean Diameter (D)	20	mm		

4.4	Wire Diameter (d_1)	2.5	mm		
4.5	Length (l')	280	mm		
4.6	Indexing distance (d_2)	50	mm		
4.7	Spring Rate(f)	5	N/mm from Gutekunst spring catalogue (Type no Z-156FI)		
D	**Total Mass Transferred M = m1 + m2**				
(i)	Mass of WPC and Component → m1 = n×w + n×n'×w'	22.5	Kg		
(ii)	Mass of Shaft → m2 = l ×d	0.05117	Kg		
	Total Mas → m1 + m2	23	kg		
E	**Linear Acceleration a = 2 × s / t^ 2**				
(i)	Initial velocity (u)	0	m/sec		
(ii)	No of stations (n')	5	nos		
(iii)	Total indexing time t = (2×1.1'×n') / 8	1.3	sec		
(iv)	Displacement (s)	50	mm	0.05	m
	Linear acceleration $a = (2 \times 0.05) / (1.3)^2$	0.0591	m / sec^2		
F	**Force required F = m × a**				
(i)	Force required for WPC and Component considering sliding friction	F1' = m1 × $(a+9.81)\times\mu_s$	136.09	N	
(ii)	Force required for Shaft considering rolling friction	F1" = m2 × $(a+9.81)\times\mu_r$	0.04035	N	
	Total Force (F1)	F1 ' + F2 '	136.2	N	
G	**Calculation of Spring force $F2 = f \times d_2 \times n''$**				
(i)	Before Indexing				
	F2 '= 5×50×4	1000	N		
(ii)	After Indexing				
	F2 "= (5×50×4)+F2'	2000	N		
	Total Spring force (F2)	2000	N		

H	**Total force required for WPC in order to index Face Cam (F)**		
	Total force (F1) +Total Spring force (F2) = (F)	2136	N
I	**Torque required (T)**		
	T= Total force (F) × radius (r_) = 2136.09×0.116	248	Nm

J Tangential Force at Indexing side ($F_{t\,1}$)				
$F_{t\,1} = F / \cos \Theta = 2136.09 / \cos 37^\circ$	2674.6	N		
K Tangential Force at driving side (cam side) ($F_{t\,2}$)				
$F_{t\,2} = T / R = 248 / 0.145$	1708.8	N		
Angle at which the $F_{t\,2}$ is acting $\Theta = 37^\circ$				

L Effective Force acting on the Cam (F ')		
$F' = F_{t\,2} / \cos \Theta = 1708.8 / \cos 37^\circ$	2139.64	N

Table 3.2(a)

IV. Results and Discussions

4.1 Material Properties considered for the analysis[3]

Material - Case hardened Steel
Density - 7.85×10^{-9} Tonnes / mm^3
Youngs modulus - 2.1×10^{5} N/ mm^{2}
Poissons ratio - 0.3
Yield strength - 250 N/mm^2

4.2 Geometry received for Analysis

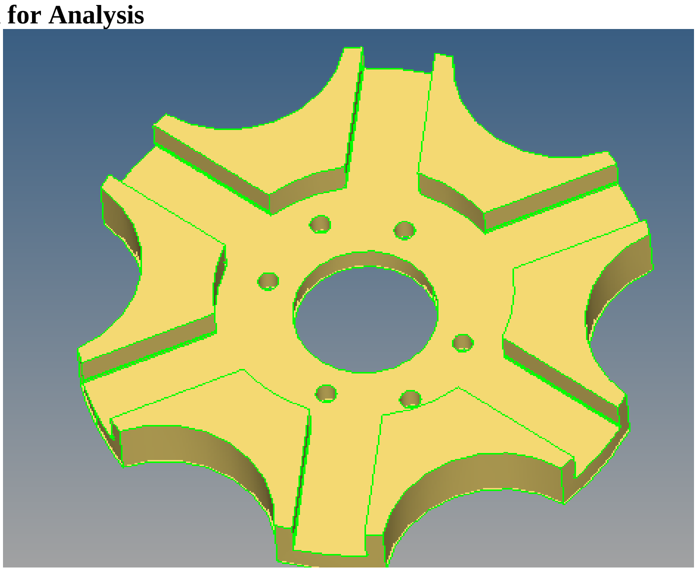


Fig 4.2 (a) 3 D Part Model of Geneva Wheel

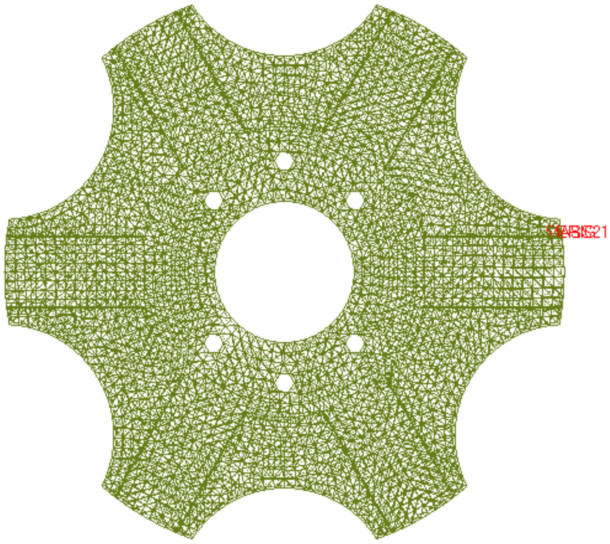


Fig 4.2 (b) Isometric View of Meshed Component [4]

Number of nodes = 9183 Number of elements =34448

4.3 Boundary and loading conditions for Geneva Wheel 4.3(a) Load Case -1

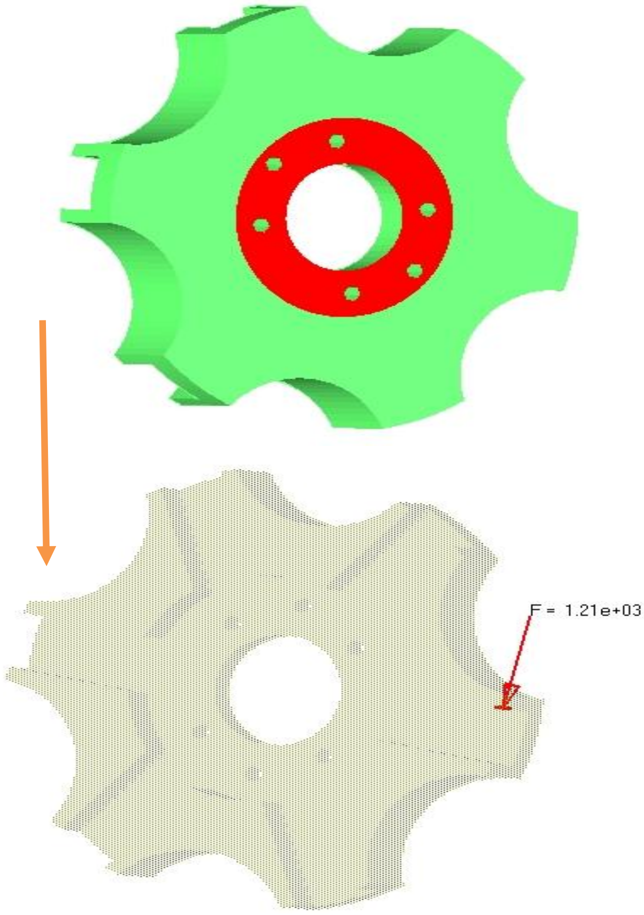


Fig 4.3(a)

Constrained in all DOF Tangential force which is acting in its maximum position

4.3(b) Vonmises Stress distribution for Load Case 1 [5]

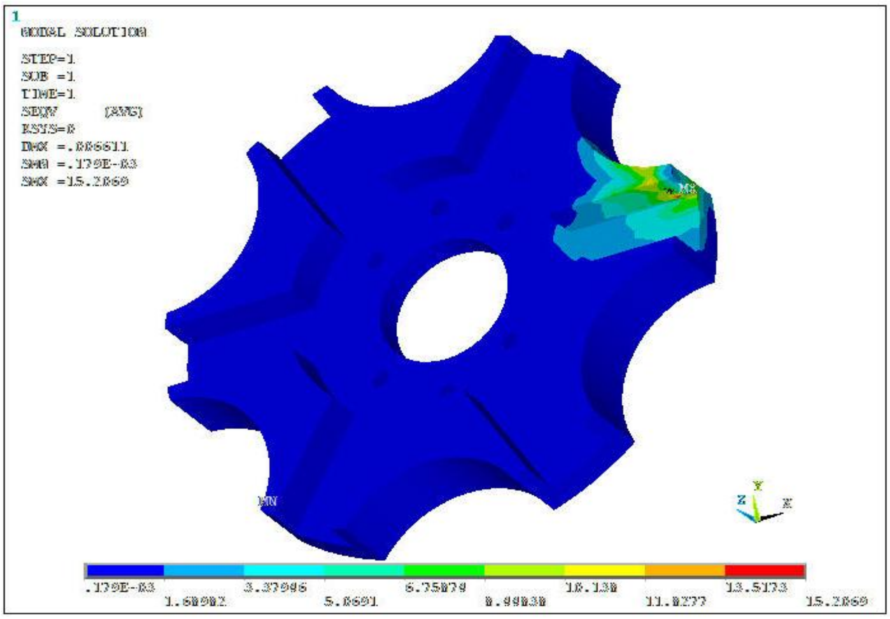


Fig 4.3(a)

The above fig shows the stress distribution which gives the maximum stress value 15.269 Mpa.

4.3(b) Displacement Plot for Load Case 1

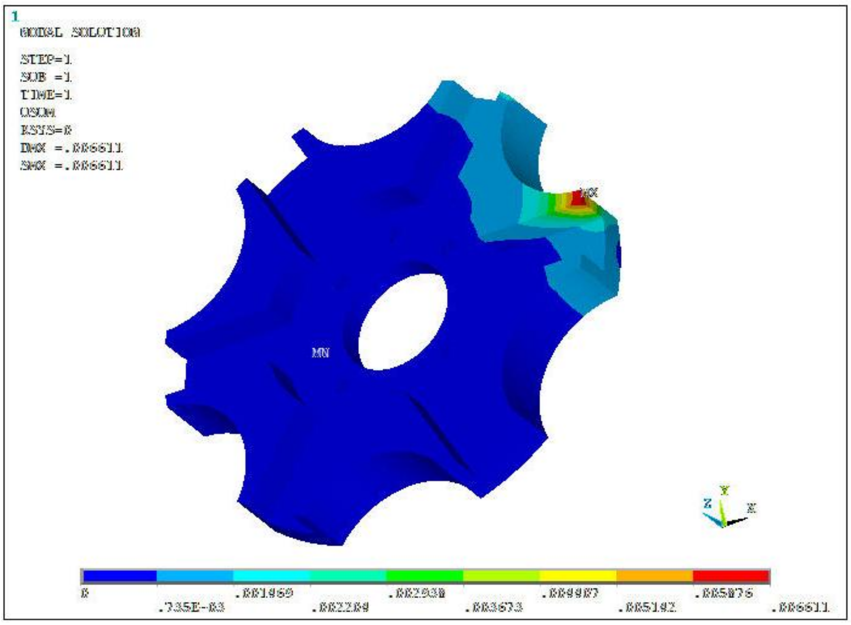


Fig 4.3(b)

For the required loading the displacement plot is as shown in the above figure where the maximum displacement is 0.0066mm which is negligible.

4.3(c) Variation of Stress and Displacement for the force acting in maximum position

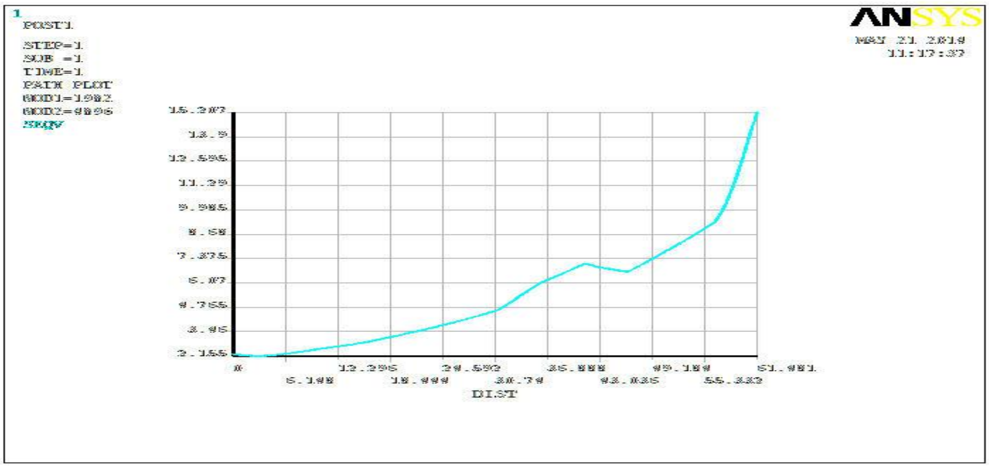


Fig 4.3(c)

The variation of displacement with the increase in stress for the force of 1.21 e^{+3} acting on the maximum position of the geneva wheel is as shown in the above fig.

4.3(d) Load Case 2

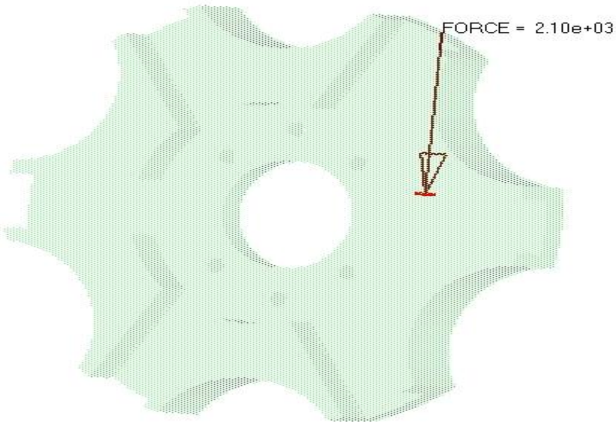


Fig 4.3(d)

Tangential force which is acting in its minimum position

4.3(e) Von Mises stress distribution for Load Case 2

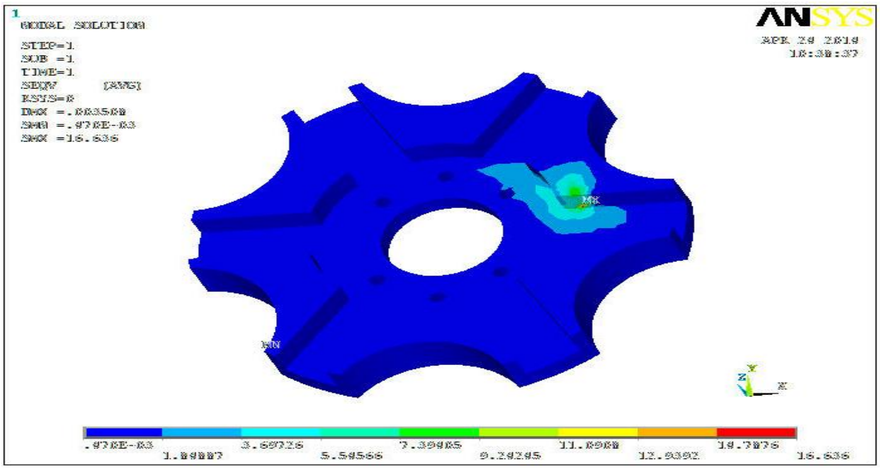


Fig 4.3(e)

The above fig 5.4(a) shows the stress distribution which gives the maximum stress 16.636Mpa.

4.3(f) Displacement Plot for Load Case 2

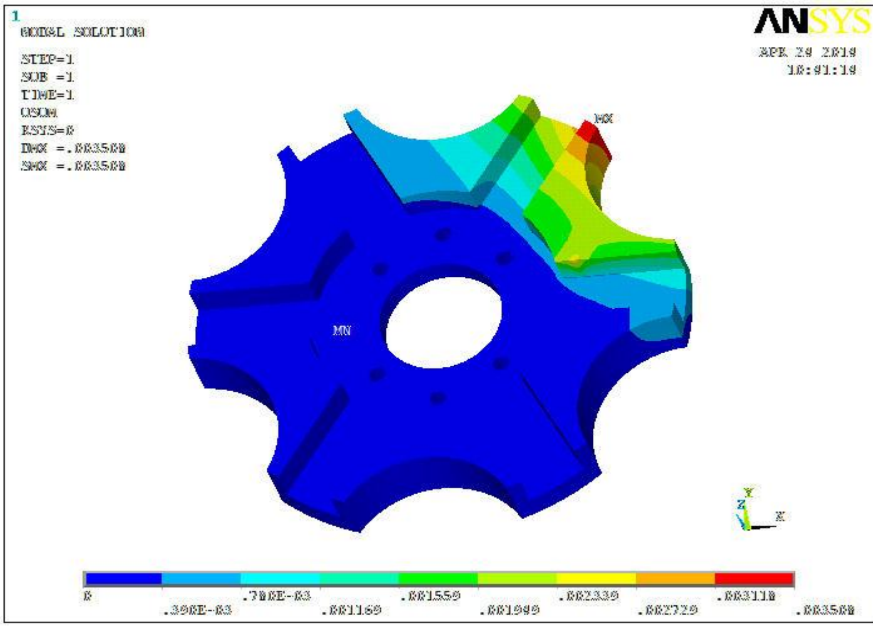


Fig 4.3(f)

The Displacement plot is as shown in the above fig where the maximum displacement is 0.0035mm.

4.3(g) Variation of Stress and Displacement for the force acting in minimum position

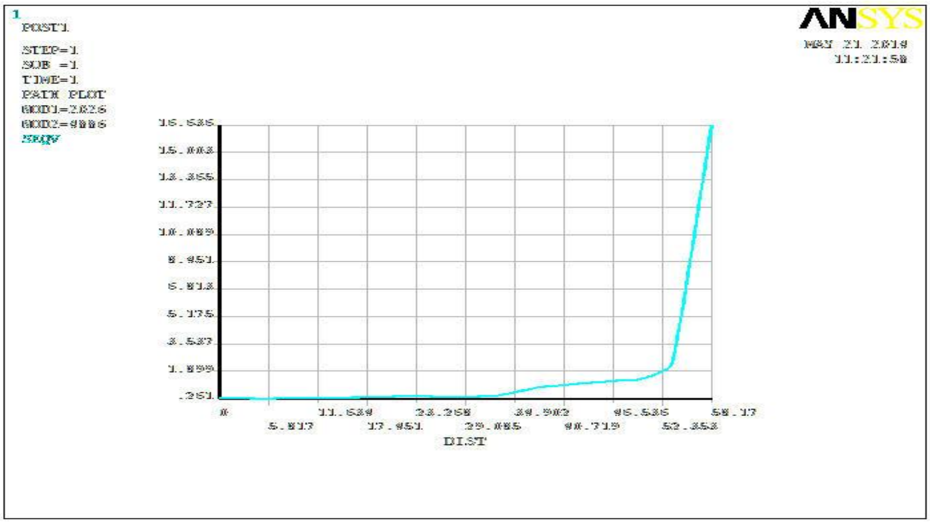


Fig 4.3(g)

The variation of displacement with the increase in stress for the force of 1.21 e^{+3} acting on the minimum position of the geneva wheel is as shown in the above fig.

4.4 Geometry received for Analysis

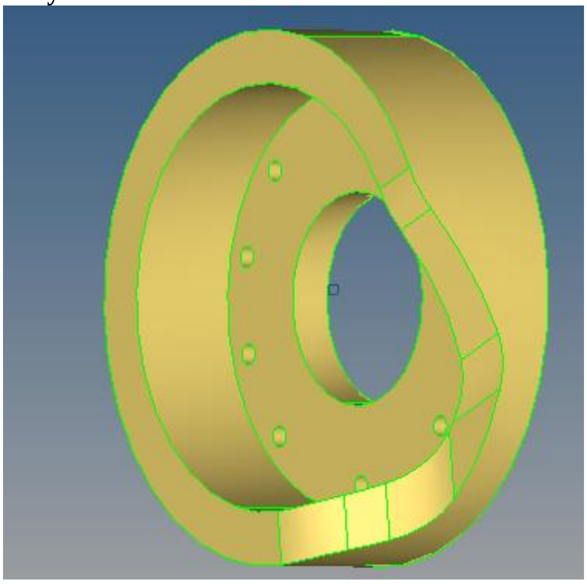


Fig 4.4 (a) 3D Part Model of Face Cam

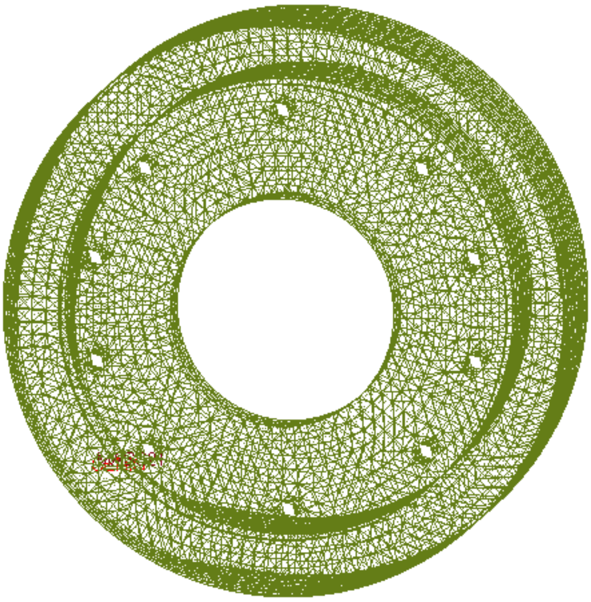
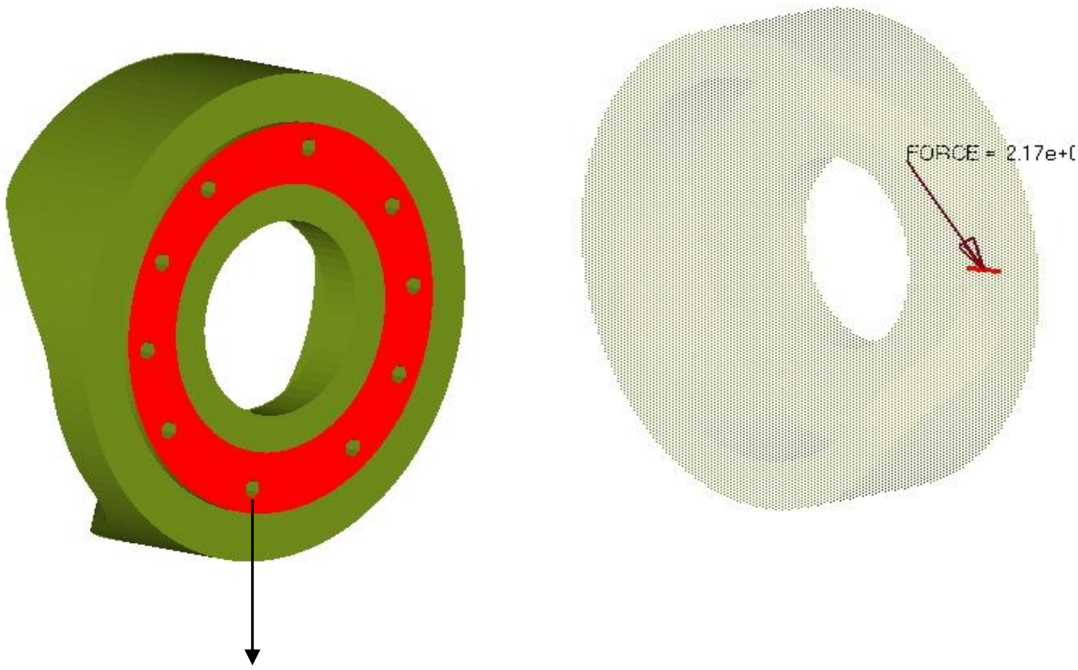


Fig 4.4(b) Isometric view of the Meshed component

Number of nodes = 6551 Number of elements =24564

4.5 Boundary and Loading Conditions for Face Cam



Constrained in all DOF   Tangential force is applied in horizontal direction.

Fig 4.5

4.5(a) Vonmises Stress distribution

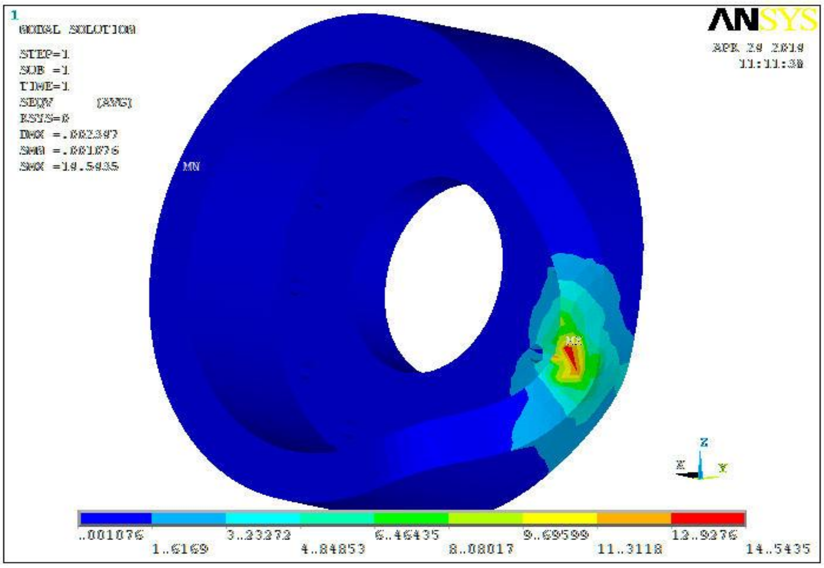


Fig 4.5(a)

The above fig shows the stress distribution which gives the maximum stress 14.54Mpa.

4.5 (b) Displacement Plot

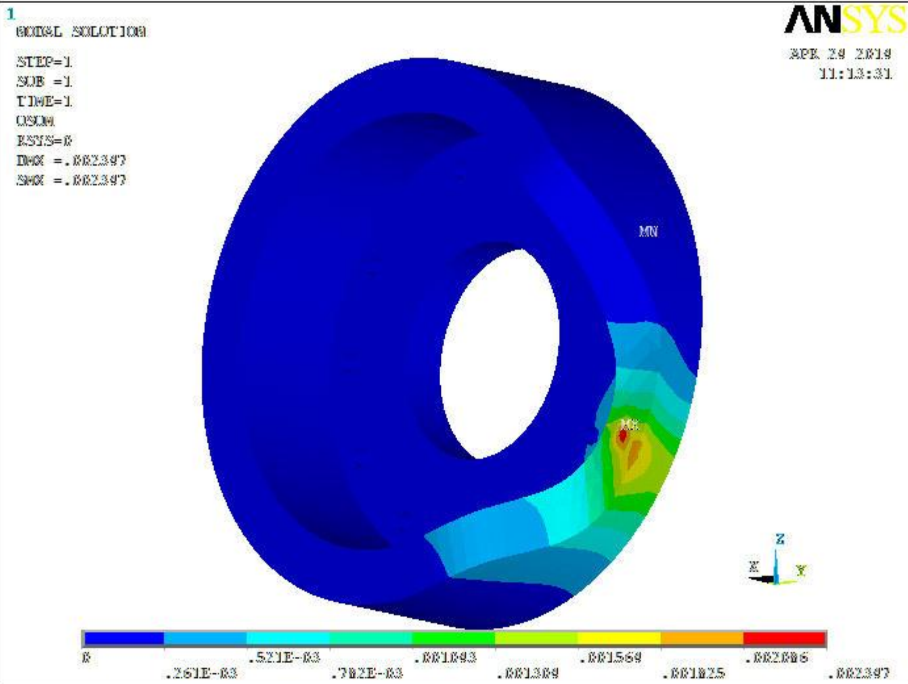


Fig 4.5(b)

The Displacement plot is as shown in the above fig where the maximum displacement is 0.0023mm.

4.5(c) Variation of Stress and Displacement for the force acting on the Face Cam

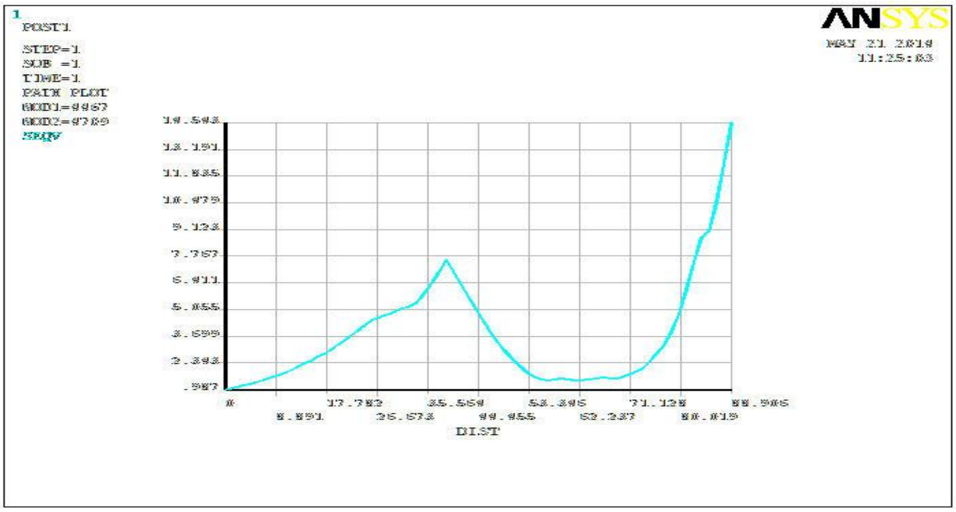


Fig4.5(c)

The variation of displacement with the increase in stress for the force of 2.17 e^{+3} acting on the Face Cam is as shown in the above fig.

V. Conclusion

- FEA has enabled a complete view of the stress distribution around the Geneva wheel and Face Cam.
- Deflection is small for the force acting on maximum and minimum position of Geneva Wheel.
- Similarly deflection is small for the force acting on the Face Cam.
- The Variation of displacement with the stress for the maximum and minimum condition of the Geneva wheel and also Face Cam has increased non linearly.

- The factor of safety for the conditions of Geneva Wheel and Face Cam is found to be more than 10.Hence the probability of failure is very less.Thus the design is very much safe.

Reference

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