"Design, Analysis and Development of Automatic Hand Brake in Car"

Sumit Suresh Khandizod[1], Akash Balasaheb Dhonde[2], Krushna Keru Karle[3], Vikas Navnath Mhaske[4], Tushar Dattatray Gore [5]

[1] Lecturer, Mechanical Engineering Department, Sau.Sundarabai Manik Adsul Polytechnic, Chas, Ahilyanagar
[2] student of Mechanical Engineering Department, Sau.Sundarabai Manik Adsul Polytechnic, Chas, Ahilyanagar
[3] student of Mechanical Engineering Department, Sau.Sundarabai Manik Adsul Polytechnic, Chas, Ahilyanagar
[4] student of Mechanical Engineering Department, Sau.Sundarabai Manik Adsul Polytechnic, Chas, Ahilyanagar
[5] student of Mechanical Engineering Department, Sau.Sundarabai Manik Adsul Polytechnic, Chas, Ahilyanagar

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Abstract - The conventional hand brake system in automobiles requires manual operation by the driver, which may sometimes lead to improper engagement or disengagement, causing safety issues such as vehicle rollback or unnecessary wear. To overcome these limitations, this project focuses on the design, analysis, and development of an automatic hand brake system for cars.The proposed system uses sensors, actuators, and a control unit to automatically engage and disengage the hand brake based on vehicle conditions such as engine status, slope, and brake pedal operation. When the vehicle is stationary or parked, the system activates the hand brake automatically, and it releases when the driver starts moving the vehicle.The design process includes selection of suitable components like electric actuators, control circuits, and sensors. Analysis is carried out to ensure reliability, safety, and efficiency of the system under different operating conditions. The developed prototype aims to reduce driver effort, improve vehicle safety, and enhance convenience.

This project is particularly useful in modern vehicles and can be further extended with advanced technologies such as electronic control units (ECU) and smart braking systems. The automatic hand brake system represents a step toward automation in automotive safety and control.

Keywords: -*Automatic Hand Brake, Electronic Braking System, Automotive Control System*

1.INTRODUCTION

In cars, the parking brake, additionally known as emergency brake, hand brake, or e-brake, is a latching brake sometimes used to keep the vehicle stationary. It's generally additionally accustomed prevent a vehicle from rolling once the operator desires each feet to work the clutch and throttle pedals. Automobile hand brakes sometimes contain a cable directly connected to the brake mechanism on one finish and to a lever or pedal at the driver's position. The mechanism is usually a non-automatic lever (hence the emergency brake name), on the ground on either aspect of the motive force, or a pull handle situated below and close to the wheel column, or a (foot-operated) pedal situated way with the exception of the opposite pedals.

Although generally called a hand brake, using it in any emergency wherever the footbrake continues to be operational is probably going to badly upset the brake balance of the automotive and immensely increase the probability of loss of management of the vehicle, for instance by initiating a rear-wheel skid. To boot, the stopping force provided by using the handbrake is tiny and wouldn't considerably aid in stopping the vehicle. The hand brake operates totally on the rear wheels that have reduced traction whereas braking however in some cases, hand brake operates on front wheel, as wiped out most Citroens manufactured since the tip of World War II. The emergency brake is instead supposed to be used just in case of mechanical failure wherever the regular footbrake is inoperable or compromised. Trendy brake systems square measure usually terribly reliable and equipped with dual circuit hydraulics and low-brake-fluid sensing element systems, which means the handbrake is never accustomed stop a moving vehicle.

Conventional hand brake feat involves the human interference. While not pull or pushing the lever, the hand brake won't work. Also, generally as a result of negligence or in emergency conditions, we have a tendency to humans usually forget to use parking brakes. This could result in rolling of auto just in case of slopes and collision with different vehicles in park. Constant enhancements in active safety and enhancements with relation to the dependableness and luxury of operation mean that mechanical handbrakes are progressively being replaced by mechanical device systems. This gave birth to concepts of electrical hand brake techniques. The elemental operate of the electrical hand brake (EPB) is to activate and unharness the hand brake once the vehicle is at a standstill. In 1st generation of electrical hand brake fitted, activate the control board replaces the standard handbrake lever accustomed operate the mechanical hand brake. This switch utilizes associate degree electronic management unit (ECU) to trigger mechanical device mechanisms among the wheel brakes or central actuator that operates the rear wheel brake via a Bowden cable. Any, for reducing driver's effort and reminding for application of hand brake, there was a requirement for a very machine-controlled hand brake system, which can be concepts of mechatronic. This paper is predicated on the event of 1 such system, involving the ideas of automobile, mechanical and natural philosophy, called mechanical device hand brake.

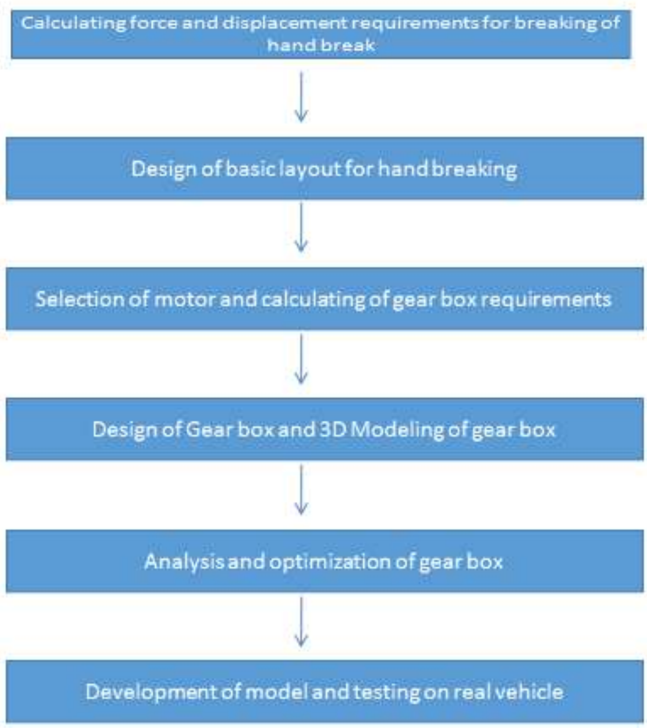
2. PROBLEM STATEMENT

1. Insufficient of force applied by the driver against parking brake system.
2. Occupies more space and size in Front side of the drivers driving seat that is not ergonomically in nature.
3. Driver has not remembered many times to apply and release a break.
4. In lock condition if vehicle is running its cause in break drum heat and broken due to overheat.
5. Same case happen in Electrical vehicle then causes of overheating of wiring of vehicle or motor will be bust due to over loading.

3.OBJECTIVES

1. To reduce the effort of the driver that leads in conventional one.
2. To increase the comfort and safety for the driver by using modified parking brake system named as automatic handbrake for engagement and release system.
3. In this to developed a warm and warm wheel gear for self-locking of system
4. As when the ignition switch turned ON, handbrake must disengage and vice versa when ignition switch is OFF, handbrake must engage.
5. System may work electro mechanically using motor, sensor and gear box.

4.DESIGN METHODOLOGY



5.DESIGN MATERIAL

5.1 Selection of proper motor by using given data from the industry

- Hand Brake should be applied in 0.5 sec & in this the cable wire travel distance should not Exceed 60 mm
- Consider output shaft dia =10mm

$= 2\pi r$

$= 2x\pi x5$

$= 31.4$

So we required = 240 rpm

5.2 Selection of Motor

Motor Model:- 95 to 135 cc		
1	Rated Voltage	12 v
2	Rated Power	0.35 kw
3	Assured Performance @ 10v	80A Max. 7000rpm
4	Lock Torque @ 6v	250A max
5	Application	Starter Motor

5.3 Considers Out shaft diameter of Motor is 10 mm

Input (12v motor)	Output
Motor Power = 0.35 kw	Speed of out Shaft = 240R.P.M
Speed of Motor = 7000 R.P.M	

5.4 Speed reduction gear box calculation

Therefore, now we have Input speed & output speed.
Input speed = 7000 R.P.M
Output speed = 240 R.P.M
Speed Ratio = Input speed / Output speed
= 7000 / 240
= 29.16

1:30 Gear Ratio for this speed reduction is required Hence, we require warm and warm wheel gear box for large speed reduction as well as self-locking mechanism.

5.5 Design of Warm and Warm wheel Gear Box

5.5.1 Basic Consideration in warm and warm wheel design

This standard is intended as a design procedure for fine-pitch worms and worm gears having axes at right angles. It covers cylindrical worms with helical threads, and worm gears hobbed for fully conjugate tooth surfaces. It does not cover helical gears used as worm gears.

Hobs: The hob for producing the gear is a duplicate of the mating worm with regard to tooth profile, number of threads, and lead. The hob differs from the worm principally in that the outside diameter of the hob is larger to allow for resharpening and to provide bottom clearance in the worm gear.

Pitches: Eight standard axial pitches have been established to provide adequate coverage of the pitch range normally required: 0.030, 0.040, 0.050, 0.065, 0.080, 0.100, 0.130, and 0.160 inch.

Axial pitch: is used as a basis for this design standard because: 1) Axial pitch establishes lead which is a basic dimension in the production and inspection of worms; 2) the axial pitch of the worm is equal to the circular pitch of the gear in the central plane; and 3) only one set of change gears or one master lead cam is required for a given lead, regardless of lead angle, on commonly-used worm-producing equipment.

Lead Angles: Fifteen standard lead angles have been established to provide adequate coverage: 0.5, 1, 1.5, 2, 3, 4, 5, 7, 9, 11, 14, 17, 21, 25, and 30 degrees.

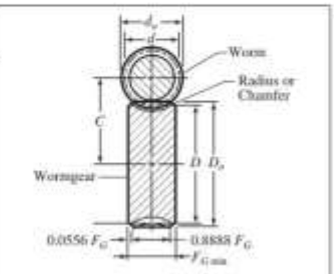
This series of lead angles has been standardized to:
1) Minimize tooling;
2) Permit obtaining geometric similarity between worms of different axial pitch by keeping the same lead angle;
3) Take into account the production distribution found in fine-pitch worm gearing applications.

For example, most fine-pitch worms have either one or two threads. This requires smaller increments at the low end of the lead angle series. For the less frequently used thread numbers, proportionately greater increments at the high end of the lead angle series are sufficient.

Pressure Angle of Worm: A pressure angle of 20 degrees has been selected as standard for cutters and grinding wheels used to produce worms within the scope of this Standard because it avoids objectionable undercutting regardless of lead angle.

Table- Formulas for Proportions of American Standard Fine-pitch Worms and Worm gears *ANSI B6.9-1977*

LETTER SYMBOLS
P = Circular pitch of wormgear
P = Axial pitch of the worm, P_x, in the central plane
P_x = Axial pitch of worm
P_n = Normal circular pitch of worm and wormgear $= P_x \cos\lambda = P \cos\psi$
λ = Lead angle of worm
ψ = Helix angle of wormgear
n = Number of threads in worm
N = Number of teeth in wormgear
$N = nm_G$
m_G = Ratio of gearing $= N \div n$



Item	Formula	Item	Formula
WORM DIMENSIONS		WORMGEAR DIMENSIONS[a]	
Lead	$l = nP_x$	Pitch Diameter	$D = NP \div \pi = NP_x \div \pi$
Pitch Diameter	$d = l \div (\pi \tan\lambda)$	Outside Diameter	$D_o = 2C - d + 2a$
Outside Diameter	$d_o = d + 2a$	Face Width	$F_{G\,min} = 1.125 \times \sqrt{(d_o + 2c)^2 - (d_o - 4a)^2}$
Safe Minimum Length of Threaded Portion of Worm[b]	$F_W = \sqrt{D_o^2 - D^2}$		
DIMENSIONS FOR BOTH WORM AND WORMGEAR			
Addendum	$a = 0.3183P_n$	Tooth thickness	$t_n = 0.5P_n$
Whole Depth	$h_t = 0.7003P_n + 0.002$	Approximate normal pressure angle[c]	$\phi_n = 20$ degrees
Working Depth	$h_k = 0.6366P_n$		
Clearance	$c = h_t - h_k$	Center distance	$C = 0.5\,(d + D)$

Single-thread worms are comparatively inefficient because of the effect of the low lead angle; consequently, single-thread worms are not used when the primary purpose is to transmit power as efficiently as possible but they may be employed either when a large speed reduction with one set of gearing is necessary, or possibly as a means of adjustment, especially if "mechanical advantage" or self-locking are important factors.

5.5.2 Design of Worm & Worm wheel

The worm gear is of 2 mm module, 20° pressure and a face width of 15 mm.

The worm is of pitch diameter of 50 mm with a face width of 15 mm.

The worm is made of steel case carburized OQ and T and ground. The worm gear is made of phosphor bronze. 20° normal pressure angle worm gear is assumed for which the lead angle should not exceed 25° and Z^2 minimum is 21.

Allowing 6° lead per thread of the worm, the worm could have 4 or less teeth. $Z^1 = 4$ or quadruple threaded worm is assumed

For worm Gear

Input speed $I = 7000/240$

$I = 29.16$

It is Possible to do $I = 30$

$\alpha = 20$ degree

Module m = 3mm

So,

Pitch p = 6 mm

N1/N2 = T1/T2

T2 = 30×T1

= 30 X 2

=60

Calculate the diameter of worm Gear

D1 = 2.4P + 1.1

= (2.4×6) +1.1

= 15.5 mm = 16 mm

Calculate the diameter of warm wheel

$D2 = (T2\times6) / \pi$

$= 60\times6 / 3.14$

D2 = 114.64 mm = 115mm

$L1 = (c \wedge (0.875)/ 2)$

$= 14.43$

$L2 = (C \wedge (0.875/1.07)$

$= 26.97$

$L1 \leq D1 \leq L2$

It is good worm gear pair it is possible to manufacturing

$CD = (d1 + d2) \div 2$

$= (16.0712+238.39)/2$

= 127.23 mm

5.6 CAD

Computer-aided design (**CAD**) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.

The term **CADD** (for Computer Aided Design and Drafting) is also used. Its use in designing electronic systems is known as electronic design automation (**EDA**). In mechanical design it is known as mechanical design automation (**MDA**) or **computer-aided drafting** (**CAD**), which includes the process of creating a technical drawing with the use of computer software. CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions.CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space.

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

The design of geometric models for object shapes, in particular, is occasionally called computer-aided geometric design (CAGD)

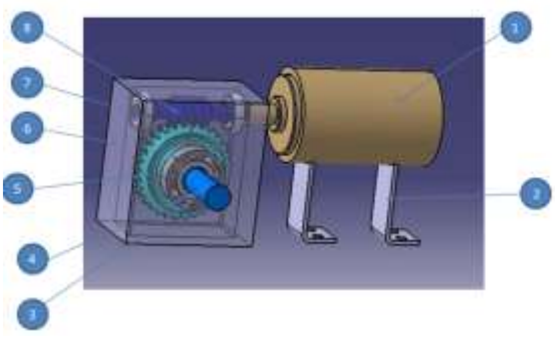


Fig. -Proposed 3D model of Automatic break

Table-Proposed automatic brake part list

Sr. No.	Name	Qty
1	Motor	1
2	Motor Support	1
3	Bearing	2
4	Out Put Shaft	1
5	Worm Wheel	1
6	Gear Box	1
7	Bearing	2
8	Worm	1

6. FINITE ELEMENT ANALYSIS

Introduction of Finite Element Analysis

The finite element analysis (FEA) is a problem-solving approach for the practical (engineering) problems. The problems are first converted to matrix and partial differential equation forms. Eventually the partial differential and integral equations are being solved to reach the solution of the problem. The volume of the equations to be solved is usually so large that arriving solution without using computer is practically impossible. And, that's why the need of different FEA packages is felt. There are many FEA packages available for different applications. Some popular FEA packages are Pro Mechanical, ANSYS, NASTRAN, and Gambit etc.In mathematics, the finite element analysis (FEA) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It uses subdivision of a whole problem domain into simpler parts, called finite elements, and variation methods from the calculus of variations to solve the problem by minimizing an associated error function. Analogous to the idea that connecting many tiny straight lines can approximate a larger circle, FEA encompasses methods for connecting many simple element equations over many small sub domains, named finite elements, to approximate a more complex equation over a larger domain.Finite element analysis (FEA) is a useful and powerful technique for determining stresses and strains in structures or components too complex to analyze by strictly analytical methods. With this technique, the structure or component is broken down into many small pieces (finite number of elements) of various types, sizes and shapes. The elements are assumed to have a simplified pattern of deformation (linear or quadratic etc.) and are connected at "nodes" normally located at corners or edges of the elements. The elements are then assembled mathematically using basic rules of structural mechanics, i.e. equilibrium of forces and continuity of displacements, resulting in a large system of simultaneous equations. By solving these large simultaneous equations system with the help of a computer, the deformed shape of the structure or component under load may be obtained. Based on that, stresses and strains may be calculated. The finite element analysis (FEA) is probably the most versatile way of calculating stress intensity factors. This method primarily involves the evaluation of displacements at nodal points of the body which has been idealized into a system of elements connected at the nodal points. The FEA has become a powerful tool for the numerical solution of a wide range of engineering problems. The FEA has been extensively used to solve problems involving irregular regions and complicated modals.

Steps of Finite Element Analysis

FEA solution of engineering problems, such as finding deflections and stresses in a structure, requires three steps:

1. Pre-processing

2. Solution

3. Post processing

A brief description of each of these steps follows

Step1: Pre-processing

Using a CAD program that either comes with the FEA software or 3D CAD modeling tools like Pro-E, Catia, and solid Edge etc. provided by another software vendor, the structure is modeled. The final FEA model consists of several elements that collectively represent the entire structure. The elements not only represent segments of the structure, they also simulate its mechanical behaviour and properties.

Regions where geometry is complex (curves, notches, holes, etc.) require increased number of elements to accurately represent the shape; whereas, the regions with simple geometry can be represented by coarser mesh (or fewer elements). The selection of proper elements requires prior experience with FEA, knowledge of structure's behaviour, available elements in the software and their characteristics, etc. The elements are joined at the nodes, or common points. In the pre-processor phase, along with the geometry of the structure, the constraints, loads and mechanical properties of the structure are defined. Thus, in pre-processing, the entire structure is completely defined by the geometric model. The structure represented by nodes and elements is called "mesh".

Step 2: Solution

In this step, the geometry, constraints, mechanical properties and loads are applied to generate matrix equations for each element, which are then assembled to generate a global matrix equation of the structure. The form of the individual equations, as well as the structural equation is always,

$\{F\} = [K]\ \{u\}$

Where

$\{F\}$ = External force matrix,

$[K]$ = Global stiffness matrix,

$\{u\}$ = Displacement matrix.

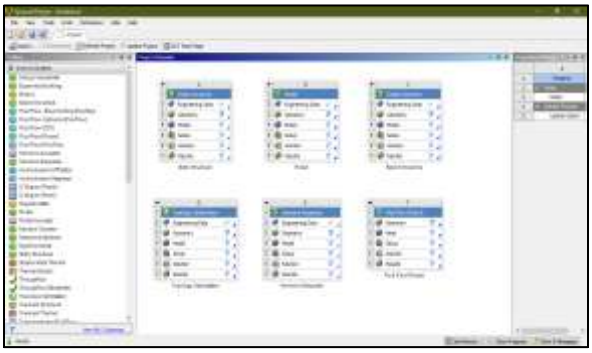
The equation is then solved for deflections. Using the deflection values, strain, stress, and reactions are calculated. All the results are stored and can be used to create graphic plots and charts in the post analysis.

Step 3: Post processing

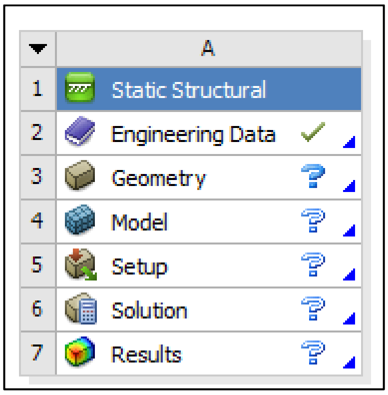
This is the last step in a finite element analysis. Results obtained in step 2 are usually in the form of raw data and difficult to interpret. In post analysis, a CAD program is utilized to manipulate the data for generating deflected shape of the structure, creating stress plots, animation, etc. A graphical representation of the results is very useful in understanding behavior of the structure.

In present research for analysis ANSYS (**An**alysis **Sys**tem) software is used. Basically, its present FEM method to solve any problem. Following are steps in detail

1. Geometry
2. Discretization (Meshing)
3. Boundary condition
4. Solve (Solution)
5. Interpretation of results



Workbench contain analysis of different types namely static, modal, harmonic, explicit dynamics, CFD, ACP tool post, CFX, topology optimization etc. as per problem defined.



Step 1: Details of material namely copper, steel, grey cast iron, composite material, fluid domain material is defined in engineering data. I.e. ANSYS default material is structural steel.

Step 2: Import of geometry created in any CAD software namely CATIA, PRO E, SOLIDWORK, INVENTOR etc. in geometry section. If any correction is to be made it can be created in geometry section in Design modeller or space claim.

Step 3: In model section after import of component

➢ Material is assigned to component as per existing material

➢ Connection is checked in contact region i.e. bonded, frictionless, frictional, no separation etc. for multi body components.

➢ Meshing or discretization is performed i.e. to break components in small pieces (elements) as per size i.e. preferably tetra mesh and hexahedral mesh for 3D geometry and for 2 D quad or tria are generally preferred.

Step 4: Boundary condition is applied as per analysis namely in fixed support, pressure, force, displacement, velocity as per condition.

Step 5: Now problem is well defined and solve option is selected to obtain the solution in the form of equivalent stress, strain, energy, reaction force etc.

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Warm

Model

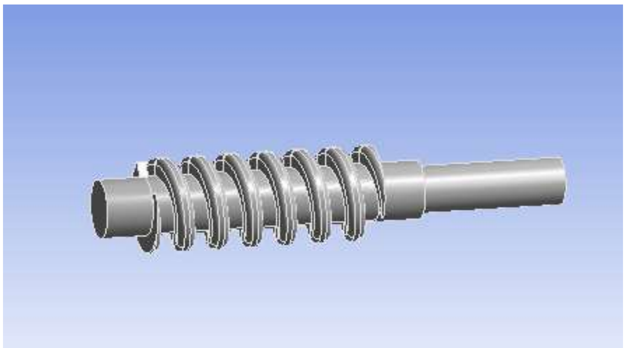

Fig. Geometry imported in ANSYS of Warm

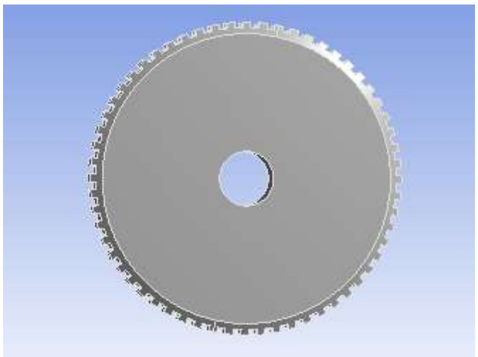

Fig.- Geometry imported in ANSYS of Warm wheel

Meshing

Meshing is an integral part of the computer-aided engineering simulation process. The mesh influences the accuracy, convergence and speed of the solution. Furthermore, the time it takes to create and mesh a model is often a significant portion of the time it takes to get results from a CAE solution. Therefore, the better and more automated the meshing tools, the better the solution.For 2-D solid models, meshing technologies from ANSYS provide robust, well-shaped quadratic and triangular meshing along with free and mapped meshing, on even the most complicated geometries. With automatic contact detection and setup, a user requires little training to perform sophisticated analysis. In addition, users can generate pure hex meshes using one of several mesh methods, depending on the type of model and whether the user wants a pure hex or hex-dominant mesh.

In present FE model, the meshed set using the 'Global controls' available with the 'mesh tool'. Smart mesh set to 3 and triangular mesh is preferred for plate with circular, triangular, square and rectangular cut out. Meshing on test specimen is shown in fig.

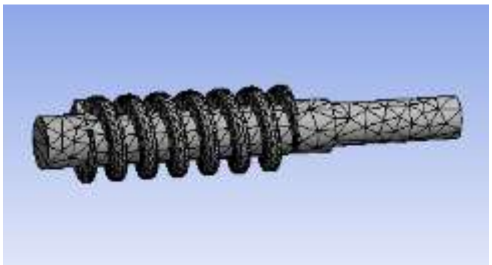

Fig.- Meshing of Warm

Statistics	
Nodes	10042
Elements	5175

Fig.-Meshing details of Warm

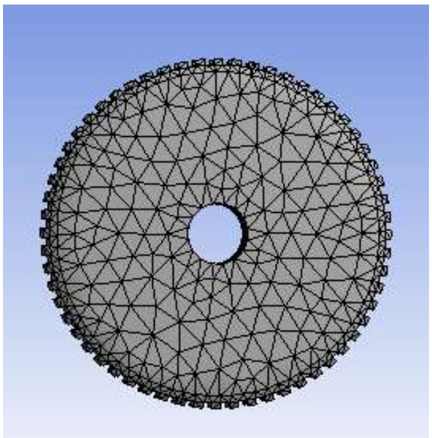

Fig.-Meshing of Warm wheel

Statistics	
Nodes	11565
Elements	6094

Fig.-Meshing details of Warm Wheel

7.ANSYS RESULTS

BOUNDARY CONDITION

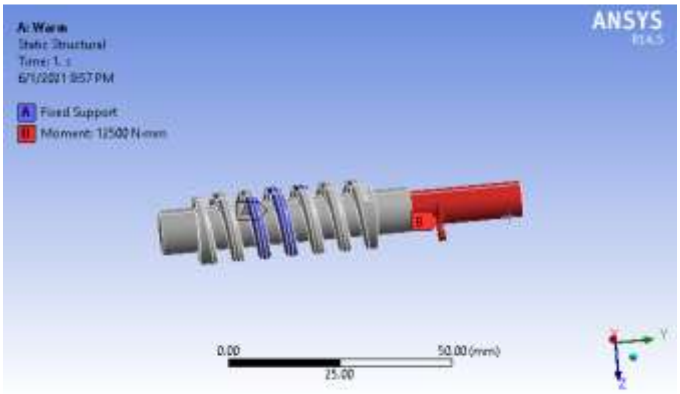

Fig.-Show a boundary condition of applied 12500 N-mm Moment at one end of the shaft and Outer Dia. is fix in warm

STRESS

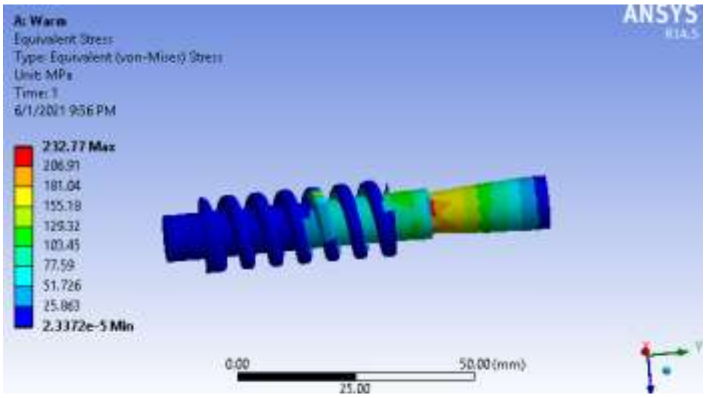

Fig.-Show a stress in shaft after applied 12500 N-mm Moment at one end of the shaft and Outer Dia. is fix in warm

DEFORMATION

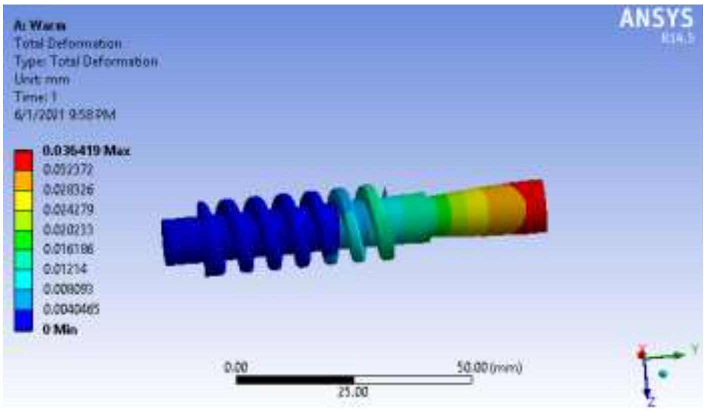

Fig.-Show a Deformation in shaft after applied 12500 N-mm Moment at one end of the shaft and Outer Dia. is fix in warm

BOUNDARY CONDITION

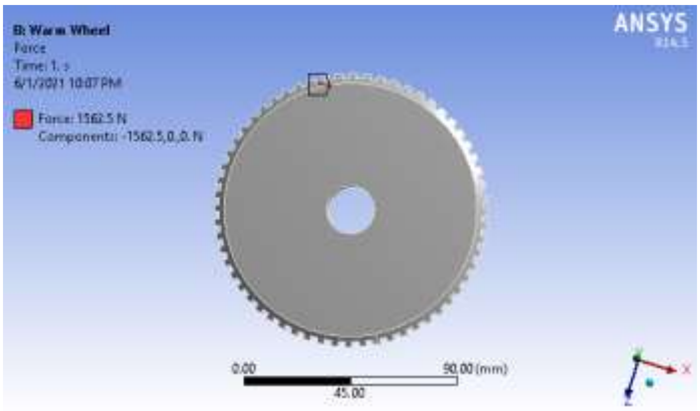

Fig. Show a boundary condition of applied 1562.5 N force at one tooth and center of warm wheel is fixed

STRESS

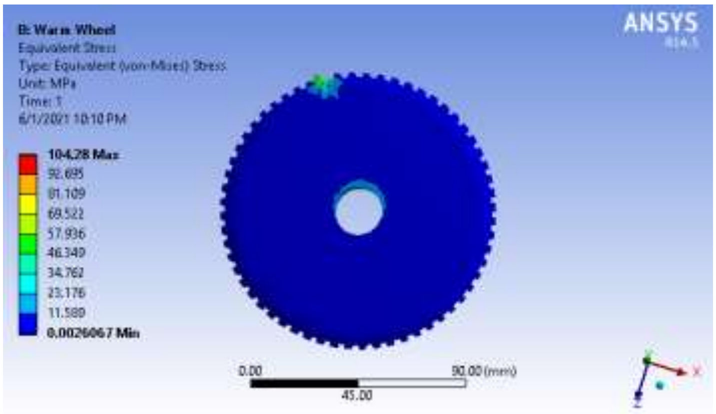

Fig.13 Show a Stress of applied 1562.5 N force at one tooth and center of warm wheel is fixed

DEFORMATION

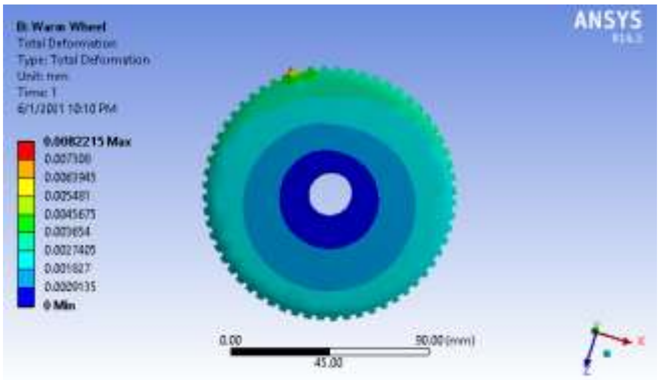

Fig.-Show a Deformation of applied 1562.5 N force at one tooth and center of warm wheel is fixed

8.RESULT TABLE

Sr. No.	Boundary Condition	Warm		Warm Wheel	
		Deformation (mm)	Stress (MPa)	Deformation (mm)	Stress (MPa)
1	1562.5 N force	NA	NA	0.00822	104.28
2	12500 N-mm Moment	0.036	232.77	NA	NA

Table- Results of applied moment for both gear

9.CONCLUSION

➢ Automatic hand brake release mechanism is beneficial for operator's safety by reducing accident chances as well as disengaging chances of braking. This system can also be used in commercial cars for ease of operating as well for reducing cost purpose.

- Along with it, we can also modify our system by using the spring at the power actuator by using it as reverse purpose. Thus, our project is still a demonstration of it, no car has yet used such concept on ignition switch.
- This project gives a new idea of automatic hand braking system which can be applied in car manufacturing industries as well as companies.
- The working is quite simple and doesn't require any extra effort to operator or driver.
- Even though when any driver forgets to pull the hand brake in regular car, the driver can be in any critical situation but by using the concept of automatic handbrake system, there is no possibility of risk because by putting the ignition switch OFF, the hand brake system is automatically gets locked

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