Design and Analysis of a Safety Wheel for Automobile Tyre Burst

A Project Report

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in partial fulfillment for the award of the degree
of

Bachelor of Engineering
in
Mechanical Engineering

DEPARTMENT OF MECHANICAL ENGINEERING

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APRIL– 2007

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ABSTRACT

The project **"DESIGN AND ANALYSIS OF A SAFETY WHEEL FOR AUTOMOBILE TYRE BURSTS USING FEM"** is a solution for a real time problem. The main objective of this project is to provide balance and to help in retaining the control of the vehicle even after the tyre bursts. The reasons for tyre bursts are most common and many drivers condoning them.

If any one of the front tyres of an automobile burst suddenly, say if it is right side one, the driver will lose his control and the vehicle will start moving towards right. The result will be the most undesirable and unpredictable. The driver could not able to control the vehicle even at a speed of 30kmph. This project mainly concentrates on providing solution to this problem by attaching disc to the front wheels of the vehicle. The disc is designed in such a way that it can take all the impact force (reaction) created by the static and kinetic load of the rolling mass.

The attachment disc (BURST WHEEL) has been analyzed for its structural stability using FEM. For the acquired maximum stress, the design stability has been checked and the best design is derived. By incorporating this attachment, the safety of the vehicle is ensured and it can be decelerated to the safest condition without any mishap. The complete details of the analysis conducted have been presented here.

ACKNOWLEDGEMENT

We take the privilege to express our deepest gratitude to our project guide **Dr.V.Velmurugan, Assistant Professor** who rendered his valuable guidance and support to perform our project work extremely well.

We are extremely thankful to **Dr. N. Gunasekaran, H.O.D.** Department of Mechanical Engineering for his valuable advice and suggestions throughout this project.

We are immensely grateful to our principal **Dr. Joseph.V.Thanikal**, for his invaluable support to come out of this project.

We would like to thank all the faculty members and non teaching staffs whose valuable guidance, inspiration and continuous encouragement throughout the course made it possible to complete this project

Dedicated to

Our

Parents

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CHAPTER 1

INTRODUCTION

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INTRODUCTION

1.1 GENERAL DESCRIPTION

It is strange but true today that in a country where expressways and world-class highways are emerging, a country that's set to become an automotive hub of many a global giant, safety regulations are still vaguely defined. Particularly in case of tyre burst. There are many chances for tyre burst because of heat developed in the tyres. The main reason is irregular speeding. In addition to that we can go on adding up reasons for tyre burst. Out of these some are unavoidable especially burst due to over heat. Certain things we can't control in these cases.

This project mainly concentrates on providing solution to this problem by attaching disc to the front wheels of the vehicle The worst case scenario would occur when a front tyre bursts, leading the whole truck weight to transfer to its side due to instability. It would be worse when the burst occurs while travel. Unlike this it would be safer if it occurred at the rear because it would have a tyre to support its weight. That's why we prefer the front wheel for the fitment of a burst wheel.

The disc is designed in such a way that it can take all the impact force (reaction) created by the static and kinetic load of the rolling mass. The attachment disc (burst wheel) has been analyzed for its structural stability using Finite element Analysis.

To protect occupants from an accident during tyre burst the BURST WHEEL should take up the entire load of the vehicle without loosing its structural stability and should allow the driver to control the vehicle for smooth deceleration. For this requirement the Burst Wheel should be designed in such a way that it can able to withstand the potential energy load and kinetic energy load which will act on it at the time of impact. This requirement is achieved by analyzing the Burst Wheel in

ANSYS for the applicable loads and the final design is established.

The following tasks have been reported here in the project.

1) Solid modeling of the Burst Wheel.
2) Finite element meshing of the Burst Wheel, defining material properties and boundary conditions.
3) Impact simulation of burst wheel and studying the behavior of impact.

The modeling is done using ProE 2001 modeling software and analysis is done with the help of ANSYS10 FE package. Finally, results are validated.

1.1.1 Scope of the Project

The Burst Wheel we have designed can easily accommodate in the existing set up without making much alterations. So the people owning old vehicles too will turn up. To fix this Burst Wheel in the vehicle the only alteration required is the stock front bolts should be replaced with the stock back bolts.

1.2 TYRES AND REASONS FOR ITS FAILURE

1.2.1 Tyres

Tyres are the final stage of transmission which brings in the power delivered from an engine to the road. Tyres are designed to provide comfort and friction to the whole vehicle without considerable wear out during their tread.

Tyres are one of the parts which demand constant maintenance and attention, but have been the most neglected among them all. Improper maintenance of tyres could result in the worst accidents. In our project we are going to focus more on tyre bursts.

1.2.2 Tyre Structure

There are a number of classifications that come under tyre structures. The two broad classifications on the tyre structure are,

1) Radial Ply
2) Bias Ply

Shown below are the structural diagrams of both these types.

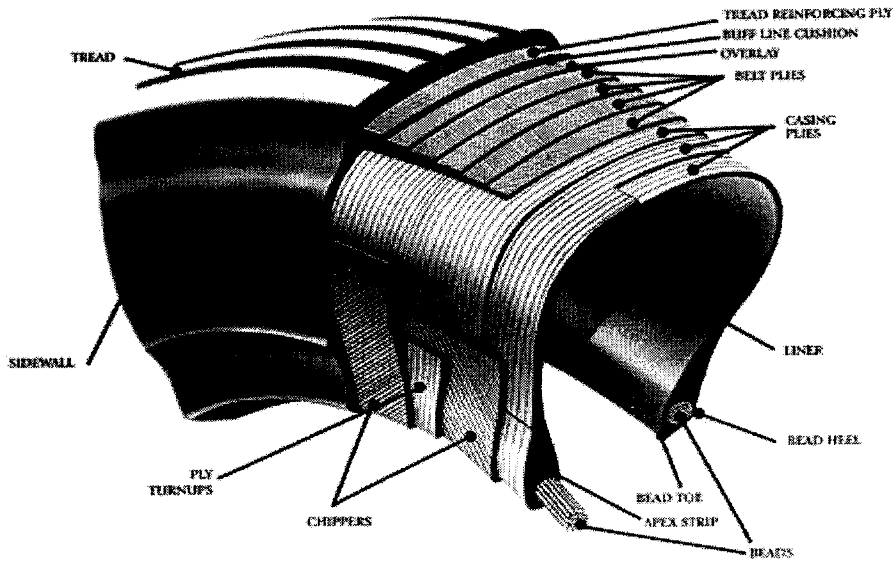

FIG 1.1 STRUCTURAL DIAGRAM OF RADIAL PLIES

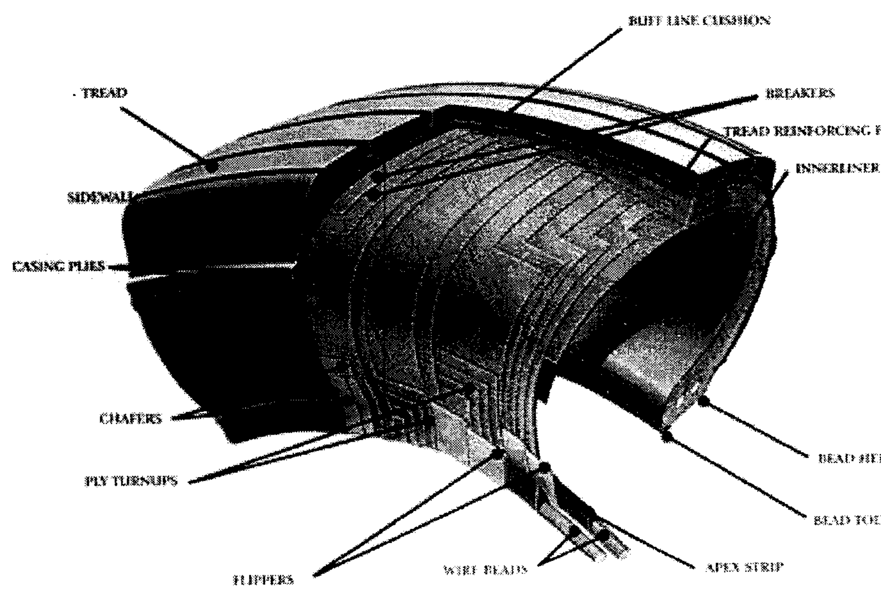

FIG 1.2 STRUCTURAL DIAGRAM OF BIAS PLIES

As these diagrams show, tyres are made up multiple layers. These layers are sandwiched together to act as a single unit. Broadly classifying there are two types of layers.

Layer 1

An inner layer, that in all effect is an air tight layer of synthetic rubber, which acts as the air chamber, is formed from one bead across internal structure of the tyre to the other bed.

Layer 2

Body plies which gives the tyres its form and structural strength, and belt plies which re-enforce the tread area of the tyre, consists of rubber and steel cables molded together into flat sheets, then cut into correct width and angle, together with the tread are basically sandwiched together. When this sandwich construction is cured, the tyre should be one complete non-separate unit.

However air gets trapped and contaminants can cause separation of these "sandwich" layers which cannot be detected by the human eye.

1.2.3 Tyre Fail

Improper maintenance of tyres always tends to cause tyres to fail. Listed below are few common reasons

1) Improper maintenance of inflation pressure
2) Lack of fingertip diagnostics
3) Lack of visual inspection on tyres
4) Exceeding tread depth standards
5) Application of heat on tyres
6) Exposure of tyres to heat and moisture while not used
7) Mixing of tyres
8) Avoiding the process of washing tyres
9) Tyre retread practices
10) Misalignment

1) Improper maintenance of inflation pressure

This is the No. 1 maintenance issue facing fleets today, regardless of the season. Under inflation leads to increased tire deflection, this leads to increased heat. Heat is a tire's worst enemy. Low inflation leads to reduced tire miles, reduced retread ability, poor fuel economy and even an increase in the number of punctures.

2) Lack of fingertip diagnostics

Running one's hand across the tread surface can identify alignment-related wear conditions. For example, if you run your hand across the tread surface and you feel a "stepped" wear pattern (not smooth), you probably have a vehicle toe-in condition. Catching alignment wear conditions early will allow the truck to be corrected so the tire can still achieve high removal miles.

3) Lack of visual inspection on tyres

Tyres demand visual inspection periodically. The whole tyre from sidewalls to the tread should be inspected. Any uneven wear should be detected and checked.

4) Exceeding tread depth standards

Depending on specific service vocation, it should be made sure the fleet does not exceed removal tread depth standards. If any significant amount of off-road service is seen, one may be best served to ensure he has enough remaining rubber before retreading to make sure the casing is protected against stone damage and stone drilling.

5) Application of heat on tyres

Application of heat or an attempt to weld tyres must be avoided because they can change the property of tyres` layers. The consequences could be immediate or later tyre burst which could cause accidents and personal injury.

6) **Exposure of tyres to heat and moisture while not used**

Tyres should be stored properly stored when not used. They should be kept in a cool and dry place. Exposure to direct sunlight and moisture should be avoided since it could change the property of rubber and bring in premature ageing.

7) **Mixing of tyres**

The practice of mixing tyres should be avoided, for example, deep treaded tyres should not be mixed with normal tread tyres. This practice could lead in improper and greater wear of tyres.

8) **Avoiding the process of washing tyres**

Tyres should be washed periodically. This practice is usually neglected by all not knowing that washing avoids premature ageing of tyres.

9) **Tyre retread practices**

Tyres should be retreaded according to factory norms. The same type of tread should be applied while retreading. Retreading a normal tread tyre with a deep treaded tyre should be avoided. Most importantly retreaded tyres should not be used on the driving axle.

10) **Misalignment**

Misalignment of the axle should be avoided. This could lead to the pulling of the vehicle towards one side. This could also lead in uneven wear in tyres. Sometimes the tyre itself could be a standing reason. This is because of two main reasons

- Difference in inflation pressures
- Tyre mixing.

1.2.4 Heat-the Unavoidable and Inevitable Factor

In every moving part heat is generated as energy has to be dissipated in its form because of friction. As far as tyres are concerned, heat cannot be avoided. Heat is generated due to many reasons in a tyre. Listed below is some of the common reasons why tyres are subjected to heat.

1) Friction
2) Heat from brakes
3) Climatic conditions
4) Retreading
5) Irregular speeding
6) Under inflation of tyres

1) Friction

The purposes of tyres are a main reason for friction itself. As tyres tread on the road friction comes into play. Besides the rubbing of the tube against the tyre it generates considerable amount of heat. These factors cannot be avoidable especially when the fleet has a great distance to cover everyday.

2) Heat from brakes

Trucks uses drum type brakes for braking. These brakes are known to emit considerable amount of heat. Proper driving habit could put a check to it but situations like a downhill drive could be a great exception since good driving demands the proper usage of brakes. The heat generated through these brakes is sufficient to affect the properties of the layers of tyres.

3) Climatic conditions

Extreme climatic conditions are sufficient to cause a considerable amount of heat input to the tyres. India is in fact a country with extreme climatic conditions. Hence such a factor cannot be escaped.

4) Retreading

Retreading is a way of giving tyres a new life and promoting recycling. But retreaded tyres demand more maintenance. These tyres are more subjected to wear and tear since they have a fresh tread placed on an old tyre and the tyre is mainly evaluated by the users inspecting the tread alone, neglecting the sidewalls.

5) Irregular speeding

An irregular speeding practice which consists of a series of acceleration and deceleration is another factor which constitutes the total heat generated in a tyre. This kind of driving cannot be avoided in case of stop and go conditions that occur in heavy traffic.

6) Under inflation of tyres

Air always plays a vital role in tyres in every aspect from performance to maintenance. Under inflation of tyres is a great hazard. Studies have shown that 2psi of under inflation could cause a rise of 5degrees of temperature.

As discussed above we can infer that heat is the unavoidable factor in the maintenance of a tyre. India is a country in which a great diversity of climate roads and landscape occur. In such a country tyre wear out and even tyre bursts are the most likely event to occur. This is exactly where the need for a burst wheel could come in handy. It is because tyre burst could put a threat not only to the goods carried, but also to the survival of the driver under circumstances.

1.2.5 Tyre Bursts

Tyre bursts are defined as the uncontrolled release of a tyre's inflation pressure leading a tyre to deflate instantaneously.

Why does a tyre burst?

A tyre bursts when the structural integrity of the tyre is damaged to the point where the force of inflation pressure is greater than the depleted strength of the tyre's strength.

Potential Hazards

- High pressure gust of air
- Shower of debris
- Impaired control of the vehicle
- Accident that could result in personal injury or death

Causes

- ❖ Severe contact with sharp objects
- ❖ Structural fatigue
- ❖ Worn through the tyre structure
- ❖ Depleted structural strength

Common tyre damaged that lead to tyre burst

- ❖ Tread cut
- ❖ Cut separation
- ❖ Tread separation
- ❖ Cut through from inside
- ❖ Sidewall cut
- ❖ Foreign object left in the tyre
- ❖ Breaking up of casing

Worst cases of a tyre burst

There are two worst reasons for tyre burst. They are,

1) External tyre fire
2) Tyre explosion

1) External tyre fire

The ignition temperature for rubber is around 400 degrees Celsius. But the tyres'bonding begins to break down at temperatures above 105degrees Celsius.

If tyres are spun on the spot persistently it is possible to generate enough heat on the tyre's surface to ignite rubber. In the presence of an external source of fire such as brake sparks or oil, explosion would occur that is hazardous.

Consequences would be explosion at the pressure of 1.3 times the inflation pressure and flow of molten rubber and steel.

2) **Tyre explosion**

An external ignition source is needed (e.g. high voltage, heat, contaminants) to start an internal tyre fire. The fire releases gases that build up to explosive levels, gases are ignited and an explosion occurs. The explosive force is many times greater than the initial inflation pressure. The consequence is an explosion with a pressure of 7 times the inflation pressure.

1.2.6 The Consequence of a Tyre Burst

The worst case scenario would occur when a front tyre bursts, leading the whole truck weight to transfer to its side due to instability. It would be worse when the burst occurs while travel. Unlike this it would be safer if it occurred at the rear because it would have a tyre to support its weight.

The main objective of our project is hence to overcome the brutal hazards of tyre burst over the driver by avoiding any accident mainly due to tyre burst.

1.3 BURST WHEEL - A REMEDY FOR TYRE BURST

1.3.1 Wheel Burst – A Danger

As discussed in the previous chapter, wheel burst could lead in serious accidents. Wheel bursts are an unexpected event and can happen anytime and anywhere.

1.3.2 The Event of a Wheel Burst

When a wheel bursts, instantaneously it leads to the expulsion of debris in large volumes. The event would be worse if it is an internal tyre burst which occurs at a greater pressure compared to the external tyre fire. The expulsion of debris would first lead to the impairing of the driver's vision. This would be the first event which would lead to the panic of the driver.

The next event would be the difficulty of steering the vehicle. Tyres are supposed to bear the weight of the vehicle while rest and tread. Any event of the tyre burst would instantaneously lead an impact to the steering wheel making it steer the vehicle. The immediate consequence would be the pulling of the vehicle towards a particular direction. Losing control would lead to the first possibility of accident. Head on collision and the truck running off road would be the result of loss of control.

The final and most dangerous consequence would be the weight transfer of the truck. Weight transfer is defined as the shift of the center of gravity when a vehicle is in motion. A simple event of steering a truck through tight corners could lead to weight transfer due to under steering. As in the case of tyre burst, there is an instantaneous event of weight transfer. A tyre burst at the front would lower the whole body towards one side. The rim at the burst tyre would experience more weight than any other tyre in the truck. Conditions could be worse if the truck is loaded to very tall heights. This could lead to the tumbling and roll over of the vehicle. Consequences could be unpredictable for the driver, pedestrians and other vehicles nearby.

1.3.3 The Burst Wheel

A burst wheel would be a circular disc of a metal of our choice which would be bolted on to the outer part of the front wheel which would be bigger in diameter of the rim and slightly smaller than the tyre, allowing uninterrupted tread.

1.3.4 Requirements of the Burst Wheel

1) As stated before the dimension of the burst wheel should be such that it helps situations of tyre bursts and does not interrupt the smooth treading of the vehicle.
2) The material selected should be such that the material would withstand the dynamic load while the wheel bursts.
3) The disc should not be too heavy which would lead difficulty in the steer of the vehicle.

1.3.5 Burst Wheel in Action

According to our vision in the event of tyre bursts the burst wheel should help support the vehicle leading minimum weight transfer, which could provide enough room for control of the vehicle. Even in the absence of a tyre, the burst wheel would provide enough support even in dynamic conditions.

1.4 VEHICLE STRUCTURE

1.4.1 Classification

Trucks are broadly classified based upon their load carrying capacity, total capacity of goods in terms of volume, the rate at which the goods are transferred and special purpose trucks such as tippers, tankers, trailors.

Pertaining to our project, the truck which most concern can be listed out as,

1) 6-wheelers.
2) 8-wheelers.
3) Truck with more than 8 wheels.

Of these kinds, 6-weelers are taken into account for our project.

TABLE 1.1 SPECIFICATIONS OF THE 6 WHEELER TRUCK

Model	1613H
Engine	H Series WO6DTI 2D Turbo charged inter cooled : Bharat Stage II
Max power	132 PS (97 KW) @ 2400 rpm
Max torque	43.8 Kgm @ 1600 - 1800 rpm
Suspension	Semi elliptic leaf springs in front and rear
Tyres	10.00 x 20 - 16 PR
Brakes	Dual line Full air
Loading Span	18 Feet
Max Speed	74.5 Kmph
Wheel Base	170.5"
Gross vehicle weight	16200Kg

Wheels

Next, narrowing down to the wheel of truck. Based on the usage and special features, they are differentiated as,

1) Single piece wheel.
2) Double piece wheel.
3) Three piece wheel.

Of these, three piece wheels are the most used and hence taken as the model for our project.

The three piece wheel:

This consists of three components, they are,

1) Wheel rim.
2) Lock nut.
3) Lock ring.

Wheel Hub Assembly:

The wheel hub assembly consists of four main components. They are,

1) Hub.
2) Brake drum.
3) Wheel.
4) Bolts.

Hub

It is a rotating member which is used to fix the wheel assembly

FIG 1.3 HUB

with the vehicle. It has eight holes to accommodate eight fixtures (bolts). Also it is used to transmit the load from the vehicle to the wheel.

Brake Drum

Brake drums are made of iron and have a machined surface on the inside where the shoes make contact.

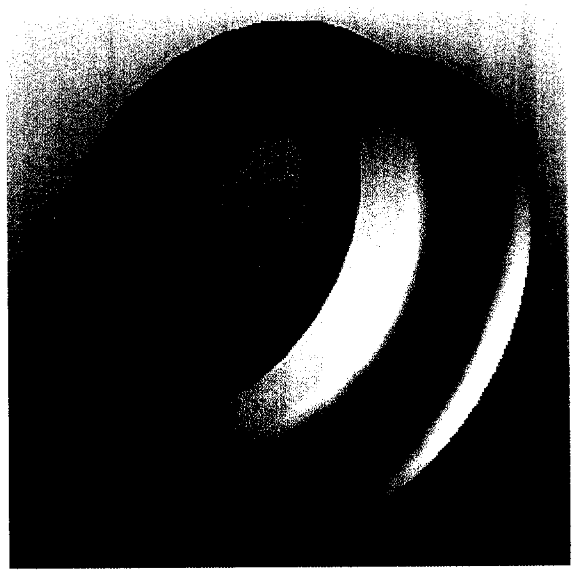

FIG 1.4 BRAKE DRUM

Just as with disk rotors, brake drums will show signs of wear as the brake linings seat themselves against the machined surface of the drum. When new shoes are installed, the brake drum should be machined smooth. Brake drums have a maximum diameter specification that is stamped on the outside of the drum. When a drum is machined, it must never exceed that measurement. If the surface cannot be machined within that limit, the drum must be replaced.

Wheel

A wheel is a circular device capable of rotating on its axis, facilitating movement or transportation or performing labour in machines. A wheel together with an axle overcomes friction by facilitating motion by rolling. Common examples are found in transport applications.

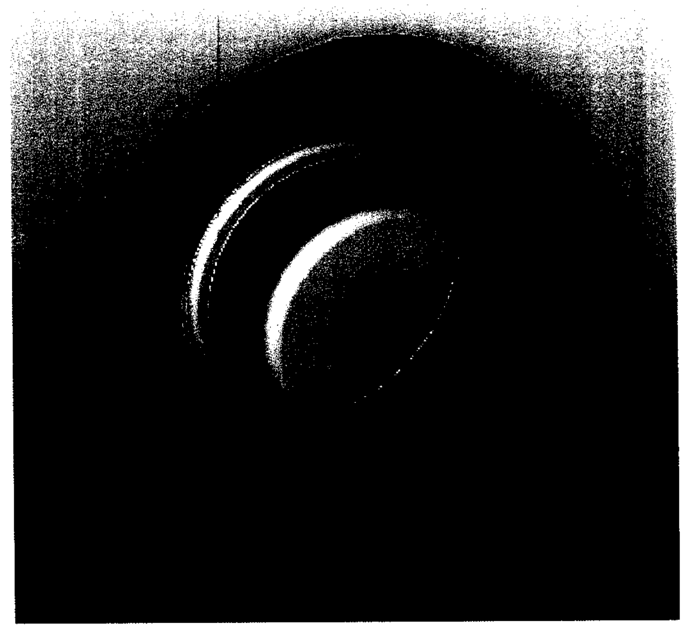

FIG 1.5 WHEEL AND TYRE

More generally the term is also used for other circular objects that rotate or turn, such as a Ship's wheel and flywheel.

Bolts

Bolts are fixtures used to fix the wheel assembly with the vehicle. Here in our wheel, 8 bolts are used.

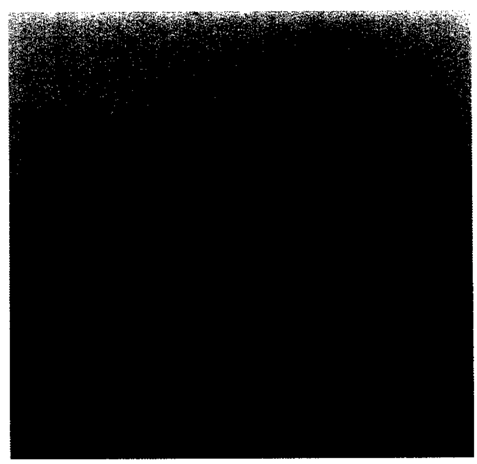

FIG 1.6 BACK BOLT

FIG 1.7 FRONT BOLT

The front wheel bolts and the rear wheel bolts differ in their length. The rear wheel bolts are 30 mm longer than the front wheel bolts since it has to hold up two wheels.

FIG 1.8 WHEEL HUB ASSEMBLY

1.4.2 Accommodation of the Burst Wheel

Accommodating the burst wheel in the truck should happen without making modification. The burst wheel has to attached besides the front wheels on the outer side, in order to carry out the above, the stock bolts in the front wheel does not have sufficient extra projection to accommodate the placing of the burst wheel.

This problem is countered by using the bolts used in the rear wheel of the truck which has an extra length of 30mm than of the front wheel. In order accommodate the Burst Wheel in the truck without doing much alteration to the existing setup we have to constrain our Burst Wheel design to have thickness of 30mm.Thus aptly suiting the burst wheel.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

In 1998, BMA Marketing, in conjunction with the Aluminium Federation of Southern Africa (AFSA) developed Namathela Tyrelok™. They developed a safety device which prevents a major disaster due to sudden tyre failure to an extent. The primary function of wheel-well fillers such as the Tyrelok™ Safety band is to close the well of the single piece tubeless tyre wheel rim. With the well closed the tyre cannot leave the wheel rim in the event of any form of tyre failure, thereby ensuring that the driver does not lose control of the vehicle. The essential purpose inherent to the Tyrelok™ Safety band is that it is designed primarily to prevent death and injury to people and damage to vehicles and assets, rather than saving tyres.

Tyreloks™ come into play in the event of any form of tyre failure, be it a sudden tyre burst or a gradual deflation. When a tyre deflates, and the bead of the tyre dislodges, the tyre is able to drop into the well of the rim. Once this happens the tyre can leave the rim resulting in the metal being exposed to the road. This makes it extremely difficult for the driver to control the vehicle, particularly on curves in the road.

Tyrelok™ is the world's first aluminium wheel safety band designed in conjunction with the Aluminium Federation of Southern Africa. It is rust proof, lightweight and easily fitted. With Tyreloks™ installed, the driver will not only be able to retain control of the vehicle but, if necessary, be able to travel between 20 and 25kms to a place of safety. This is extremely important in the light of the dangers posed when motorists are stranded at the side of the road.

The bands are fixed into place on the wheel rim with the unique semi-sinusoidal clip and a M5 stainless steel set screw with Nylock nut. The spring clip is manufactured from AA6082 alloy temper T-6 technical grade, and is secured into position in the wheel well.

Thus BMA Marketing manufactures a safety device which can be used for the tube less tyres. But for our trucks, we use only tyres with tubes. So this product cannot be used for the safety of our trucks during the event of the sudden tyre bursts.

CHAPTER 3

PRE PROCESSING

CHAPTER 3

PRE PROCESSING

3.1 CAD MODELLING OF BURST WHEEL

3.1.1 Dimensions

The thickness of the burst wheel should be 30mm or less than that. This is because the rear wheel bolts are 30 mm longer than the front wheel bolts and by replacing this we can establish the Burst Wheel without any ateration. I section is selected for to provide better stable design with the least material consumption.

In order to determine the diameter of the burst wheel, the following factors have to be considered.

1) The outer diameter of the tyre assembly under no load condition.
2) The outer diameter of the tyre assembly under maximum load condition.
3) The maximum reduction in the diameter of the tyre assembly due to wear and tear during driving

The diameter of the tyre in the normal unloaded condition with the proper inflation will be 1m. But when loaded the lower part of the tyre will get compressed for 1.5 cm. These are clearly explained in the following fig 3.1

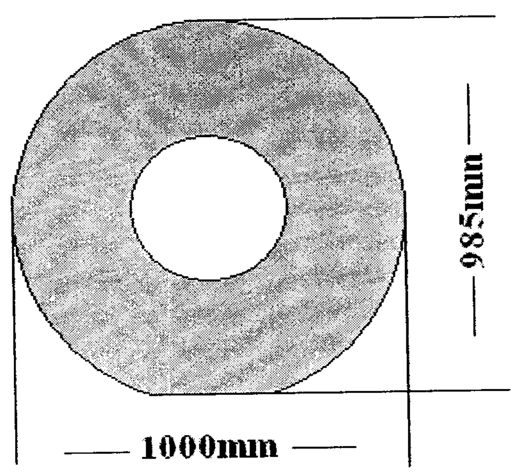

FIG 3.1 TYRE AT LOADED CONDITION

The tolerance value of the above are determined and diameter of the burst wheel is calculated as follows

1) Recommended Inflation pressure for our truck-100 PSI
2) For the above inflation pressure, the total diameter of the tyre assembly-1000mm
3) Change in diameter of the tyre assembly in full loaded condition-15mm (one side only)
4) Maximum wear of the tyre-30mm

Thus the total diameter of the BURST WHEEL with a clearance of 10mm is **920mm**

3.1.2 Modelling in PROE 2001

The dimensions of the burst wheel were calculated and explained above. Keeping I cross section for the design the part is modeled in the PROE using revolve option. The model is shown below in fig 3.2

FIG 3.2 BURST WHEEL

3.1.3 Accomodation

By changing the stock front bolts with the rear bolts we can establish extra 30mm in the front Wheel hub assembly.

FIG 3.3 HUB ASSEMBLY WITH BACK BOLTS

In that space we can easily place our design. The Burst Wheel assembled with the wheel hub assembly is shown below in fig 3.4

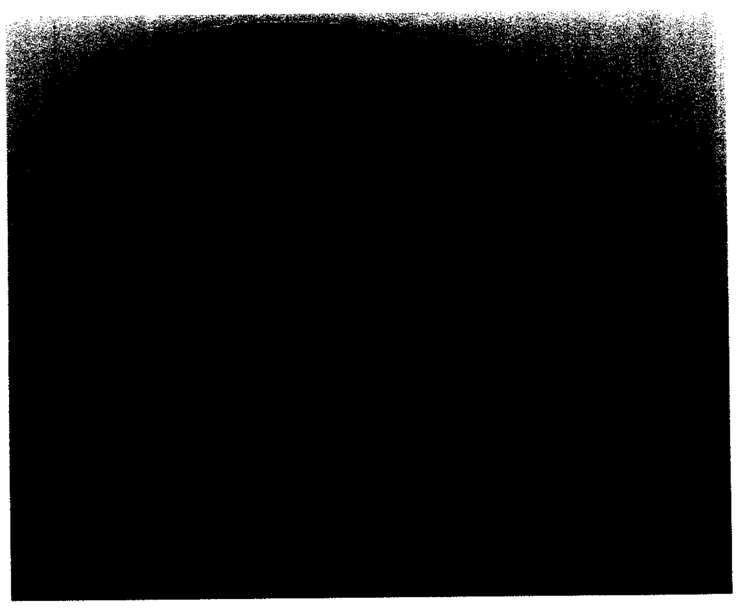

FIG 3.4 ASSEMBLED BURST WHEEL

The detailed design of the BURST WHEEL is shown below in the fig 3.5

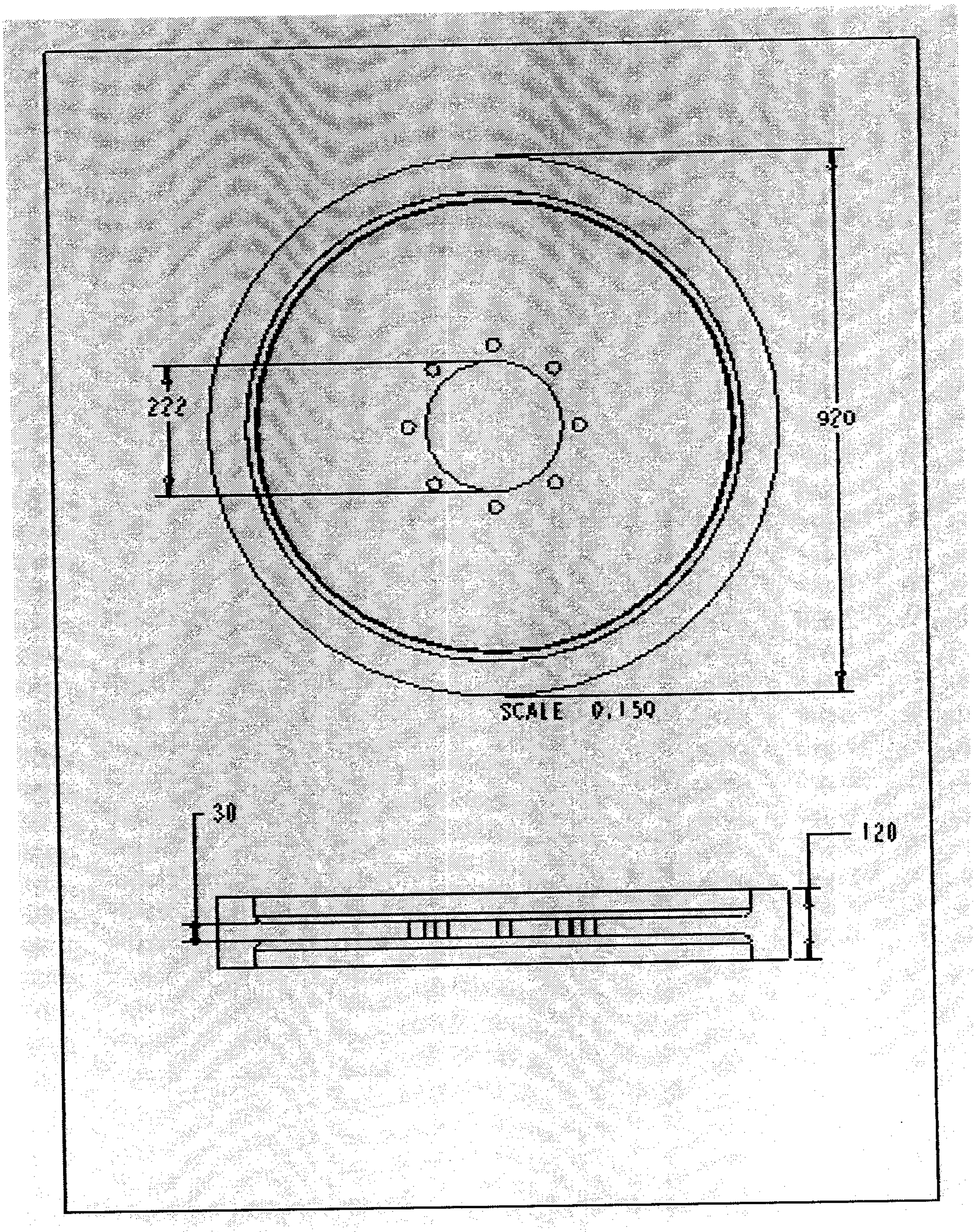

FIG 3.5 DETAILED DESIGN OF BURST WHEEL

3.2 FINTE ELEMENT ANALYSIS OF BURST WHEEL

3.2.1 Introduction to Finite Element Analysis

Finite element analysis (FEA) is a computer simulation technique used in engineering analysis. It uses a numerical technique called the finite element method (FEM).

The finite element analysis was first developed in 1943 by Richard Courant, who used the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 established a broader definition of numerical analysis. Development of the finite element method in structural mechanics is usually based on an energy principle such as the virtual work principle or the minimum total potential energy principle.

3.2.2 Work Behind FEA

In its applications, the object or system is represented by a geometrically similar model consisting of multiple, linked, simplified representations of discrete regions i.e., finite elements on an unstructured grid. Equations of equilibrium, in conjunction with applicable physical considerations such as compatibility and constitutive relations, are applied to each element, and a system of simultaneous equations is constructed. The system of equations is solved for unknown values using the techniques of linear algebra or nonlinear numerical schemes, as appropriate. While being an approximate method, the accuracy of the FEA method can be improved by refining the mesh in the model using more elements and nodes.

3.2.3 Use of Finite Element Analysis

A common use of FEA is for the determination of stresses and displacements in mechanical objects and systems. However, it is also routinely used in the analysis of many other types of problems, including those in heat transfer, solid state diffusion and reactions with moving boundaries, fluid dynamics and electromagnetism. FEA is able to handle complex systems that defy closed-form analytical solutions.

Analysis can help the user in accomplishing the following tasks

1) Reduce cost by simulating the testing of your model on the computer instead of expensive field tests.

2) Reduce time to market by reducing number of product development cycle.

3) Improve products by quickly testing many concepts and scenarios before making a final decision, giving you more time to think of new designs.

Finite element analysis is a way to simulate loading conditions on a design and determine the design's response to those conditions. There are many finite element software packages, both free and proprietary. ANSYS is one of those softwares with capabilities in many verticals. In general, there are three phases in any computer-aided engineering task.

1) Pre-processing(defining the finite element model and environmental factors to be applied to it.)
2) Analysis solver (solution of finite element model)
3) Post-processing of results (using visualization tools)

3.2.4 Applications of FEA to the Mechanical Engineering Industry

A variety of specializations under the umbrella of the mechanical engineering discipline such as aeronautical, biomechanical and automotive industries all commonly utilize the benefits of integrated FEA in the design and development of their products. Several modern FEA packages include specific components such as thermal, electromagnetic, fluid and structural working environments. In a structural simulation FEA helps tremendously in producing stiffness and strength visualisations and also in minimizing weight, materials and costs. FEA allows detailed visualisation of where structures bend or twist, and indicate the distribution of stresses and displacements. FEA software provides a wide range of simulation options with regards to controlling the complexity of both the modeling and the analysis of a system.

3.2.5 FEA and the Truck Industry

The truck industry is becoming more like other industries such as the automotive industry with regard to FEA's involvement in the design process (FEA Information 2005). However due to the unique need by truck manufacturers to provide a variety of different body configurations, it is unlikely that trucks will ever move to the unitary streamlined FEA integration process, as seen in the automotive industry (FEA Information 2005). The design process hasn't reached the required level of maturity where it can be simulation-driven. Furthermore the traditional design philosophy of the tried and tested truck designing techniques taking precedence is still held strong across the truck industry (FEA Information 2005). Although the industry remains far from adopting a complete bottom-up FEA integrated design process, FEA is fast increasing its role in product design and development in the truck industry.

3.3 INTRODUCTION TO ANSYS

The ANSYS program is a powerful multipurpose finite element tool that can be used in a variety of industries such as automobiles, railways, electronics, power generation and power transmission. The ANSYS program has many finite-element analysis capabilities, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis. The analysis guides in the ANSYS documentation set describe specific procedures for performing analyses for different engineering disciplines. ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping. With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.

3.3.1 Structural Capabilities of ANSYS

Structural analysis is probably the most common application of the finite element method as it implies bridges and buildings, naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools.

Static Analysis - Used to determine displacements, stresses, etc. under static loading conditions. ANSYS can compute both linear and nonlinear static analyses. Nonlinearities can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

Transient Dynamic Analysis - Used to determine the response of a structure to arbitrarily time-varying loads. All nonlinearities mentioned under Static Analysis above are allowed.

Buckling Analysis - Used to calculate the buckling loads and determine the buckling mode shape. Both linear (eigenvalue) buckling and nonlinear buckling analyses are possible.

In addition to the above analysis types, several special-purpose features are available such as Fracture mechanics, Composite material analysis, Fatigue, and both p-Method and Beam analyses.

3.3.2 Generic Steps to Solving any Problem in ANSYS

Like solving any problem analytically, we need to define the following.

1) Solution domain
2) Physical model
3) Boundary conditions
4) Physical properties

You then solve the problem and present the results. In numerical methods, the main difference is an extra step called mesh generation. This is the step that divides the complex model into small elements that become solvable in an otherwise too complex situation. Below describes the processes in terminology slightly more attune to the software.

Build Geometry

Construct a two or three dimensional representation of the object to be modeled and tested using the work plane coordinates system within ANSYS.

Define Material Properties

Now that the part exists, define a library of the necessary materials that compose the object (or project) being modeled. This includes thermal and mechanical properties.

Generate Mesh

At this point ANSYS understands the makeup of the part. Now define how the modeled system should be broken down into finite pieces.

Apply Loads

Once the system is fully designed, the last task is to burden the system with constraints, such as physical loadings or boundary conditions.

Obtain Solution

This is actually a step, because ANSYS needs to understand within what state (steady state, transient... etc.) the problem must be solved.

Present the Results

After the solution has been obtained, there are many ways to present ANSYS' results, choose from many options such as tables, graphs, and contour plots.

3.4 PRE-PROCESSING

3.4.1 Geometric Model

The modeled BURST WHEEL, in Pro/ENGINEER software is stored in IGES format, is imported to the ANSYS workspace. This is done by using import option selected using the following GUI path.

ANSYS Utility Menu Bar → File → Import → IGES.

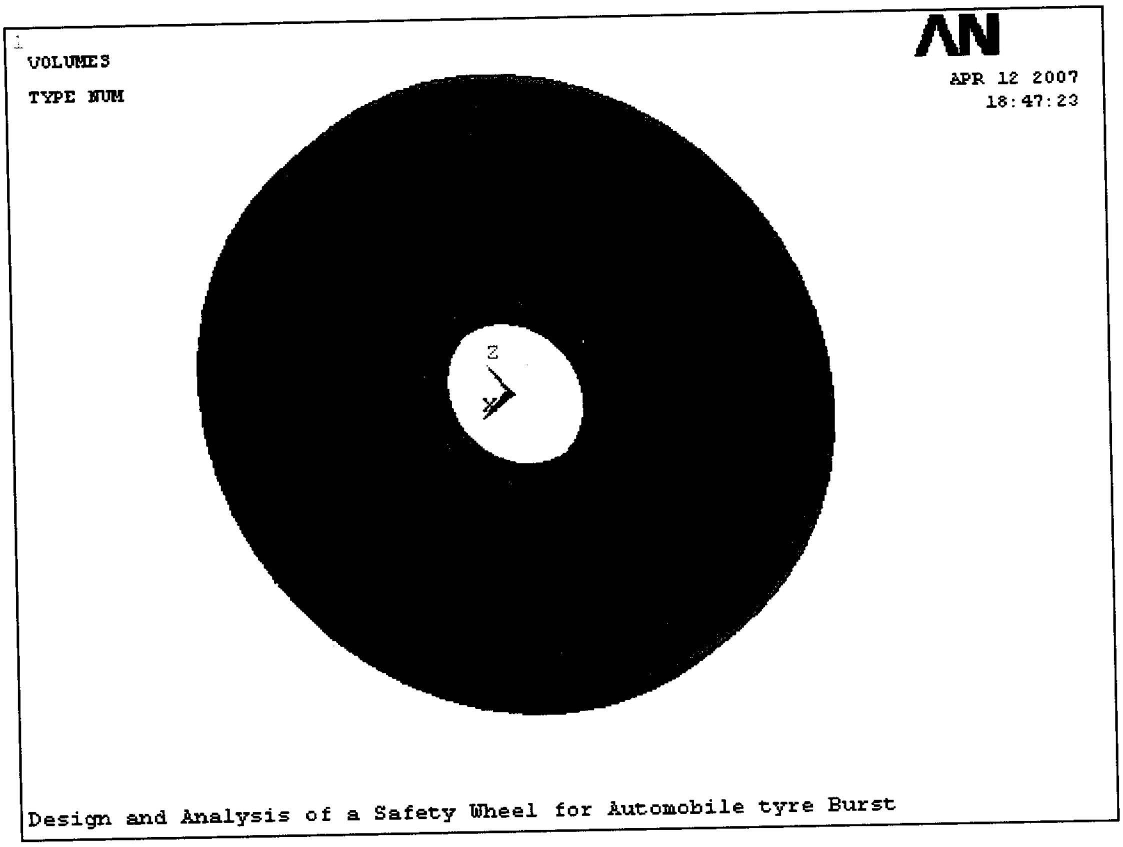

FIG 3.6 GEOMETRIC REPRESENTATION OF BURST WHEEL

While importing this model there was no data loss occurred because of conversion. The model is checked for its volume.

3.4.2 Defining Element Type

The ANSYS element library contains more than 150 different element types. Choice of suitable mesh is vital to the accuracy and economy of the output of finite element analysis. While going through the literature available in ANSYS element module, it was found that the following elements were suitable to the nature of load which we dealt with our analysis.20-Node Non-Layered Structural Solid (3-D SOLID186) element was suitable to be applied to the analysis, since it could take up pressure and force as input.

Non-Layered Structural SOLID 186

20-Node Non-Layered Structural Solid (3-D SOLID186) element was suitable to be applied to the analysis, since it could take up pressure and force as input.

Geometry of SOLID 186

SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities.

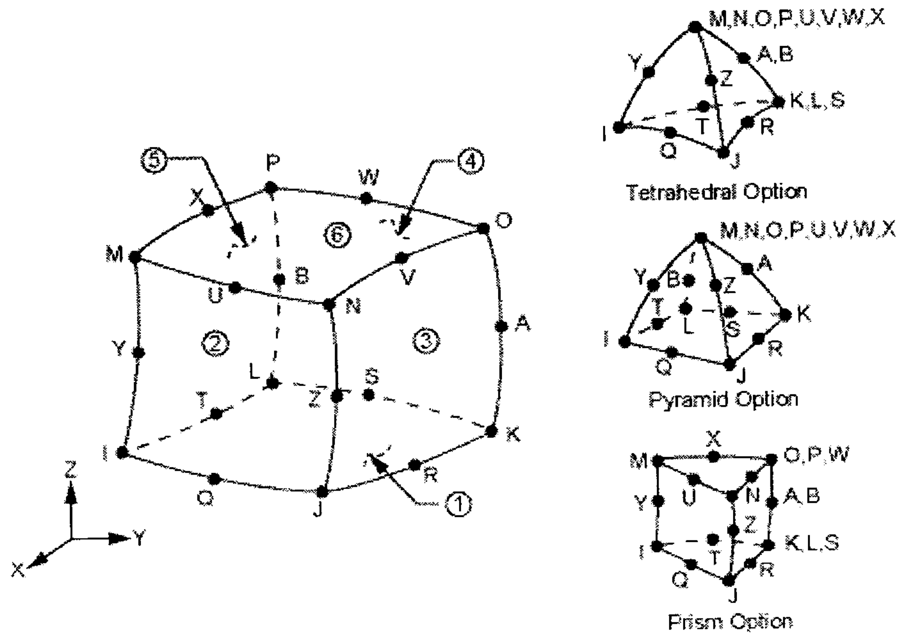

FIG 3.7 GEOMETRY OF SOLID 186

It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials.

SOLID186 Structural Solid Input Summary

Nodes

I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, A, B

Degrees of Freedom

UX, UY, UZ

Real Constants

None

Material Properties

EX, EY, EZ, ALPX, ALPY, ALPZ (or CTEX, CTEY, CTEZ *or* THSX, THSY, THSZ), PRXY, PRYZ, PRXZ (or NUXY, NUYZ, NUXZ), DENS, GXY, GYZ, GXZ, DAMP

Surface Loads

Face 1 (J-I-L-K), face 2 (I-J-N-M), face 3 (J-K-O-N), face 4 (K-L-P-O), face 5 (L-I-M-P), face 6 (M-N-O-P)

Special Features

1) Plasticity
2) Hyper elasticity
3) Viscoelasticity
4) Viscoplasticity
5) Creep
6) Stress stiffening
7) Large deflection
8) Large strain
9) Initial stress import
10) Automatic selection of element technology
11) Birth and death

SOLID186 Structural Solid Output Data

The solution output associated with the element is in two form of Nodal displacements included in the overall nodal solution.

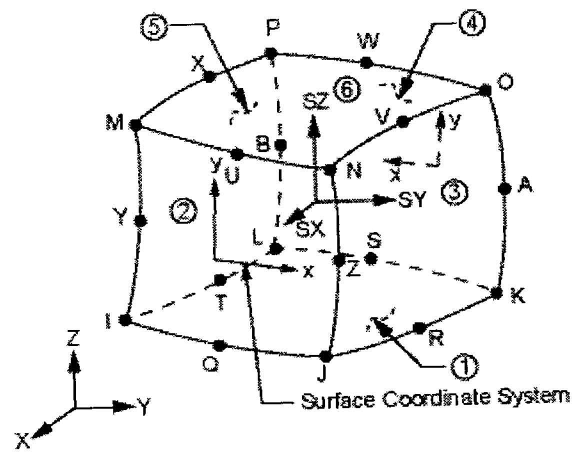

FIG 3.8 SOLID186 STRUCTURAL SOLID STRESS OUTPUT

Assumptions and restrictions

The following assumption and restrictions were applied to the element SOLID186.

1) The element must not have a zero volume.
2) An edge with a removed midside node implies that the displacement varies linearly, rather than parabolically, along that edge.
3) Use at least two elements in each direction to avoid hourglass mode if uniform reduced integration is used.

MASS 21

MASS21 is a point element having up to six degrees of freedom. The DOFs are translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes. A different mass and rotary inertia may be assigned to each coordinate direction.

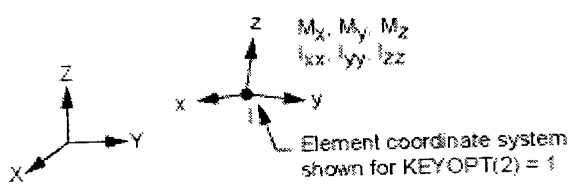

FIG 3.9 GEOMETRY OF MASS ELEMENT 21

Mass 21 input summary

Nodes

I

Degrees of Freedom

UX, UY, UZ, ROTX, ROTY, ROTZ if KEYOPT (3) = 0

UX, UY, UZ if KEYOPT (3) = 2

UX, UY, ROTZ if KEYOPT (3) = 3

UX, UY if KEYOPT (3) = 4

(Degrees of freedom are in the nodal coordinate system)

Real Constants

MASSX, MASSY, MASSZ, IXX, IYY, IZZ, if KEYOPT(3) = 0

MASS, if KEYOPT (3) = 2

MASS, IZZ, if KEYOPT (3) = 3

MASS, if KEYOPT (3) = 4

(MASSX, MASSY, and MASSZ are concentrated mass components in the element coordinate directions. IXX, IYY, and IZZ are rotary inertias about the element coordinate axes. See also KEYOPT (2)).

Material Properties

DENS (if KEYOPT (1) = 1)

Surface Loads

None

Body Loads

None

Special Features

Large deflection

Birth and death

MASS 21 Output Data

Nodal displacements are included in the overall displacement solution. There is no printed or post element data output for the MASS21 element.

MASS21Assumptions and Restrictions

1) 2-D elements are assumed to be in a global Cartesian Z = constant plane.
2) If you specify KEYOPT (2) = 1, the element operates in the nodal coordinate system (see Elements that Operate in the Nodal Coordinate System).
3) The mass element has no effect on the static analysis solution unless acceleration or rotation is present, or inertial relief is selected [**IRLF**].
4) The standard mass summary printout is based on the average of MASSX, MASSY, and MASSZ if (KEYOPT (3) = 0).
5) In an inertial relief analysis, the full matrix is used. All terms are used during the analysis.

SURF 154

SURF 154 (3-D Structural Surface Effect) was used in the loading area. SURF154 may be used for various load and surface effect applications. It may be overlaid onto an area face of any 3-D element. The element is applicable to 3-D structural analyses. Various loads and surface effects may exist simultaneously. The geometry, node locations, and the coordinate system for this element are shown in figure. The element is defined by four to eight nodes and the material properties. A triangular element may be formed by defining duplicate K and L node numbers as described in Triangle, Prism and Tetrahedral Elements. The default element x-axis is parallel to the I-J side of the element.

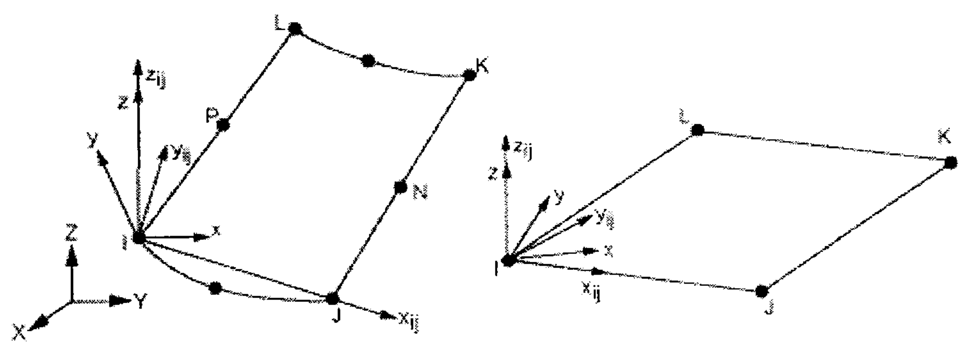

FIG 3.10 GEOMETRY OF SURF 154

SURF 154 Input Summary

Nodes

I, J, K, L if KEYOPT (4) = 1

I, J, K, L, M, N, O, P if KEYOPT (4) = 0

Degrees of Freedom

UX, UY, UZ

Material Properties

DENS, VISC, DAMP

Surface Loads

Pressures

Face 1 (I-J-K-L) (in -z normal direction)

Face 2 (I-J-K-L) (tangential (+x))

Face 3 (I-J-K-L) (tangential (+y))

Face 4 (I-J-K-L) (in -z normal direction, global taper)

Face 5 (I-J-K-L) (oriented by input vector)

Body Loads

Temperatures

T(I), T(J), T(K), T(L); also T(M), T(N), T(O), T(P) if KEYOPT(4) = 0

Special Features

Stress stiffening

Large deflection

Birth and Death

Assumptions and Restrictions

1) The element must not have a zero area.
2) The surface tension load vector acts in the plane of the element as a constant force applied to the nodes seeking to minimize the area of the surface.
3) For structural large deflection analyses, the loads are applied to the current size of the element, not the initial size.

3.4.3 Defining Material Properties

The Burst Wheel is made with High Strength Steel with the following properties. The steel grade used is Mart 1250/1520

TABLE 3.1 MATERIAL PROPERTIES

S. No.	Property	Value
1.	Ultimate tensile strength	1570 N/mm^2
2.	Modulus of Elasticity	2.1 X 10^5 N/mm^2
3.	Poisson's ratio	0.34
4.	Yield Stress	1250 N/mm^2

3.4.4 Meshing the Model

The imported model is meshed wisely for the analysis. Mesh selection is very tedious process.

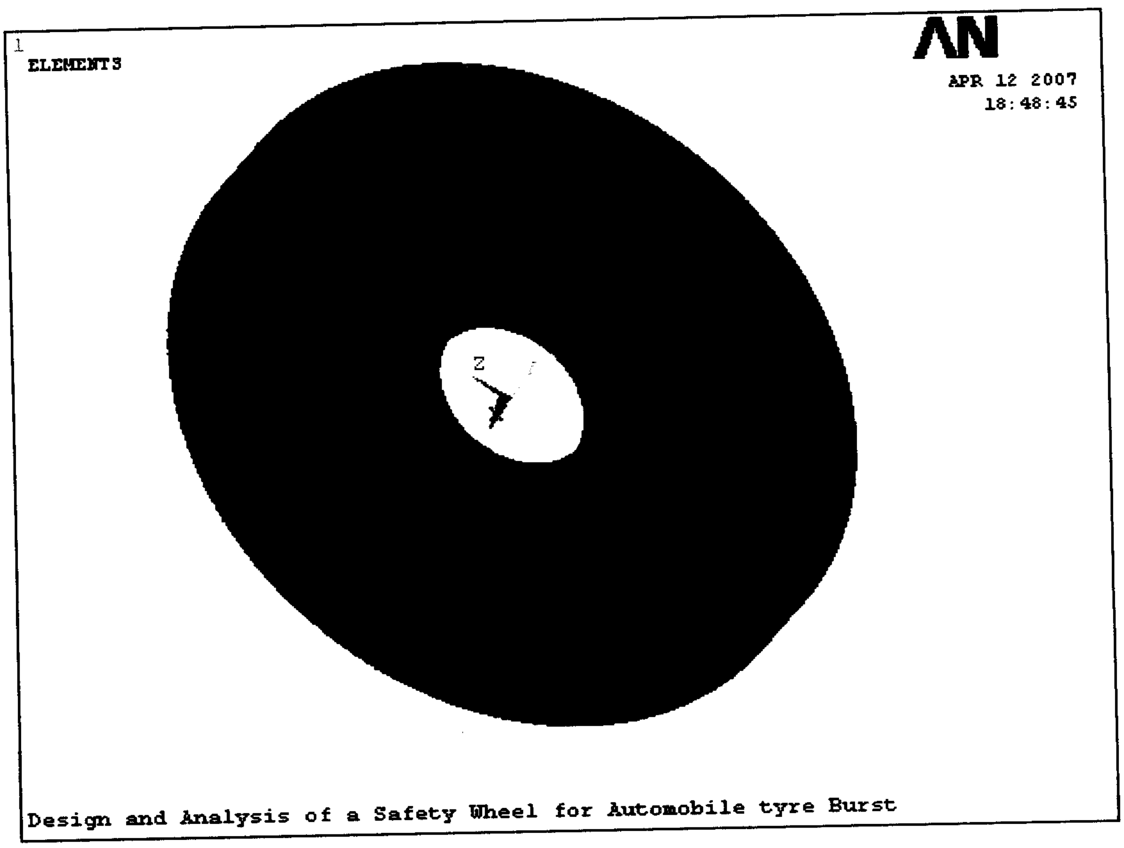

FIG 3.11 DISCRETIZED MODEL

In this case SWEEP mesh is selected and the imported model is meshed. Smart sizing gives the mesher a great opportunity to create reasonably shaped element during automatic element generation. In the mesh tool Smart sizing option is enabled and set at value 1. With that fine sizing the total no of elements and nodes what we got is mentioned below.

No. of Nodes - 72090

No. of Elements

SOLID 186 - 14420

Aspect Ratio

The element is checked for aspect ratio. Diagram shown below describes the dimension of one of the elements.

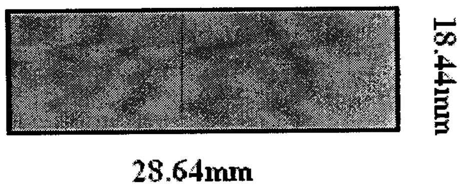

FIG 3.12 ASPECT RATIO

From the above element dimension the aspect ratio is calculated as follows.

Aspect Ratio = Height/Length (Should be between 0.6 to 0.7)

= 18.44/28.64

= **0.643**

Thus the value is within the acceptable limit. Hence the results will approach the accurate value to the best. The Burst Wheel meshed with this element is shown in the figure model is shown above in the figure.

3.4.5 Creating Surface Elements

The load on the Burst Wheel is acting in the inclined position. For applying loads in the inclined position over the selected nodes, we have to choose those particular nodes and have to change the coordinate system. Instead we can easily apply inclined and horizontal loads by incorporating Surface Elements. Here by simply giving face numbers we can change the angle in which the force acts.

Surface elements were created in the lower portion of the burst wheel which will first get contact to the road surface at the time of tyre burst. The load is applied on these surface elements. For creating these surface elements the GUI required is shown below.

From the main menu,

Modeling→Create→Elements→Surf/Contact→Surfeffect→General Surface→Extra node

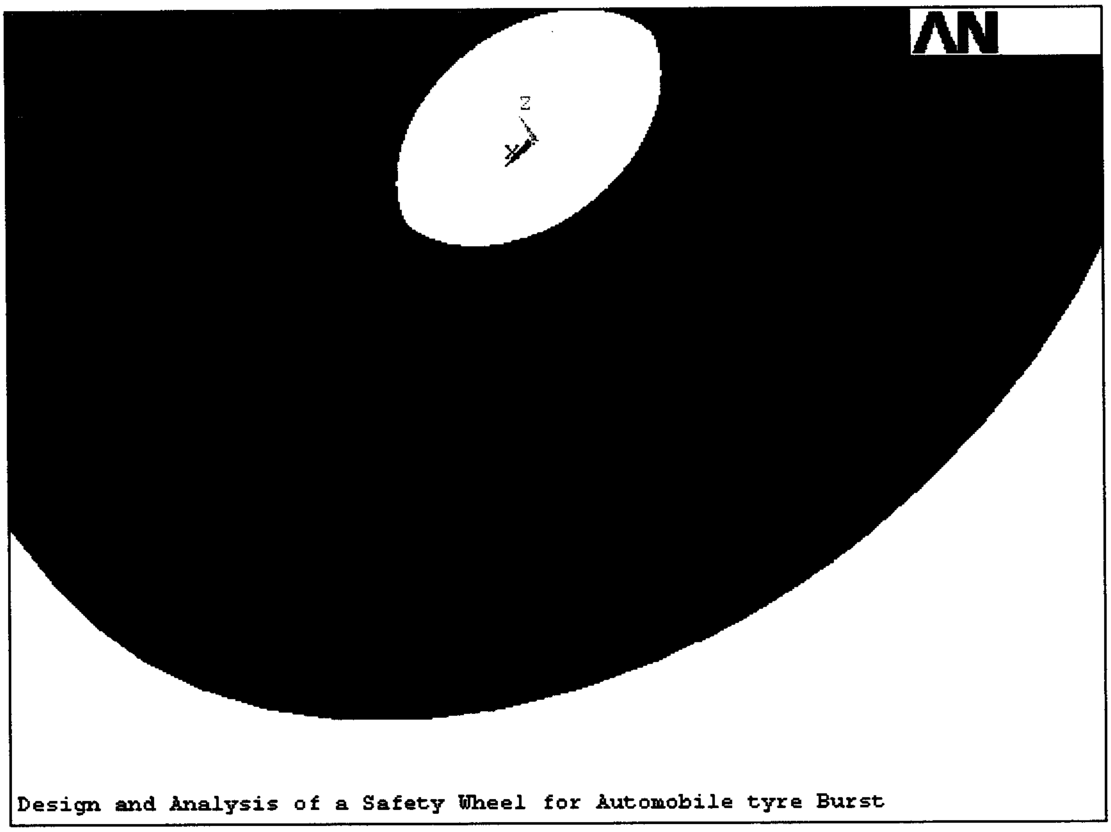

FIG 3.13 SURFACE AFFECT ELEMENTS.

The surface elements created are shown above. Since the circumference is very large compared to the length where surface elements were created, the area of the surface elements is calculated without considering its curved length.

Total no. of Surface Affect Elements - 32

Area of the Surface Elements -		(Length along the Burst Wheel X Width of the plate)
	-	130 X 120
	-	**15600mm^2**

The above shown surface elements are used to load the disc for analysis.

These are the major steps which we have to do in the pre-processing stage of this finite element analysis of BURST WHEEL.

CHAPTER 4

ANALYSIS

CHAPTER 4

ANALYSIS

4.1 LOAD CALCULATION

In this section the exact load which will act on the BURST WHEEL at the time of tyre burst is listed down. The various components of force acting on the burst wheel were calculated and explained individually.

4.1.1 Weight Distribution

The truck we have taken for our project is measured in a weigh bridge for to get the weight distribution. Weight of the truck with load and without load is measured. In both the case the truck is first positioned in the weigh bridge with its front wheels on the centre of the bridge. Then the truck is positioned in such a way its back wheels were on the weigh bridge. The load details observed is shown below.

TABLE 4.1 WEIGHT DISTRIBUTIONS

Truck load condition	Front	Back	Total
Empty	3380Kg	3250Kg	6695Kg
Loaded	4925Kg	11615Kg	16575Kg

Percentage weight distribution for the empty truck

There is a difference of 65 kg in the empty truck measurement between its total and distributed weight. This is because the surface near the weighing platform is not flat. The difference is added proportionally for exact calculations (25 to the front and remaining to the back).

Front

Weight taken by front wheels 3405kg.

So, (3405/6695) X100 = 50.8%

Back

Similarly for the back wheels, the total weight for this portion is 3290kg.

So, (3290/6695) X100 = 49.2%

Thus the weight distribution for empty truck is 51% for the front and 49% for the back. Here the proportion leads by front all because of the engine weight.

Percentage weight distribution for the loaded truck

There is a difference of 35 kg in the loaded truck measurement with its distributed weight. This is because the surface near the platform is not flat. That difference is added proportionally for exact calculations (15 to the front and remaining to the back).

Front

Weight taken by front wheels 4940kg.

So, (4940/16575) X100 = 29.8%

Back

Similarly for the back wheels, the total weight for this portion is 11635kg.

So, (11635/16575) X100 = 70.1%

Thus the weight distribution for loaded truck is 30% for the front and 70% for the back. Since the C.G. of the truck lies in the rear $2/3^{rd}$ part the rear leads in this distribution.

Here the loaded truck weight distribution is taken for calculating the components of force acting on the BURST WHEEL.

4.1.2 Potential load calculation

Total weight of the loaded truck is 16575kg and the empty is 6695kg. Thus load is 9880kg.

Considering the factor of safety, the load of the truck is multiplied by two and taken for analysis. Hence the factor of safety (FOS) is calculated as follows.

FOS = (Weight taken for calculation/actual weight)

= 33150/16575

= 2

Thus the factor of safety is 2

According to the percentage of distribution calculated above the weight which the front wheels experience will be as follows

Front = (33150 X 30)/100

= 9945kg

Back = (33150 X 70)/100

= 23205kg

The front portion has two wheels and hence experience 4972.5kg (9945/2) each (approximately 5tons). Thus the potential energy stored in the front wheel is calculated as follows.

Potential energy = mgh

= 5000 X 9.81 X 40

(40mm is clearance distance between burst wheel and the road.)

= 1951209Nmm

Force due to potential energy is given as follows,

Energy = Force X Displacement

Hence,

Force = 1951209/40

= 48780.225N

Thus the force due to potential load is calculated as **48780.225N**

4.1.3 Kinetic load calculation

Let us consider the vehicle is moving at a speed of 100kmph at the time of tyre burst. The kinetic energy stored in the rolling mass is calculated as follows. Total weight of the vehicle is 17 tons.

$$\text{Kinetic Energy} = 0.5mv^2$$
$$= 0.5 \times 17000 \times 27780^2$$
$$= 6.55 \times 10^{12}\text{Nmm.}$$

Braking distance

Assuming proper operation of the brakes on the vehicle, the minimum stopping distance for a vehicle is determined by the effective coefficient of friction between the tires and the road, and the driver's reaction time in a braking situation. The friction force of the road must do enough work on the truck to reduce its kinetic energy to zero. The coefficient of friction (μ) between road and tyre is taken as 0.3. Thus the stopping distance can be calculated as follows.

$$\text{Braking Distance (d)} = V^2 / 2\mu g$$
$$= 27.77^2/2 \times 0.3 \times 9.81$$
$$= 131.01\text{m}$$

Thus net force developed by the truck due to kinetic energy is given by

$$\text{Kinetic force} = \text{Kinetic Energy/Braking Distance}$$
$$= 6.55 \times 10^{12}/131010$$
$$= 50 \times 10^6\text{N.}$$

4.1.4 Calculating the actual magnitude of Kinetic load acting on wheel

The kinetic force calculated above wont act fully on the burst wheel as the truck will continue to run with the help of Burst Wheel even after the tyre burst. A part of this force acting on the burst wheel is calculated by performing real time analysis as follows.

Modeling and Meshing

The model for this analysis is developed in PROE and imported directly into the ANSYS after converting it to the IGES format. It consist the front wheels along with the BURST WHEEL as such in the burst condition. The model is shown below. Here the right one assumed to be in the burst condition.

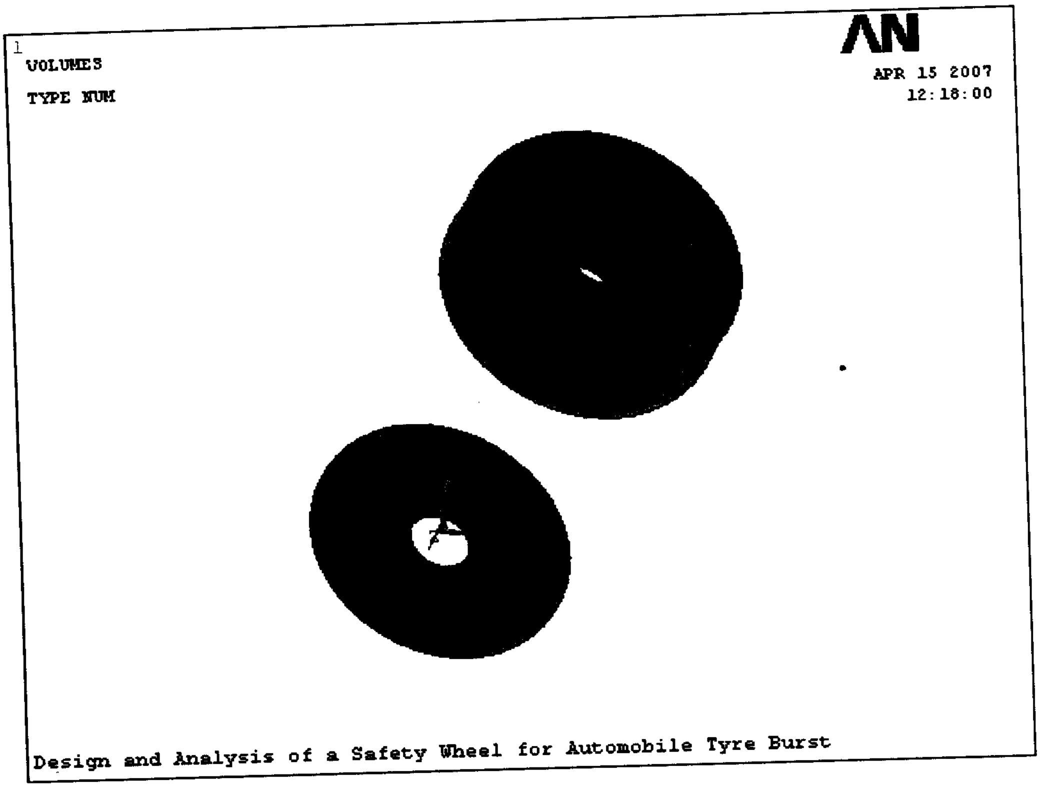

FIG 4.1 WHEELS AS IN THE BURST CONDITION

There will be an offset of 4cm lies between the centers of the wheels. This 4cm is because of clearance given between Burst Wheel and road initially.

A mass element is established at the roughly calculated C.G. to represent the total weight of the truck. The model is meshed with smart sizing one to achieve fine mesh.

No. of Nodes - 26688

No. of Elements

SOLID 186	-	5450
MASS 21	-	1

All the elements were satisfying the accepted aspect ratio range.

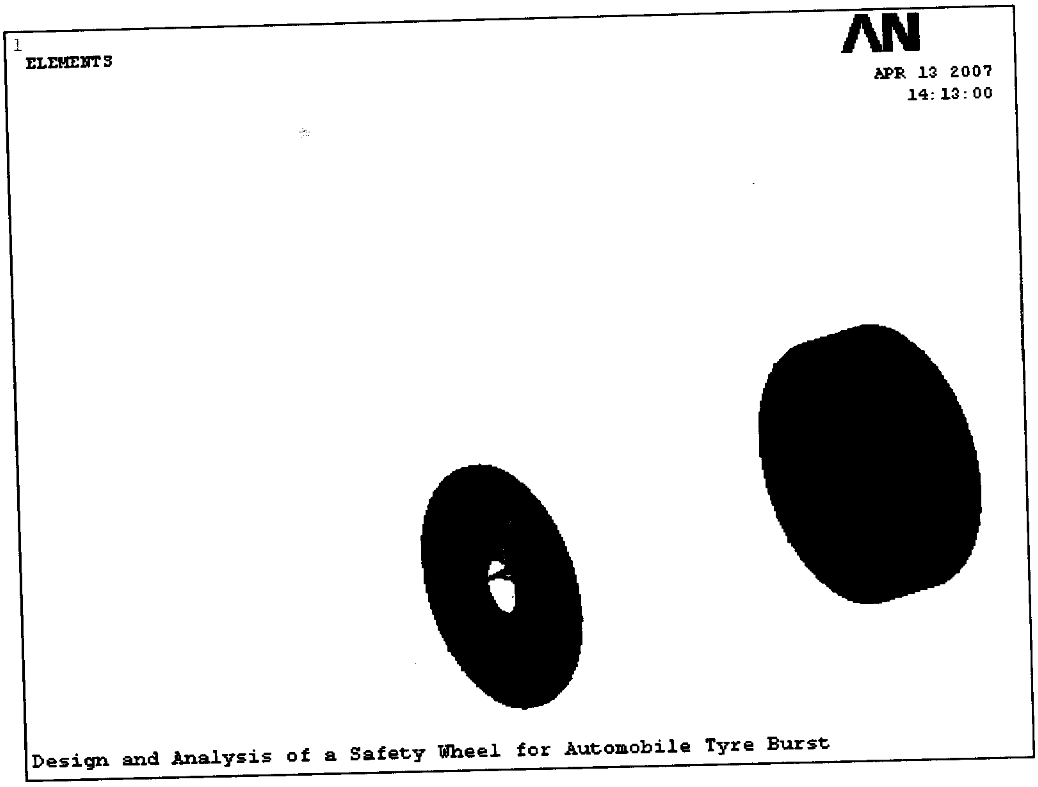

FIG 4.2 MESHED MODEL

Coupling and Constraining

The mass element is coupled with the nodes at the inner hole area and constrained for all DOF. The coupled model is shown below. Here the wheels

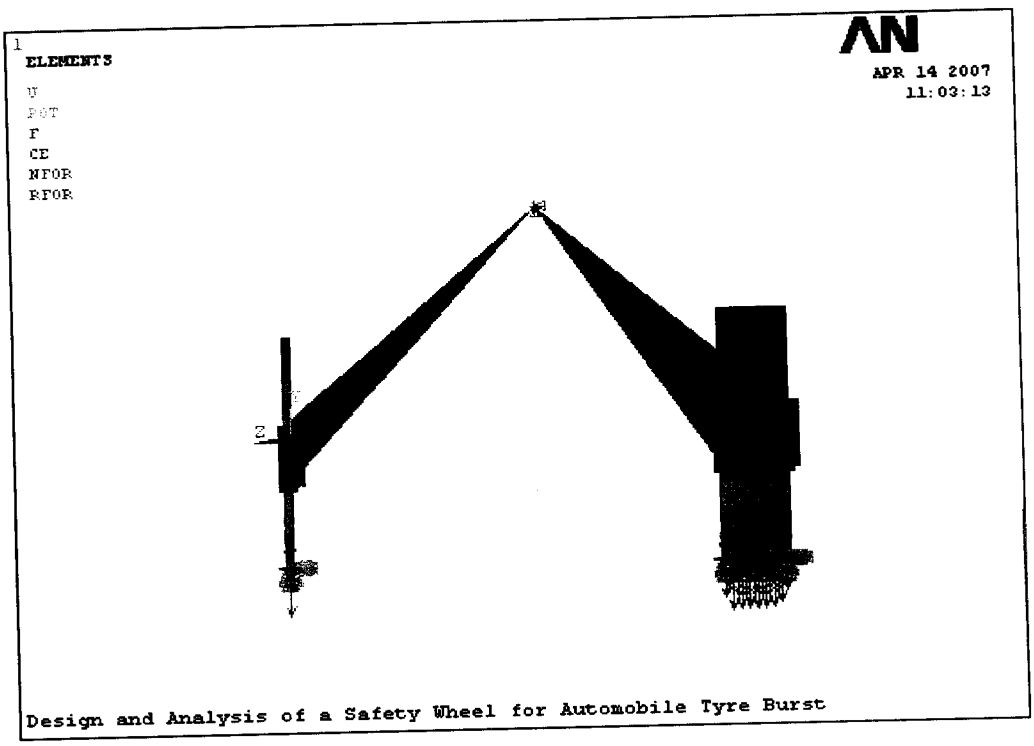

FIG 4.3 COUPLED MODEL

are constrained at its base area for 20 degrees. The constrained area is given below.

Circumference	=	2 X 3.14 X Radius
	=	2 X 3.14 X 460
	=	28888mm
Angle in radians	=	(20degrees / 180) X 3.14
	=	0.348rad

So, the length of arc is given by

=	radius X angle
=	460 X 0.348
=	160mm

Thus the area constrained is given as,

=	160mm X thickness of the plate
=	160 X 30
=	4800mm^2

The kinetic energy load calculated previously is applied at the C.G node in the FX direction. The constrained model with forces is shown below.

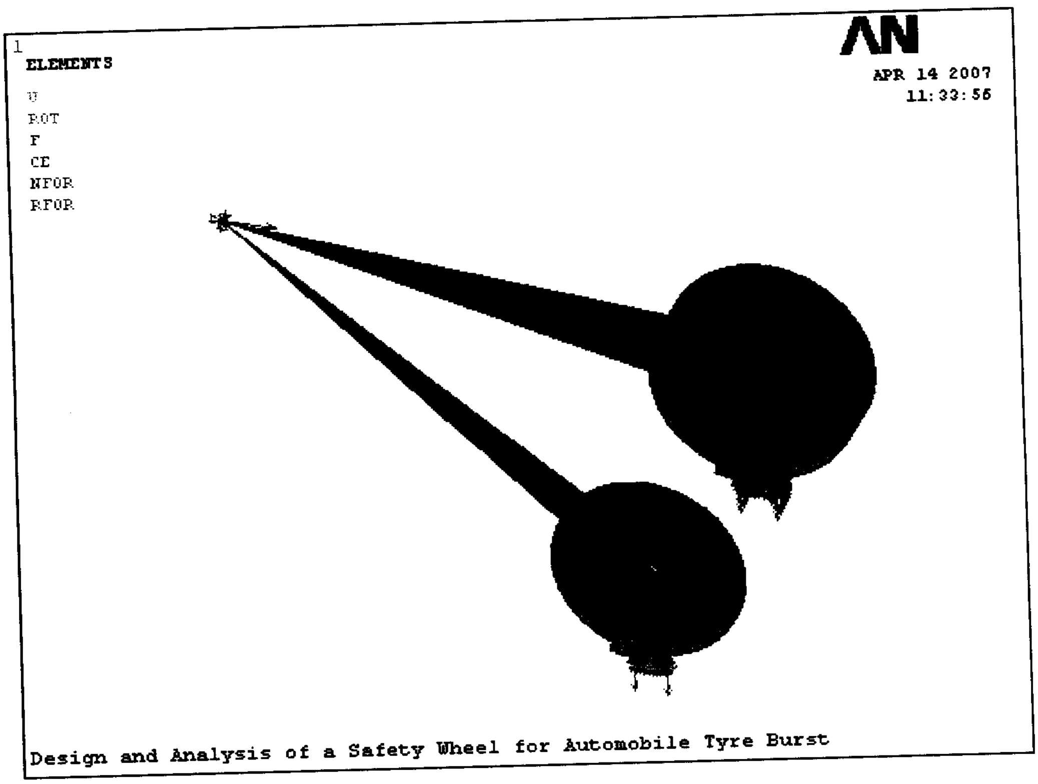

FIG 4.4 COUPLED MODEL WITH FORCES

Stress plots and Actual load calculation

The model with above initial conditions is analyzed. The various stress plot what we obtained are shown below.

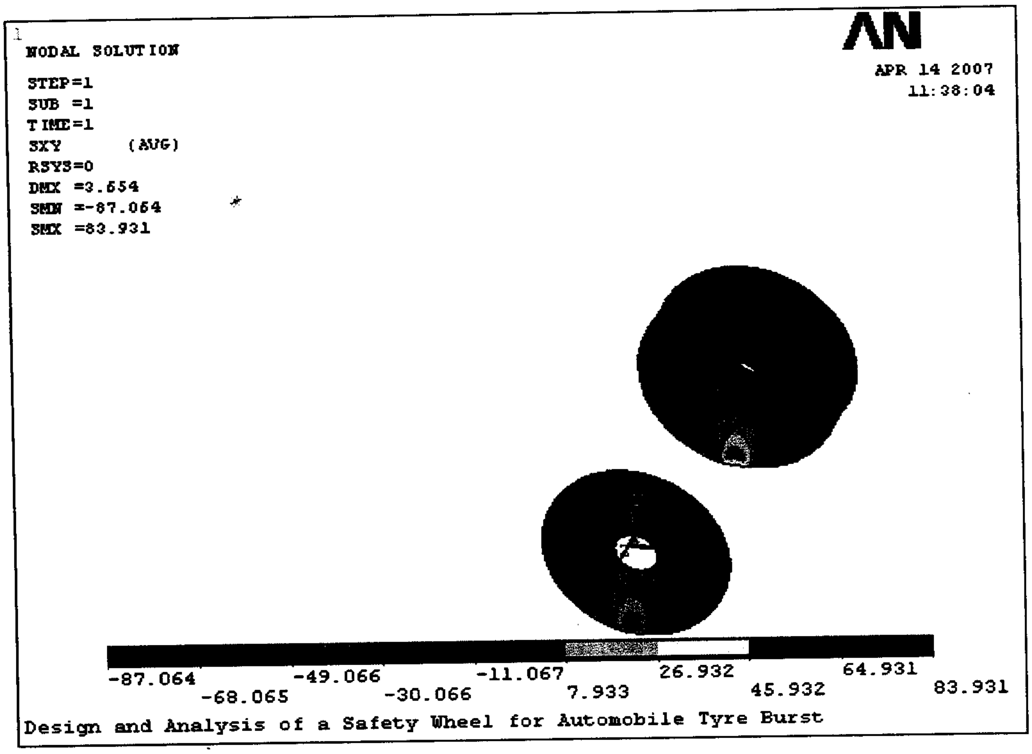

FIG 4.5 XY SHEAR STRESS

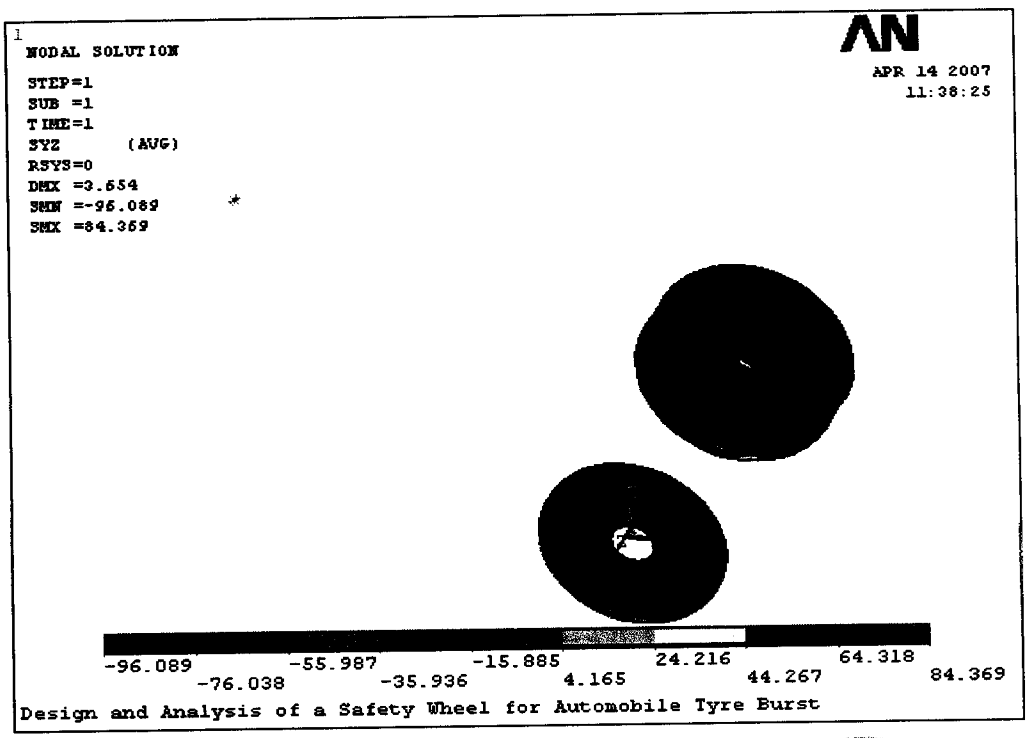

FIG 4.6 YZ SHEAR STRESS

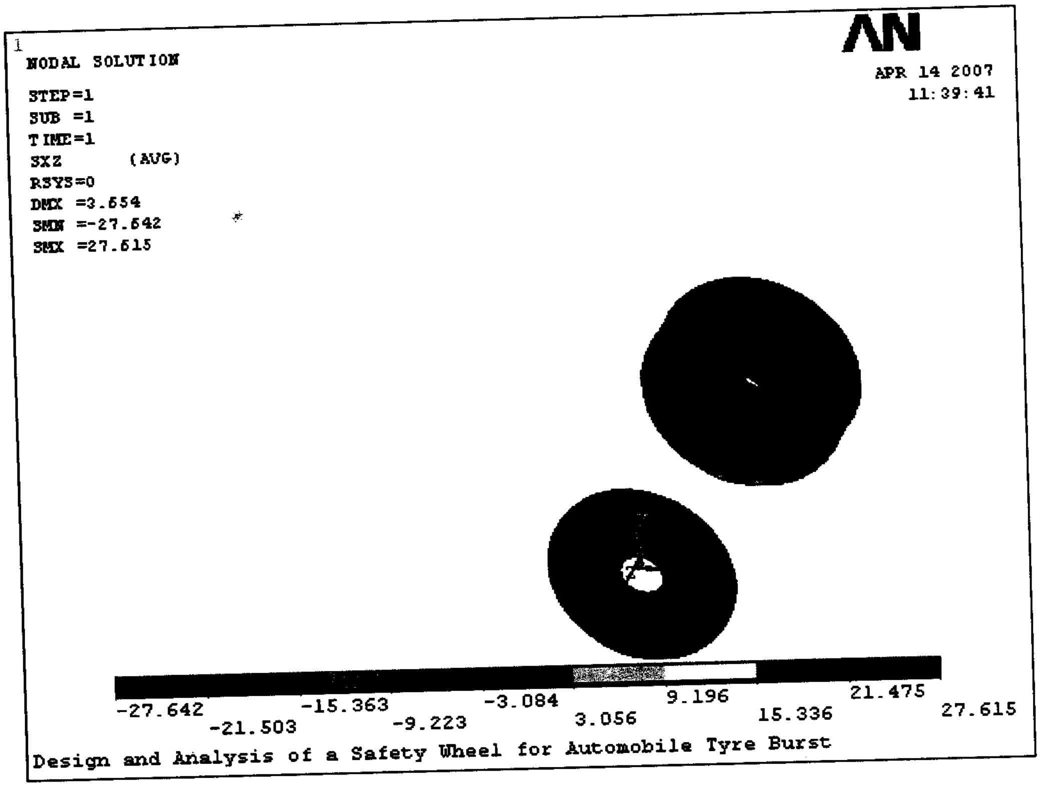

FIG 4.7 XZ SHEAR STRESS

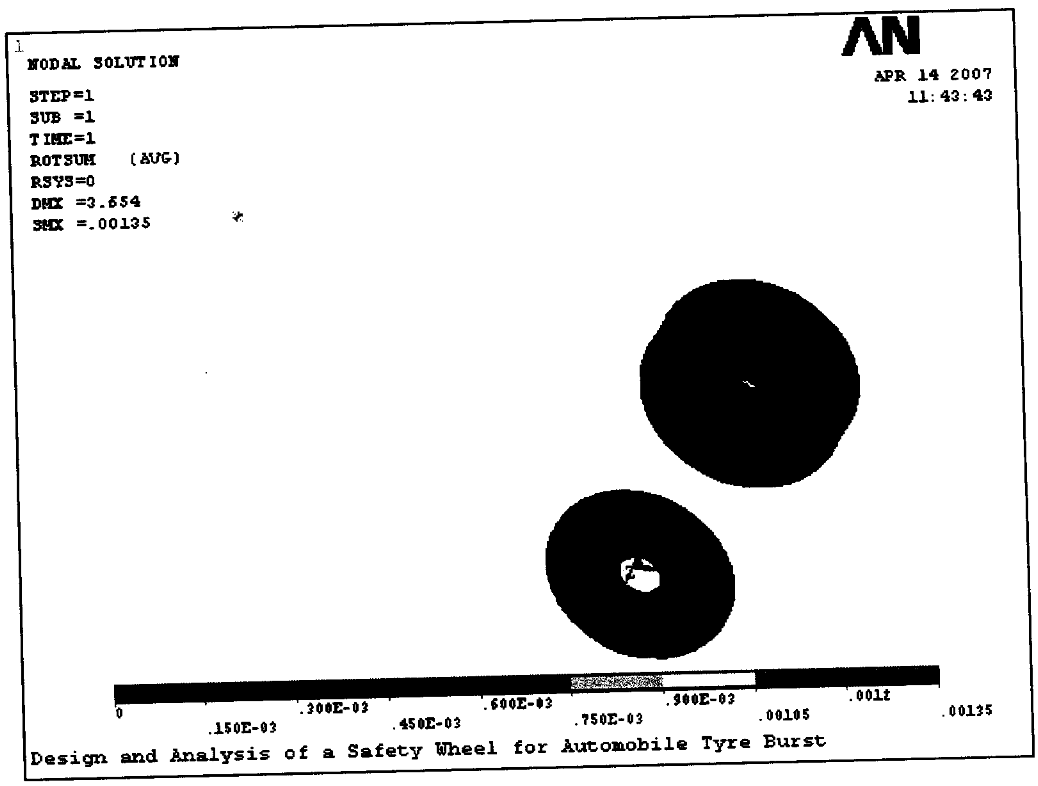

FIG 4.8 AXIAL STRESS

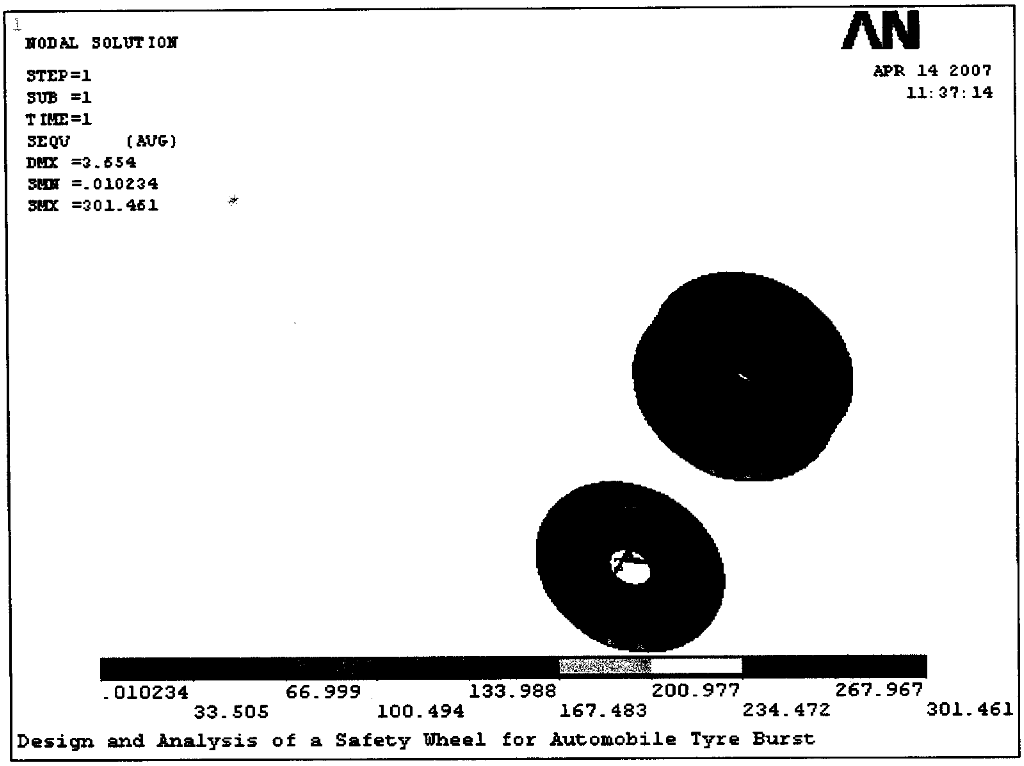

FIG 4.9 VON MISES STRESS

From the above observations the actual maximum stress experienced by the wheel is 301.461N/mm^2

So, the actual load acting on the burst wheel can be calculated as follows.

Actual load	=	301.461 X Area constrained
	=	301.461 X 160 x 30
	=	1.44 X 10^6N

Thus, Net Kinetic Force acting on the burst plate is **1.44 X 10^6N**

4.1.5 Resultant Calculation

Thus totally two forces acting on the Burst Wheel at the time of tyre burst. They are,

1) Potential Load
2) Part of Kinetic Load

The Burst Wheel will experience a reaction force at the contact area with magnitude equal to the resultant of above two loads. The potential load (P.L.) is acting vertically downwards and the kinetic load (K.L.) is horizontally outwards in the direction of the vehicle motion.

The resultant (R) is given by

R = (P.L^2 + K.L^2) ^1/2

(Since the angle between the forces is 90 degrees)

= (48780.225^2 + (1.44 X 10^6) ^2) ^1/2

= (2.0759 X 10^12) ^1/2

= **1.44 X 10^6N**

Angle = tan^-1(P.L/K.L)

= tan^-1(48780.225/1.44 X 10^6)

= 1.94 degrees

The reaction force will be in the opposite direction acting in the same angle. Since the angle is very small it is neglected and the reaction force is applied horizontally towards the disc.

In order to avoid stress singularity the above calculated load is applied as pressure in the Burst Wheel. The load is actually applied in the surface elements and hence the pressure is calculated as follows.

Pressure = 1.44 X 10^6N/Area of surface elements.

= 1.44 X 10^6N/16500

= **87.27N/mm^2**

This pressure is applied on the surface affect elements in the horizontal direction pointing towards the burst plate (As a reaction force). For to apply pressure horizontally we have to give face number 3 in the pressure loading options. The surface elements with the applied pressure are shown below.

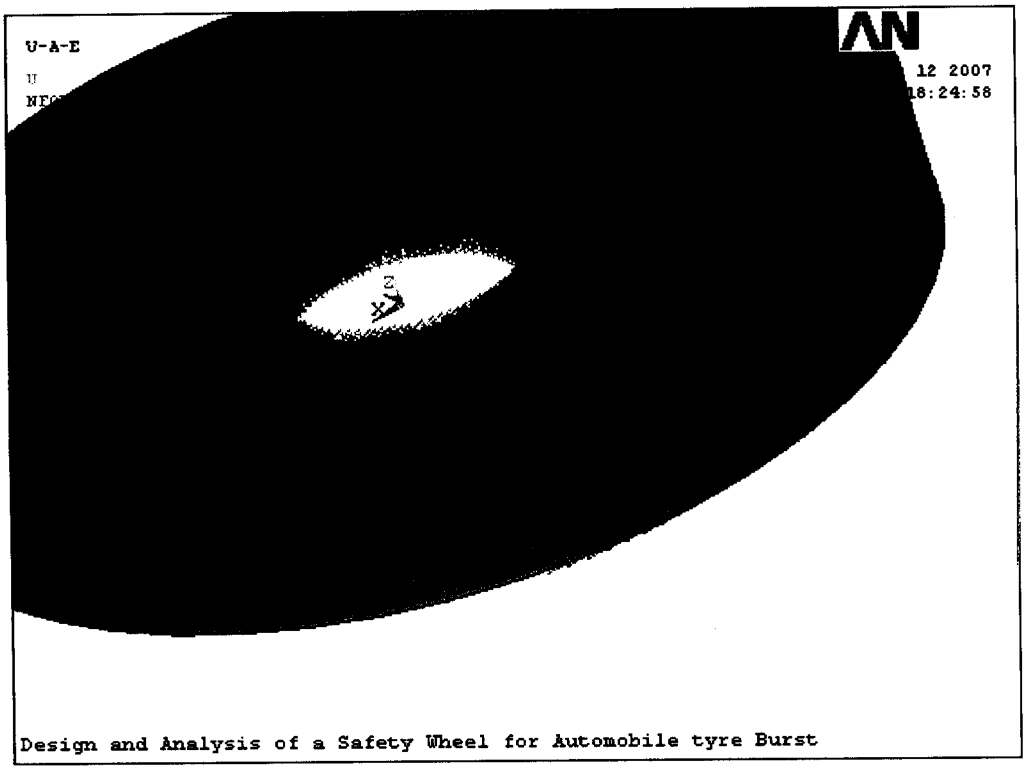

FIG 4.10 SURFACE ELEMENTS WITH LOADS

4.2 APPLYING LOAD GRADUALLY

This calculated load will be applied gradually in the real case. We have approximated the time of application, to the worse case, as 0.25 of a second and have applied this load in 5 sub steps.

This is stored as a table named LOAD in the analysis and while applying pressure the values are given from the table. The load table is shown below.

TABLE 4.2 LOAD TABLE

TIME	LOAD
0	0
0.25	87.27

4.3 TRANSIENT DYNAMIC ANALYSIS SETTINGS

After creating this table in the array parameters the following actions are to be done for to perform transient dynamic analysis.

1) In the analysis option from the main menu we have to choose new analysis and in that, analysis type as Transient.

2) Then in the load step options we have to select the output controls and DE result files. In that we have to choose results for every sub steps.

3) Next in the time/freq option we have to select time – time step. A window will appear. In that the time at the end of the load step is given as 0.25 and time step size is given as 0.05

After giving all the above steps the model is solved for its initial conditions by selecting the Solution → Solve → Current LS → Ok. The solver will take considerable amount of time and will complete the calculations.

CHAPTER 5

POST PROCESSING

CHAPTER 5

POST PROCESSING

5.1 RESULT PLOTS

After the solver completes the analysis it will calculate nodal and elemental results and will keep all the data ready for viewing. We can plot those data by selecting the following GUI path.

General Post Processing → Plot Results → Contour Plot → Nodal Solution.

A window will appear in which we can find various parameters. By selecting any of the required one, ANSYS will plot those results.

5.1.1 Displacement Plots

The displacement of the nodes created in the Burst Wheel because of load is plotted. The displacement in the X, Y, Z axes and the vector sum plot were shown below. All the results shown below belongs to the last sub step (Time-0.25sec)

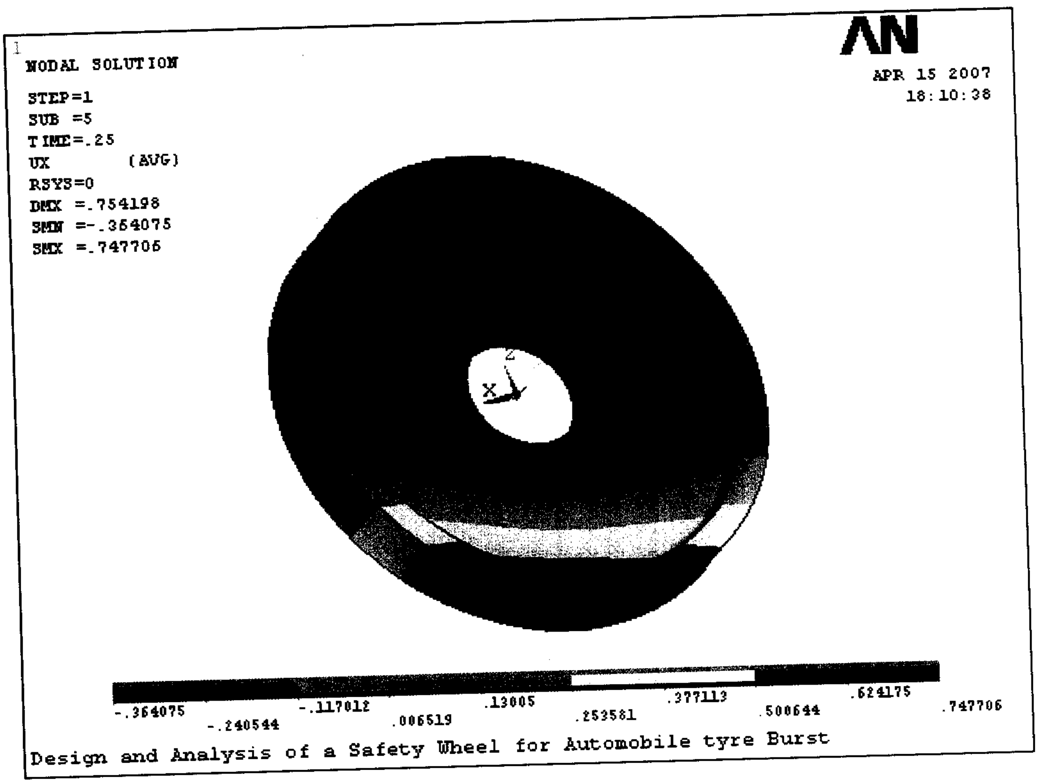

FIG 5.1 X COMPONENT OF DISPLACEMENT

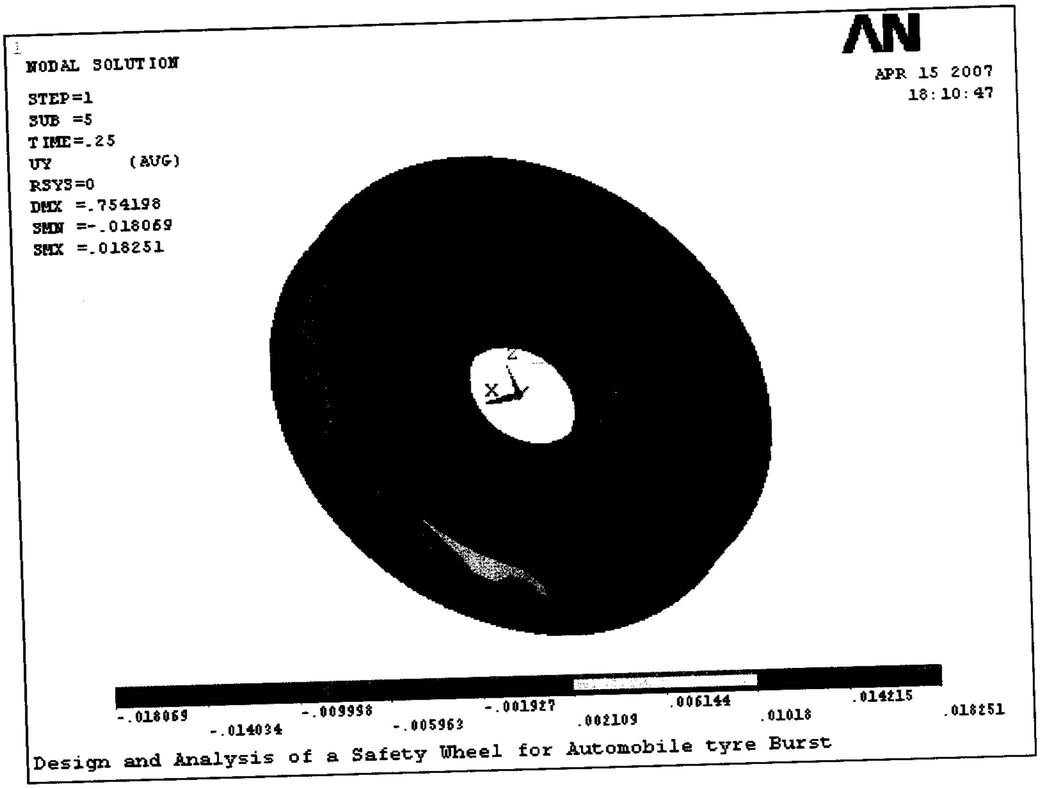

FIG 5.2 Y COMPONENT OF DISPLACEMENT

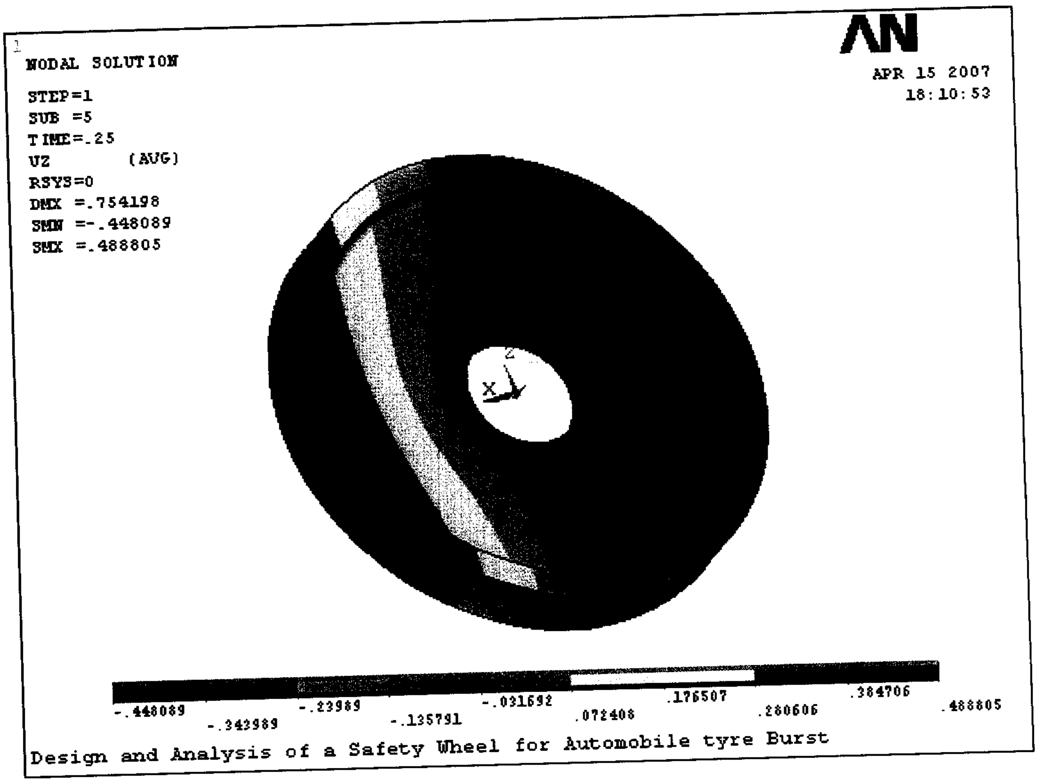

FIG 5.3 Z COMPONENT OF DISPLACEMENT

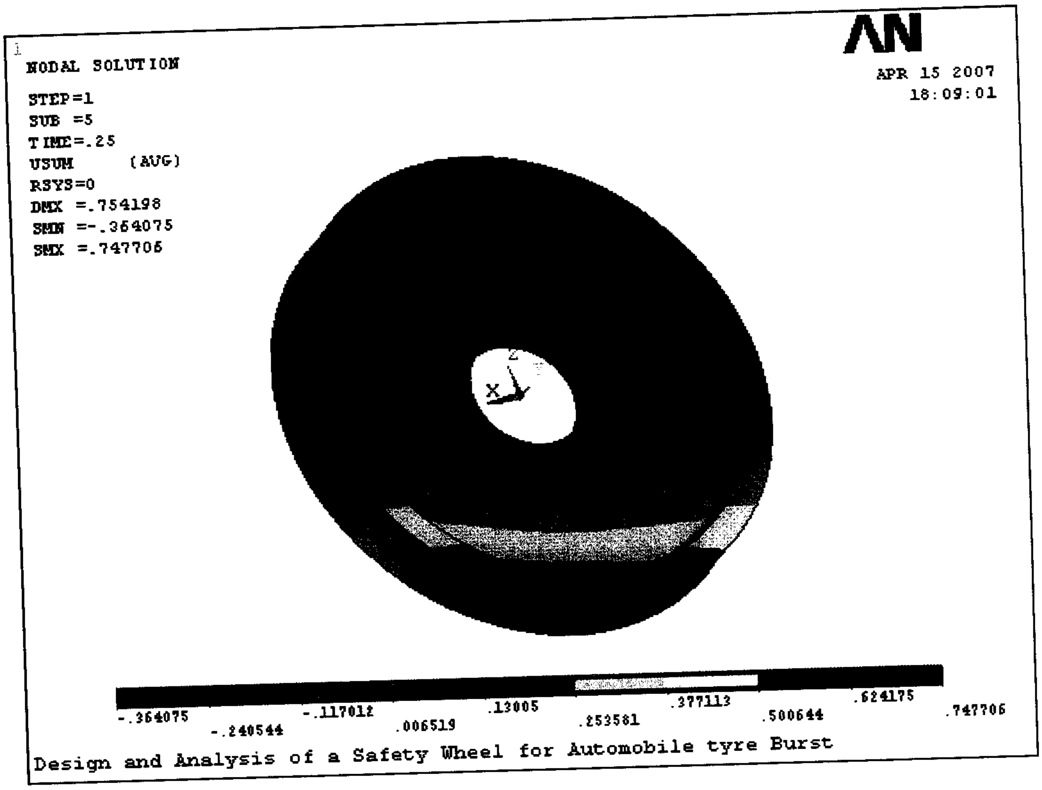

FIG 5.4 DISPLACEMENT VECTOR SUM

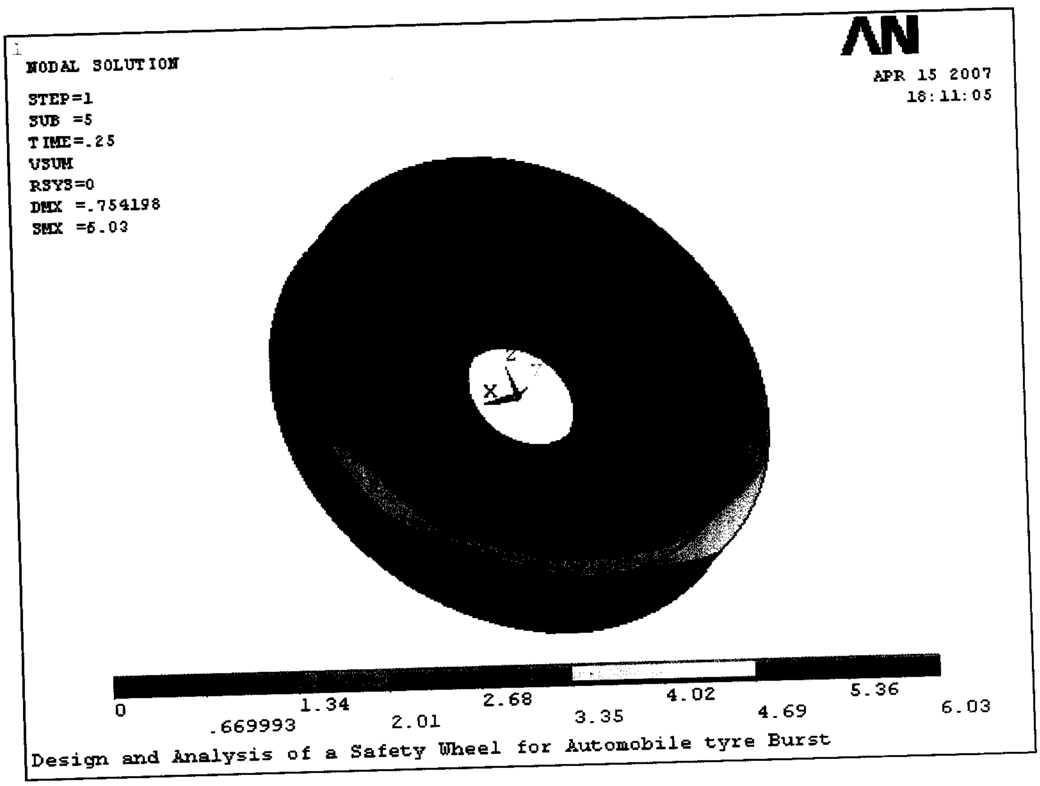

FIG 5.5 VELOCITY VECTOR SUM

5.1.2 Stress Plots

Stress developed in the Burst Wheel in various axes because of load applied were plotted and shown below.

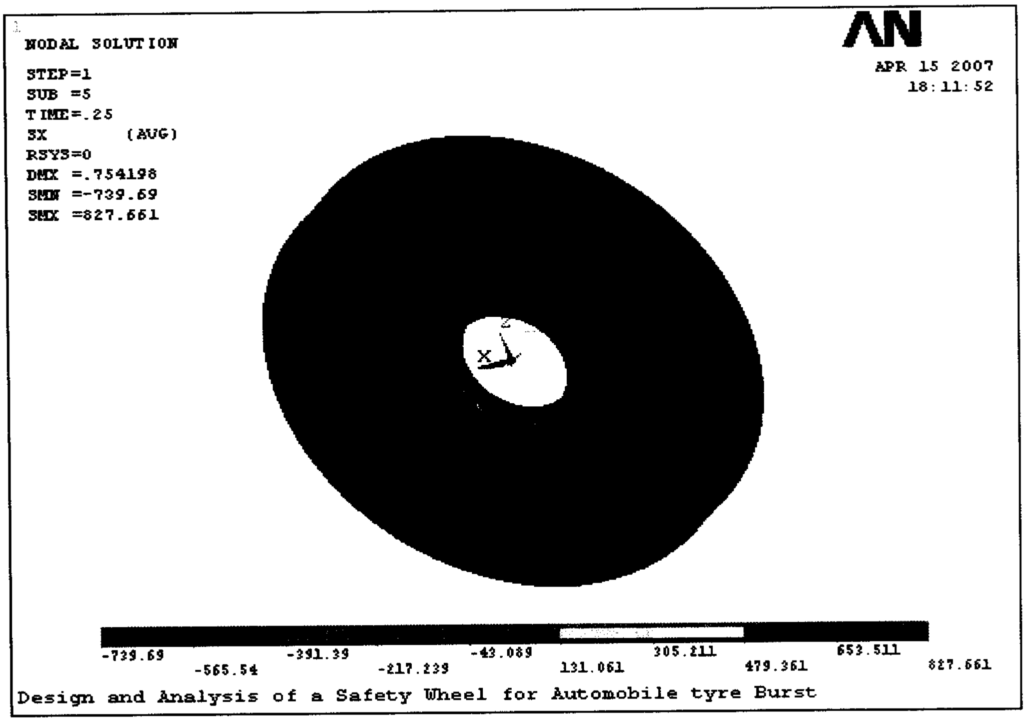

FIG 5.6 X COMPONENT OF STRESS

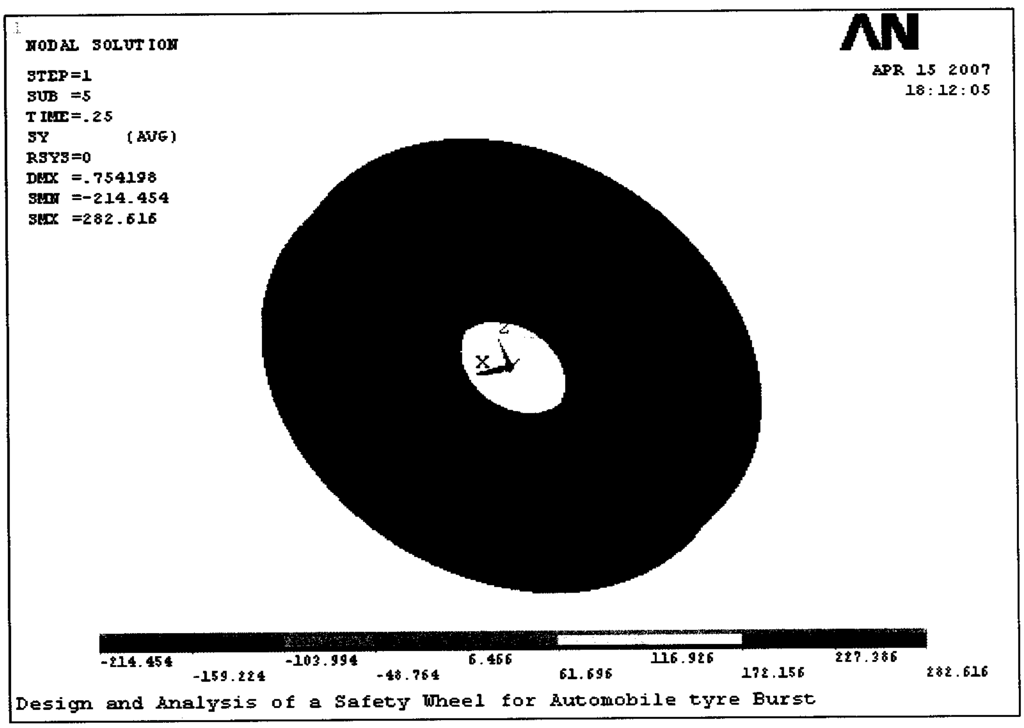

FIG 5.7 Y COMPONENT OF STRESS

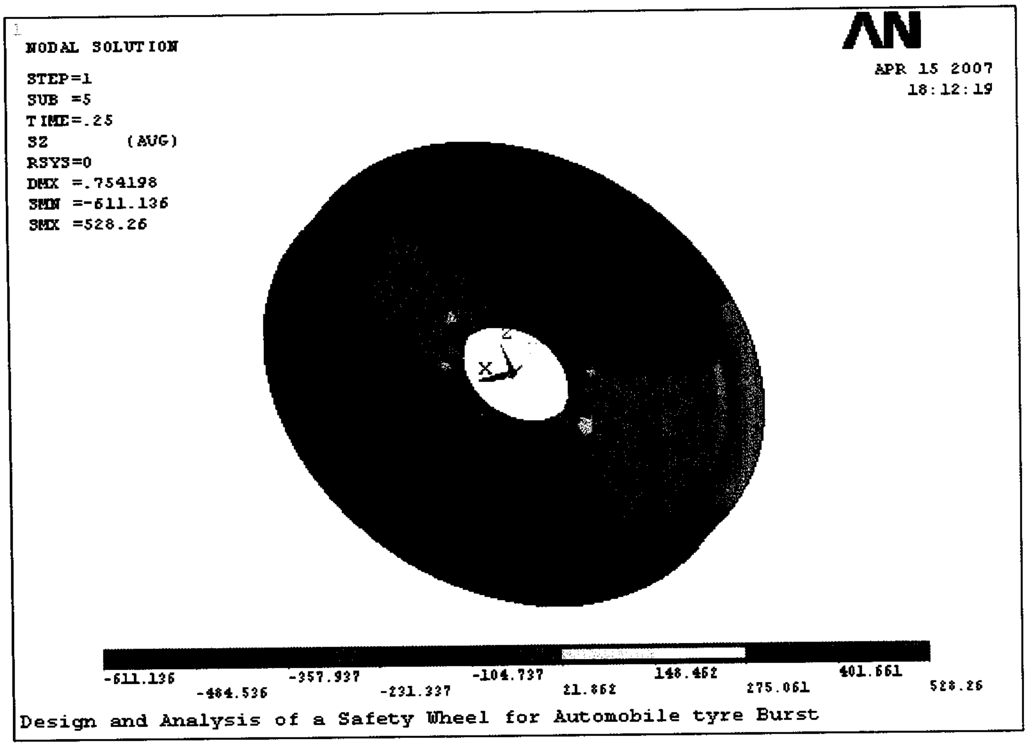

FIG 5.8 Z COMPONENT OF STRESS

5.1.3 Von Mises Stress plots at individual load step

The following five plots represent the Stress developed in each of the load sub step.

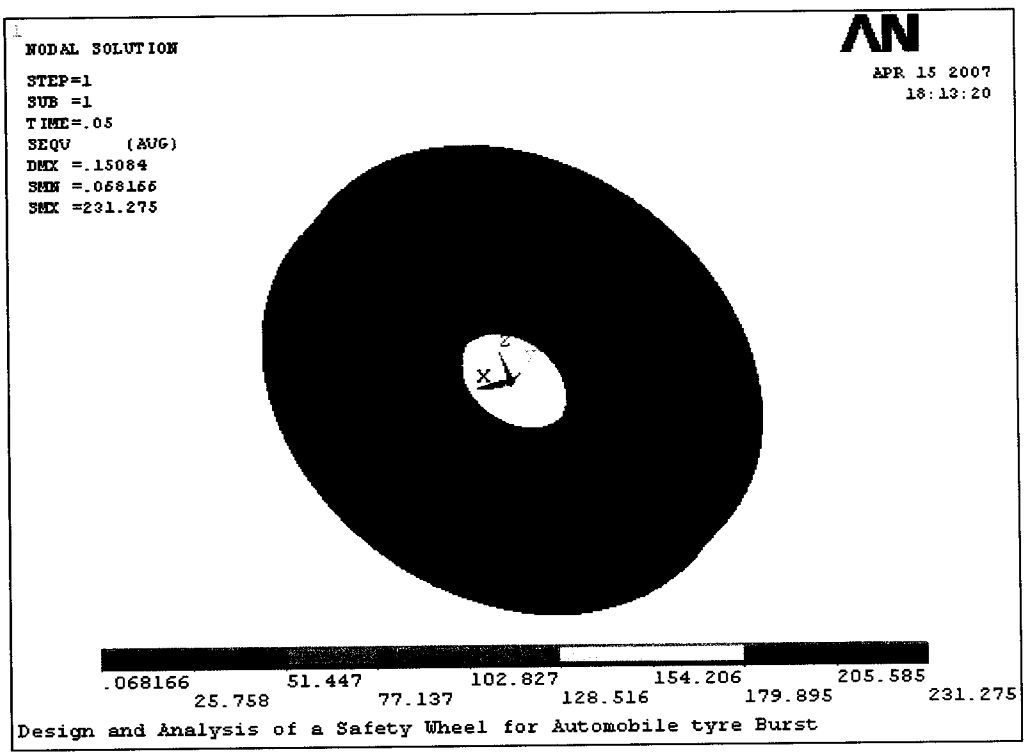

FIG 5.9 VON MISES STRESS AT 0.05 SEC

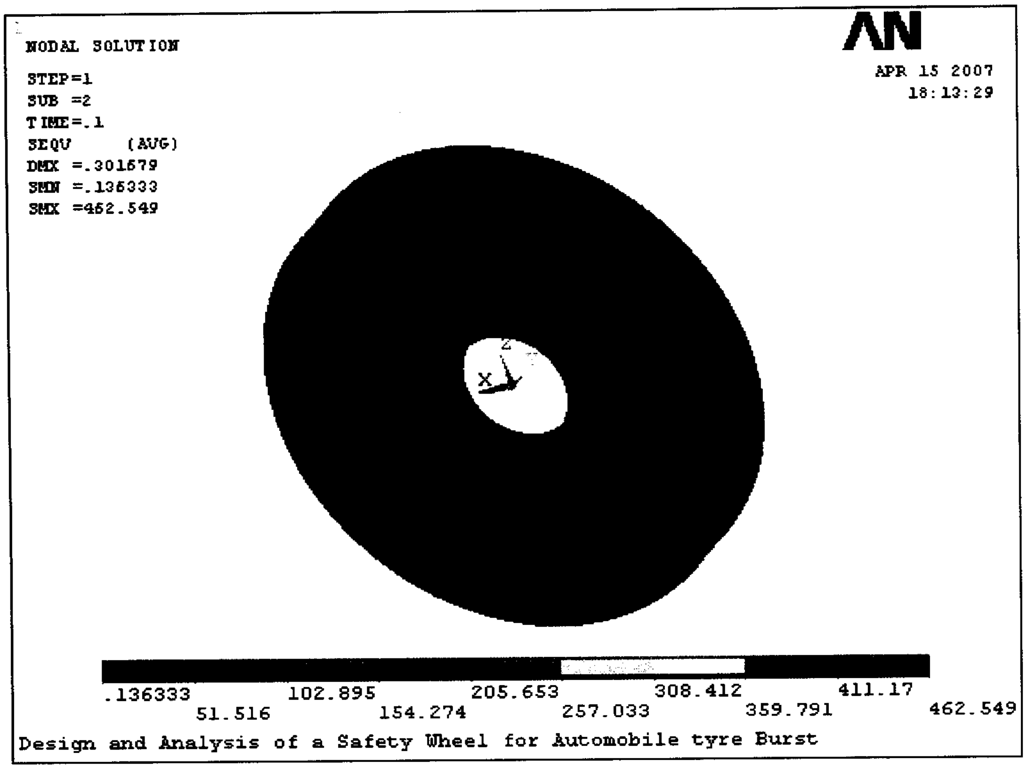

FIG 5.10 VON MISES STRESS AT 0.1 SEC

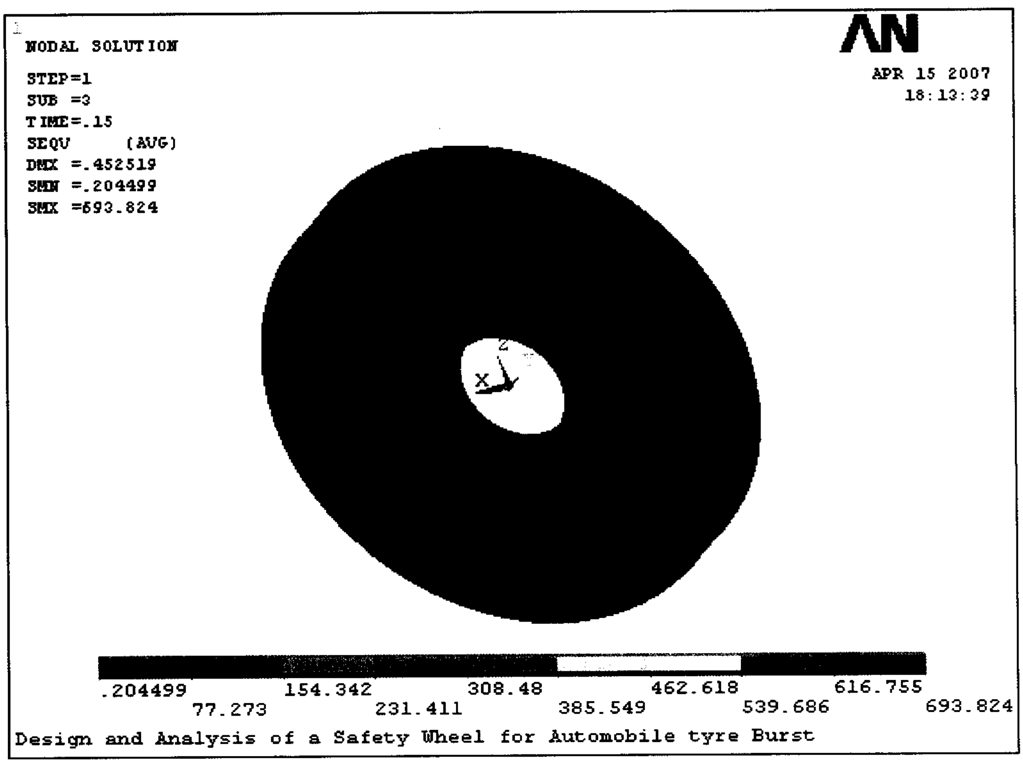

FIG 5.11 VON MISES STRESS AT 0.15 SEC

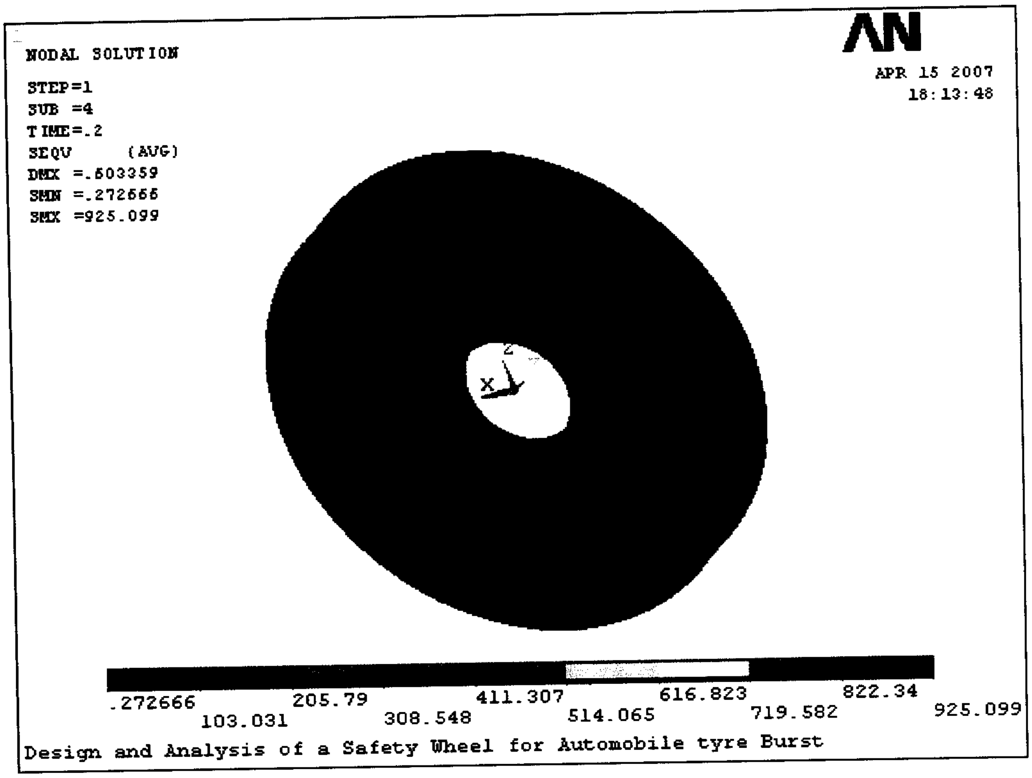

FIG 5.12 VON MISES STRESS AT 0.2 SEC

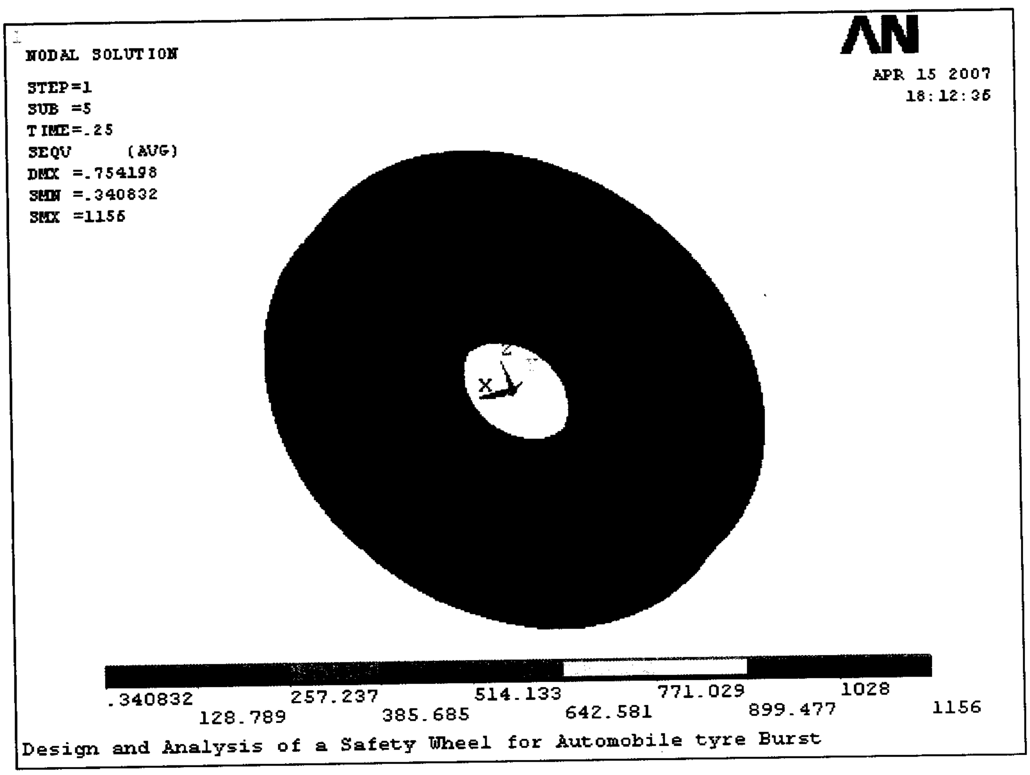

FIG 5.13 VON MISES STRESS AT 0.25 SEC

Thus the various result plots were shown above. The design stability and failure criteria are discussed in the following chapter.

CHAPTER 6

RESULTS AND DISCUSSION

CHAPTER 6

RESULTS AND DISCUSSION

6.1 STRESS VS TIME PLOTS

The stress at the two nodes of the Burst Wheel, one at the constrained part and other one near contact area, is selected in the Time history Post processing and a graph is plotted between these two values and time. The graph is shown below.

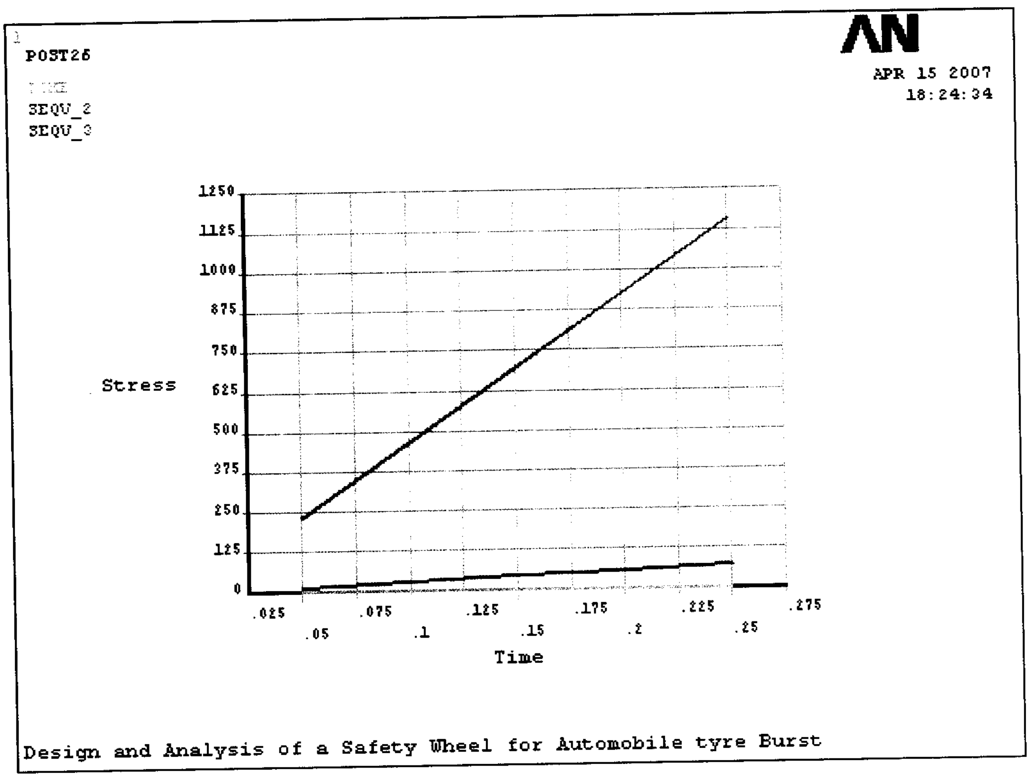

FIG 6.1 STRESS VS TIME PLOT

In the above graph it obvious that the stress in the node near the constrained part is increasing with time at a higher rate than the stress at node near the hitting area.

6.2 DISPLACEMENT VS TIME PLOT

The displacement at the two nodes of the Burst Wheel, one at the constrained part and other one near contact area, is selected in the Time history Post processing and a graph is plotted between these two values and time. The graph is shown below.

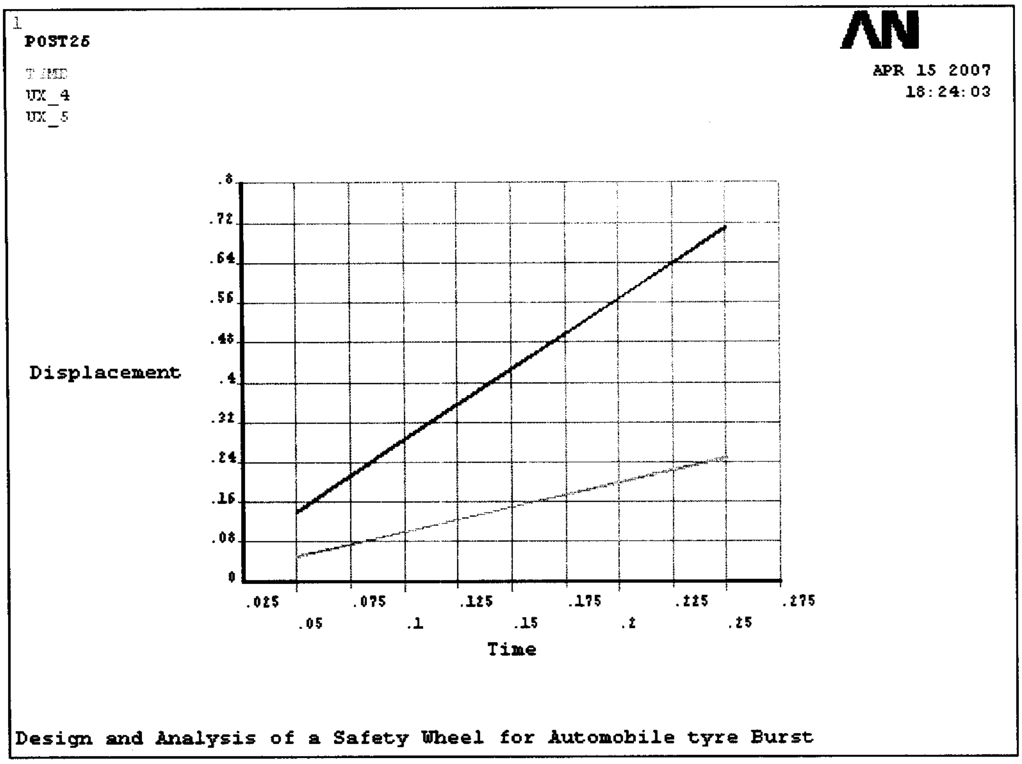

FIG 6.2 DISPLACEMENT VS TIME PLOT

In the above graph it obvious that the stress in the node near the constrained part is increasing with time at a higher rate than the stress at node near the hitting area.

6.3 DESIGN VALIDATION

The Burst Wheel is subjected to the calculated load of 87.27N/mm^2 in five steps each in 0.05sec interval. Total time of loading is 0.25 of a second. In that analysis the following stresswere obtained.

TABLE 6.1 STRESSES DEVELOPED AT INDIVIDUAL SUB STEPS

TIME **SEC**	**LOAD** **N/mm^2**	**STRESS** **N/mm^2**
0.05	17.454	231.27
0.10	34.908	462.549
0.15	52.362	693.824
0.20	69.816	925.099
0.25	87.27	1156

The above table shows the maximum value of stress developed in the structure for the applied pressure. The yield stress for the material we used is 1250N/mm^2. In the above analysis the converged maximum stress value is 1156N/mm^2. Thus the design is safe and the BURST WHEEL will take the vehicle load at the time of tyre burst in order to provide balance.

CHAPTER 7

CONCLUSION

CHAPTER 7

CONCLUSION

7.1 LIMITATION

As we aimed to design the BURST WHEEL for the existing setup without doing any major alteration, the thickness became constrained to a limit. For to provide stable structure we were in the position to go for high strength steel which is comparatively costlier.

7.2 CONCLUSION

The very aim of our project is to provide better health and safety features in today's trucks. This is what all our heavy vehicles lag and is in a great need of. The use of a burst wheel in a truck or a bus could be of good use towards safety. The project urges to bring in more safety features in today's automobiles.

However the project done here is without alteration of the stock conditions of the truck. This makes the project a bit complex and impractical. This could however be overcome by implementing design considerations for burst wheel at the development stage itself. The designer himself should make provisions for the placement of the wheel and make suitable material for apt safety factors unlike in our project in which we have considered extreme conditions for selecting the safety factor.

The burst wheel however would be an initiation towards vehicle safety against the hazards of unexpected tyre bursts.

REFERENCE

1) ANSYS RELEASE 10.0 User's Help
2) http://www.harwell.ansys.com
3) http://www.ansys.com
4) http://www.wikipedia.org