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Experiment Analysis of TBR Tire Curing Process

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Abstract*: The optimization problem was solved using the complex algorithm along with a finit element model solver. Numerical simulations were carried out to demonstrate the procedure of determining optimal cure steps for a truck/bursa dial tire. © 1999 John Wiley & Sons, Inc. J App Poly m Sci 74: 2063–2071, 1999 dynamic constrained optimization problem was formulated with the following ingredients: (1) an objective function that measures product quality in terms of Final state of cure and temperature history a at selected points in a tire; (2) constraints that consist of a process model and temperature limits imposed on cure media; (3) B-splines representation of a time-varying Profile of cure Media temperature*

Keywords: curing; internal mold; energy consumption; electromagnetic induction heating; production accuracy

I. INTRODUCTION

The curing process is energy consuming and has a strong effect on material properties.

To attain an optimal state of cure for different compounds of various dimensions at minimal capital and energy costs requires proper evaluation of the state of cure in a tire.

The anistropy of heat transfer properties of composite materials, the dependence of properties of rubber compounds on the temperature and/or the extent of cure,

the time-varying boundary conditions which include the cool down of the tire out of the press and the rigorous cure kinetic models are taken into account. which is being developed for the tire curing and rubber formulation design In the press, heat is transferred to the green tire from the mold and the bladder, which are kept at higher temperatures by circulated cure media like steam or hot water. the transferred heat provokes the curing reaction of the Tyre.''

Due to the low thermal conductivity and low rigidity of the rubber bladder, the traditional tire curing process faces problems such as low efficiency, high energy consumption, and low production accuracy. To eliminate defects, this work presents a novel direct-pressure curing technology (DPCT) with a steel internal mold heated by electromagnetic induction. Special equipment featuring this novel technology was developed and used for trial-production of tire with a specific size. The energy consumption of sample tires was measured for comparison between the new technology and the traditional one. Non uniformity and unbalance of tires are tested, meanwhile, physical properties of tread and sidewall parts of cured tires are tested. Furthermore, a finite element analysis (FEA) is carried out to investigate the heating rate of the new curing technology and to optimize the curing process. According to the results, with the new curing technology, the energy consumption per cure cycle is cut down by about 86%, while the curing efficiency and the tensile strength of sidewall part of the cured tire are improved by 22.5% and increased by 13.9%, respectively. In addition, the radial force variation (RFV), couple unbalance mass and curing temperature difference are also reduced by 16.8%, 37%, and 8 °C, respectively. These results suggest that DPCT has excellent energy-saving performance and production accuracy. As the final key process in tire production, vulcanization not only determines the manufacturing accuracy of the tire but also consumes the greatest amount of heat energy in the entire process of production. As shown in **Figure 1**, in the traditional curing process of tires, the uncured tire is heated by the saturated steam through the steel external mold and the rubber bladder, and a large amount of steam is dissipated in the pipelines from the boiler to the vulcanize. In particular, after the steam is transferred to the vulcanize r, the green tire needs to obtain heat from the bladder. The low thermal conductivity of the bladder has significant impacts on curing efficiency. In addition, since the

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saturated steam pressure is interlocked with the temperature, the curing internal temperature is not freely adjustable, leading to a long curing cycle.

that minimizes the given objective functional is to be found. The solution of an optimal control problem is usually con structured on the basis of the Pontchartrain's minimum

Principle derived from variegation calculus. But it is simply impractical to apply the minimum principle to the distributed parameter system like ours because the partial differential heat transfer equation will result in too many state equations to handle even after rough, approximate discretion. An alternative method will be to represent the control function a priori as a linear combination of appropriate basis functions. the Tyre surface are called tread. These treads make sure the gripping action in the middle of the road surface and Tyre.

II. EXPERIMENT SETUP VALUE

cure Tyre code :-9R20WMR16
FG code :- 104104
document number :- HAL/TECH /SP/76
Notification :- 2001941154
press type/no :- 65.5''
planned on :- 9-11-2023
tread line :- I
change/row Number :- 37
Specifications :-Value
Speed index :-k
mould condition :-clean
segment parting line checking :-OK
lode range :-H
Any other Marking :-Made in India Radial tube Tyre
Any other Marking 2 :-REGROOVABLE
Rim size :-Rim 7 0x20
Price marking :-Na
warning :- Safety Warning
Dirty Mould :- A/B GRADE
Item 1.Ledge width drawing no :- cur. TR001.0132/20''-1
item 2. Drawing No :- CLR-- TR001-01
Item 3 Drawing No :- CLR TR001-01
Item 4 Drawing No :- CLR-TR001-01
Item 5 Ledge Width drawing No :- CUR-TR001-01 32/20''-5
Spacer Height :- Top 260 / Bottom 260
Ledge Width :- Top 32 / Bottom 32
VCL centering in the mould - :- center
VCL paddle distance - collapsed :- top 475 / bottom 475
VCL paddle Expanded :- 500 use in top side 501 / bottom side 502
Lode range :-H
Any other Marking :- Made in India Radial tube Tyre
Any other Marking 2 :- Regrettable
Rim size :- Rim 7 0x20
Price marking :-Na
Number of plies Sidewall :- 1. Sidewall Plies Steel
VCL height- position :- 380 / use in top side 380 /bottom side 381quality /380
Ring down height:- 480/measure in/ top side 401/bottom side 402/quality -401
Stacking height :-700

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UnloadedDistance From Roll to Roll :-eng side top 700/ bottom side 701
Squeeze Force Setting 600000 / Eng side check top 680 /Bottom 690 / quality check /600
Jacket Temperature :- 154'c Degree' c / Eng side check /Top side 154 ' c
Platen Temperature :-154 'c Degree / Eng side check 152 / quality
Shaping pressure :- 1 {4PSI}
Shaping pressure :- 2 {4PSI}
reassure close Air [Program Air] MIN 4 kg,cm
HPS Hydroplaned Program Air value :-open

Figure :-1 press loading time check bladder an empirical function for an isotherm curing process, that takes into account the rate- and temperature-dependent behaviour, is presented. This model p represents the curing process very wellfor an isotherm state. after the geometry has been produced.

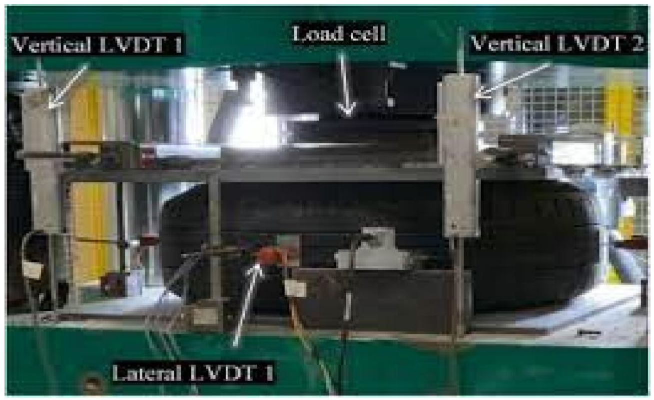

Figure 2: LOADING TIME PRESS WORKING

During the production process of a tire, both phases of the rubber are important. The uncured phase applies during moulding in the press and the cured phase in the post curing inflation. Therefore, both phases should be considered adequately. A thermos mechanical consistent formulation has to be found to assemble both phases into one model in order to be able to describe intermediate transition states as well.describes the shrinkage due to vulcanization. The state of cure is monotonically increasing from 0 to 1, therefore, the maximum curing shrinkage is defined

Grid generation test

In CFD, "grid generation" refers to a collection of methods for creating a numerical mesh throughout the whole system that will be modeled. The accuracy and resolution of the simulation results will be determined by the grid used for CFD simulations, which will also have an impact on the calculation time and amount of detail in the results.

A constitutive curing formulation is introduced into the model, to capture the shape change during the vulcanization and to ensure, that the second law of thermodynamics is fulfilled. A multiplicative split of the deformation gradient is assumed to describe in compressible material. Thermal expansion due to the change of temperature is taken into account in the volumetric part, as well as shrinkage during the vulcanization process. In the ISO choric part, simulation of an symmetric tire production process starting at the green tire inserted into the heating press up to a post-cure inflation step.

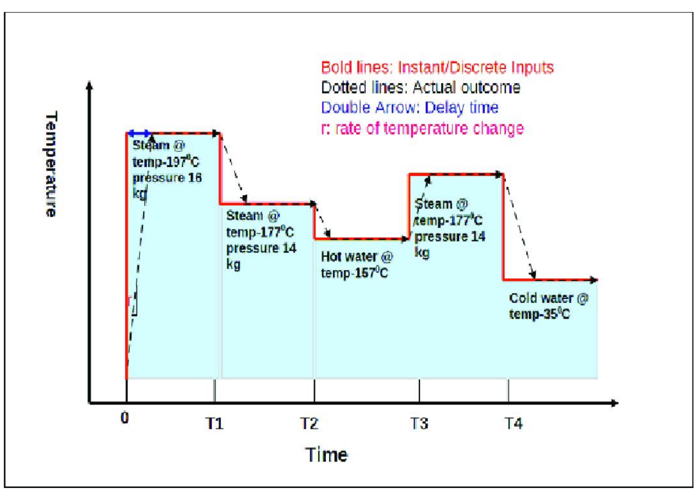

Figure :-3 curing cycle temperature and time

State of curing

A rubber sample is placed in the machine, where a rotational displacement is applied at the top surface and the reaction moment is measured at the bottom of the sample. During this test, the sample is heated and vulcanization takes place. During vulcanization, the material becomes stiffer and the reaction moment increases and reaches a maximum at the end of vulcanization. Via post-processing, the state of cure is computed as ratio of the moment at the current time step divided by the maximum moment intake and outflow conditions are pressure inlet and pressure outlet, respectively.The TYRES are required to carry the load of the automobile. The TYRES may be with tube or tubeless. In the former, the tube is inside the Tyre and contains air at high pressure. In tubeless Tyre there is no tube and Tyre’s itself contains air at high pressure. They also transfer the braking and driving torque to the road. The motion of the automobile becomes possible only when the friction acts between the Tyre surface and the road surface. This friction is required for the stability of the moving automobile. The friction must not go beyond a particular limit as it will cause wastage of power output from the engine and loss of money in the form of wastage of fuel.

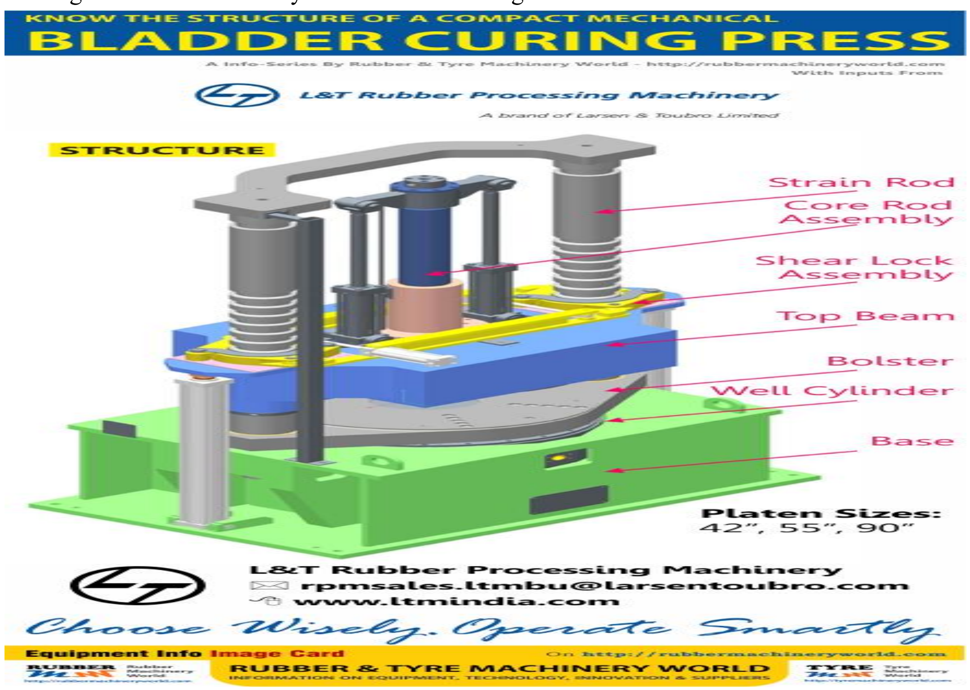

Figure 4: BLADDER CURUNG PRESS

Tyre with Nylon (reinforcement) Carcass

In Pursuant to development and introduction of Polymerize (Nylon) the strength and flexing behavior of reinforcing materials improved substantially resulting in further reduction of number of plies, consequently the weight of the Tyre. This development substantially improved the heat and impact resistance of the carcass leading to better Tyre performance and higher durability. Nylon casing gave a boost to retread-ability. Thus effective cost of the Tyre in operation became much more economical. Pursuant to development and introduction of Polymerize (Nylon) the strength and flexing behavior of reinforcing materials improved substantially resulting in further reduction of number of plies, consequently the weight of the Tyre. This development substantially improved the heat and impact resistance of the carcass leading to better Tyre performance and higher durability. Nylon casing gave a boost to retread ability. Thus effective cost of the Tyre in operation became much more economical.

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Procure Process

a) Tyre arrives in the workshop, it is cleaned thoroughly with water so, that dirt, dust and mud should all be removed effectively

Some a dynamic approach on a dynamic
press and a static approach. Parameters modified are Tyre inflation pressure and vertical load in the static experiment. Tyre at The e made for 406mm rim diameter as usually for bicycle carriers since the comfort of children in bicycle transportation is the larger scope behind the experiments.

Conventional Process

Tyre arrives in the workshop, it is cleaned thoroughly with water so, that dirt, dust and mud should all be removed effectively. b) Tyre is left for some time so that it may dry or a drier can be used for this purpose . c) Initial inspection is carried out to verify that casing is acceptable for retreading process or not. It is thoroughly examine inside and outside and marked with yellow coloured crayons. d) Buffing :- The primary objective of buffing is to prepare the worn out tread surface of Tyre to receive a retread. The original tread design and the some of the under tread is also removed to provide the casing with required dimensions and surface texture. In other words it increases the co-efficient of friction of untreated surface of Tyre so that it can hold firmly the cushion and sole of new tread.

III. TYRE RETREADING

It is very essential to know the meaning of „tread". The grooves which are cut on the Tyre surface are called tread. These treads ensure the gripping action between the road surface and Tyre. After the use of Tyre the depth of treads becomes less and a slippery action takes place between road surface and Tyre. The co-efficient of friction becomes less. A Tyre is in no more condition to be used again. Now, here becomes the choice either to replace the Tyre with a new one which is very expensive or to retread the Tyre which is less expensive as compared to the cost of new Tyre.„Retreading" means taking a worn casing of good structural quality and putting it through a process which completely renews the tread of the Tyre and sometimes the sidewall rubber.

M Retreading process can also rectify minor cuts or defects on the side walls of Tyre, beads and punctures in a single stage. A Tyre can be retreaded or not this is entirely dependable on the type of use of Tyre and condition of Tyre for example car Tyre

Figure 5: PRESS LOADING TIME CHECK TYRE

The The tires used in the tests are radial tires with symmetrical tread pattern of size 175/65R15 and the steel rims are rigidly clamped at the wheel hub. Figure 3 shows the test setup with the one Tyre mounted. Since one identical Tyre is used, the Tyre deformations equal to the deformation of a Tyre rolling on a flat road. The Tyre is driven by a 2HP, three-phase induction motor. The tachometer is used to measures the rpm of the wheel against different time in sec and load in mm. The Tyre is mounted on the axle spindle which is connected to motor shaft with the help of pulley variable. The rotation speed is controlled by a pulley variable. Different speed was given by pulley and at different speed , the Tyre was rotated and wear was measured in mm at different interval. Same procedure was done for new and retreaded Tyre. I got tread wear against different speed and different load and compared the result for both Tyre.

• Retreading is an established and well-regulated process for producing high quality re manufactured Tyre's. Retreaded Tyre are subject to stringent quality certification that matches new Tyre regulations. • Because Tyre casings are so thoroughly inspected and tested and because the recurred tread or mould cure rubber compound is chosen with the projected use in mind, retreaded Tyre often have a longer life than new Tyre and can have a lower rate of failure.

IV. MATHOD VISUAL KEY STEP

Before loading press give gymnastic for new bladder(give shaping and top ring up down 5 times) Before loading do proper GT inspection (FM, Uniform GT lubing) Check alarms and SCADA trend on HMI Put serial number in both cavity on its slot , ensure all stamping should be available (Week code ISI, in metro etc Put serial number in both cavity on its slot , ensure all stamping should be available (Week code ISI, in metro etc Press load button in auto mode Press load button in auto mode

After both VCL go inside as per sequence LHS them RHS, after both going down til VCL in down proxy sense

Then initial shaping come in bladder after that Top ring going down

After shaping pressure come as per space (i,e. 4psi OR 30 KG /CM2 both side)VCL chuck close in auto then both VLC come up & out should be not out side from top and bottom

CRITICAL CHECK POINT

(1) Shaping pressure

(2) Shaping pressure Discontinue before internal start

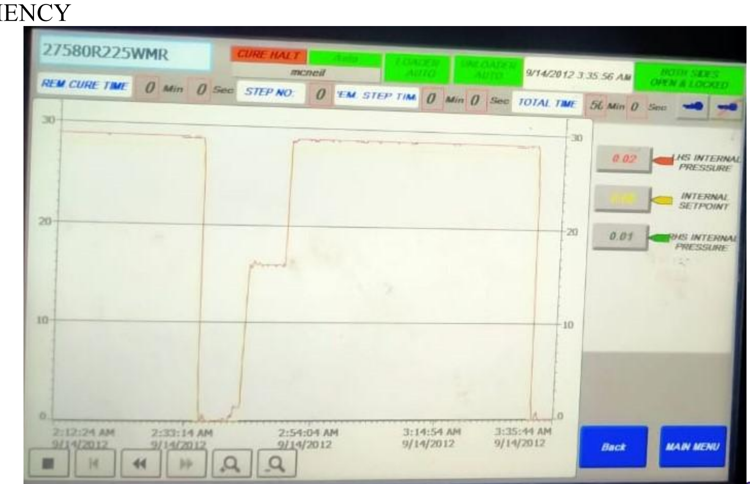
(3) No air trap in Tyre

(4) No press late close

(5) don't level press till curing is not on

Machine efficiency is everything because the tire manufacturers will decide on the number of presses they need based on the machine efficiency ratio" Curing presses are becoming smarter and more flexible in response to the proliferation of tire sizes and types. UZER Making will soon begin building smart presses for a new greenfield factory. A scanner on the loader will detect the tire specification and adjust the cure accordingly, eliminating problems arising from operators mixing up green tires. Tire curing times typically contain some tolerances when they are set by the manufacturer," observes Backcourt. "Sometimes you may over cure it, but if it were possible to get real-time data from the tire during vulcanization then you could decide when the cycle could be stopped

MACHINE EFFICIENCY



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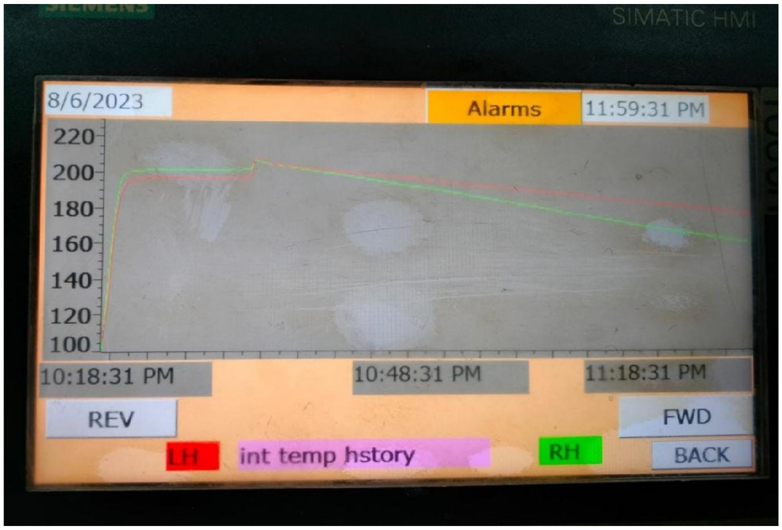

Fig :-6 MACHINE EFFICIENCY CYCLE GRAF

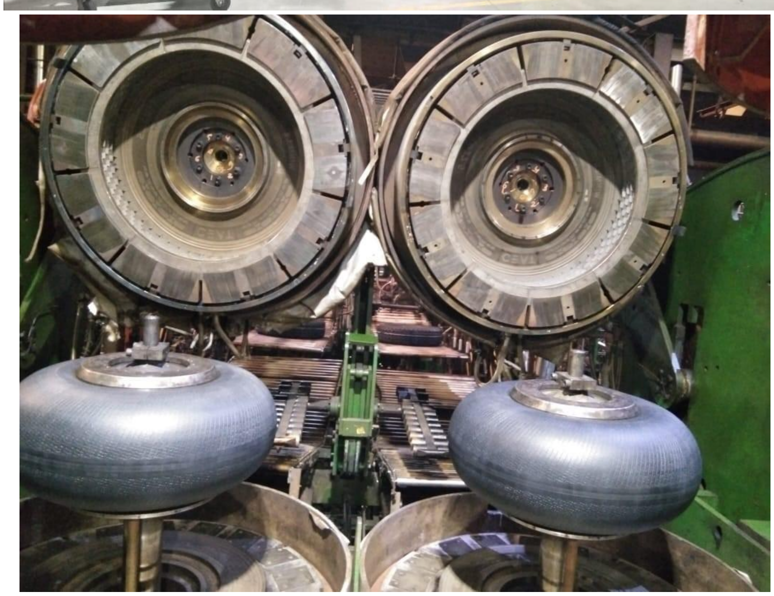

Fig :- 7 shaping time bladder

The tire curing processes was developed, which implements numerical algorithms based on a finite element method to solve the rigorous model equations governing transient heat transfer and curing reactions. Extensive simulation has been carried out ranging from simple heat conduction problems to actual tire curing processes. The results have been verified through comparison with analytical solutions or actual Therm-couple measurements. The simulator successfully describes the trends in temperature and the state of cure during the tire curing processthe tire curing processes was developed, which implements numerical algorithms based on a finite element method to solve the rigorous model equations governing transient heat transfer and curing reactions. Extensive simulation has been carried out ranging from simple heat conduction problems to actual tire curing processes. The results have been verified through comparison with analytical solutions or actual Therm-couplemeasurements. The simulator successfully describes the trends in temperature and the state of cure during the tire curing process

V. BALDDER EFFICIENCY

Other improvements in curing press efficiency are coming from automating the press itself (see Smart thinking, above) and integrating it more closely to the factory’s overall automation strategy In the future, real-time adjustment of the curing cycle may yet be achievable based on sensor data from within the press. R recompense's Cure Sense, for example, won Tire Manufacturing Innovation of the Year in our 2011 Awards. The company believed that cure times could be cut by at least 10% using its technologies, with knock-on benefits to both process and energy efficiency. Unfortunately, according to former MD, Other improvements in curing press efficiency are coming from automating the press itself (see) Smart thinking, above) and integrating it more closely to the factory’s overall automation strategy. In the future, real-time adjustment of the curing cycle may yet be achievable based on sensor data from within the press. Recompense'sCure Sense, for example, won Tire Manufacturing Innovation of the Year in our 2011 Awards. The company believed that cure times could be cut by at least 10% using its technologies, with knock-on benefits to both process and energy efficiency. Unfortunately, according to former MD,

The velocity stream line is from the CFD analysis found that it have a smoother flow of the air form the flute. Almost more than 90% of the air is flow form the tooth profile with the increment in the pressure

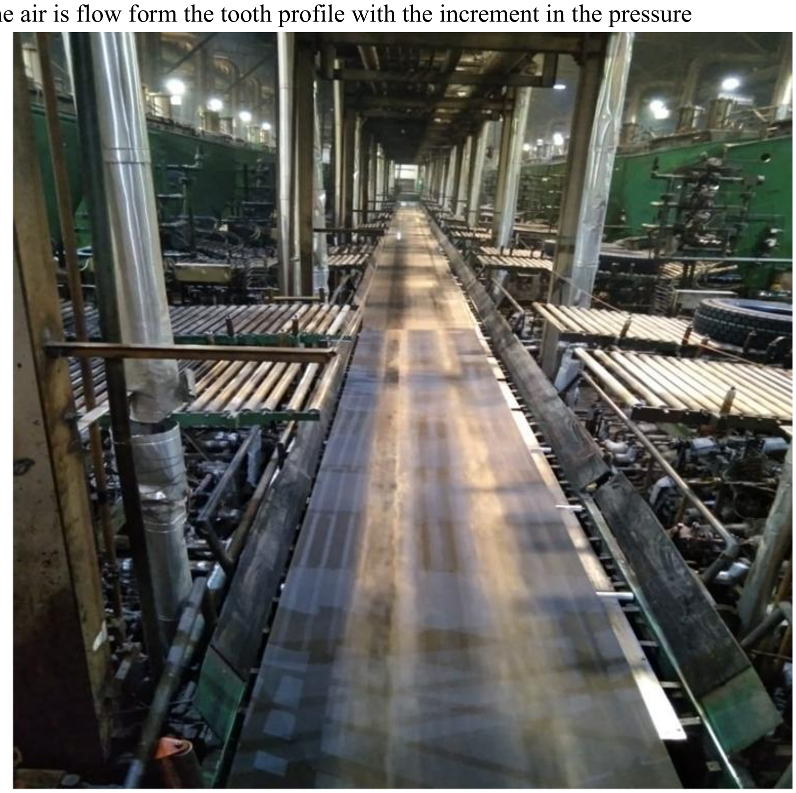

Figure :-8 FAINAL CURING TYRE PROCESS IN CONVEYER

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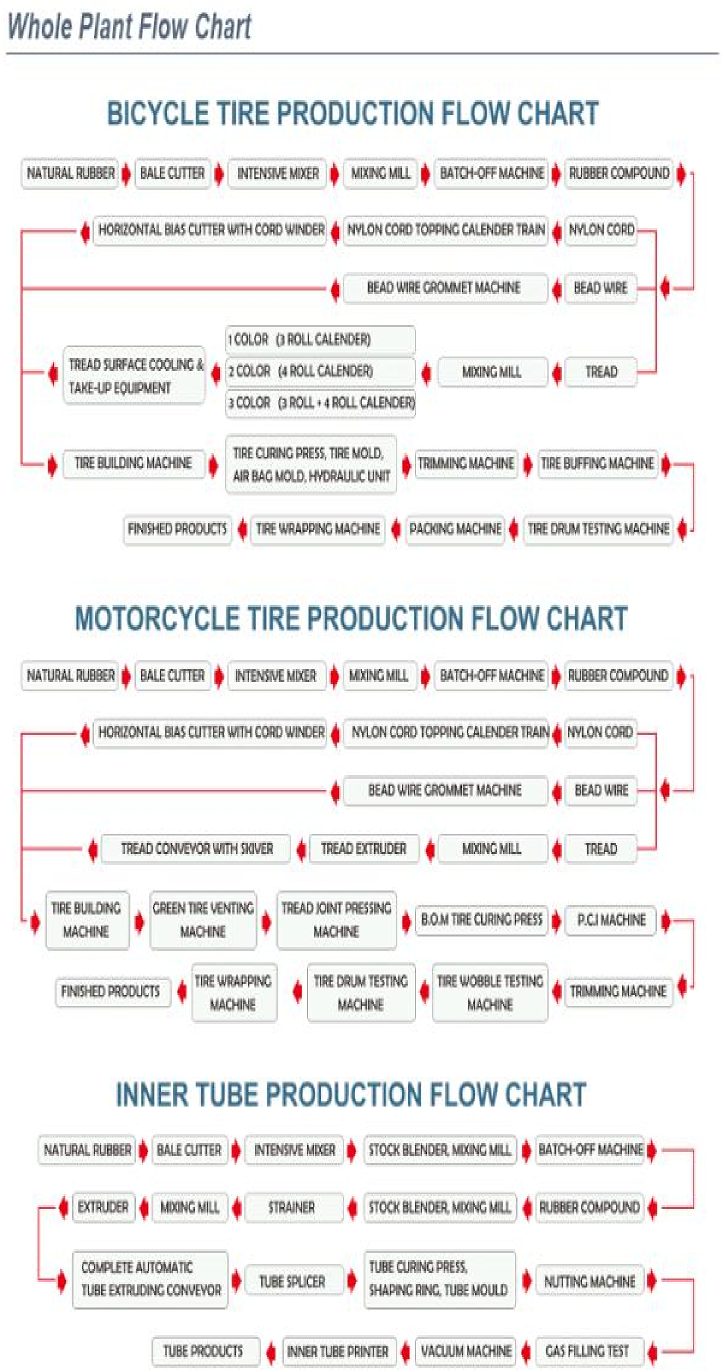
Therefore the ability to predict the distribution of cure level in a rubber part during curing is of great importance for improving the process efficiency and the quality of the final product. In this work, simulations of the curing process of a solid tire, consisting of three layers of different rubber compounds, were performed and the cure level distribution results were evaluated. The simulations are carried out using the commercial finite element software ABAQUS with the cure kinetics model for rubber implemented through the user subroutine UMATHT conditions, the finite element method appears to be an ideal candidate because of its versatility.



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Now,

Figure 9 :- press open time curing Tyre

.To attain an optimal state of cure for different compounds of various dimensions at minimal capital and energy costs requires proper evaluation of the state of cure in a tire. Various numerical models have been proposed to determine the state of cure of rubber compounds in molds. Their applications are limited to simple geometry and boundary conditions. For a tire, which has complex shape and variable boundary

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The process of curing, commonly called vulcanization, is usually accomplished under pressure and an elevated temperature provided by the mold. The curing process is energy-consuming and has a strong effect on material properties. To attain an optimal state of cure for different compounds of various dimensions at minimal capital and energy costs requires proper evaluation of the state of cure in a tire. Various numerical models have been proposed to determine the state of cure of rubber compounds in molds. Their applications are limited to simple geometry and boundary conditions.

VI. CONCLUSION

The effect of the mold heating concept (steam dome vs. heating plates) on the time history in thick parts of the cured Tyre is significant despite the indisputable differences in thermal fields in molds heated with plates or steam. Heating plates in combination with properly designed heating channels (preferably with independent heating control) seem to a promising alternative to the steam dome concept. However, it should be pointed out that development of a new curing mold should be always accompanied by detailed thermal measurement with thermocouples placed in both mold and Tyre to provide necessary setup data for FEM analyses. From thermal point of view, the influence of insert material (aluminum or steel) on thermal fields in Tyre and mold (and therefore on the cure process) is negligible and only manufacturing aspects can prevail.

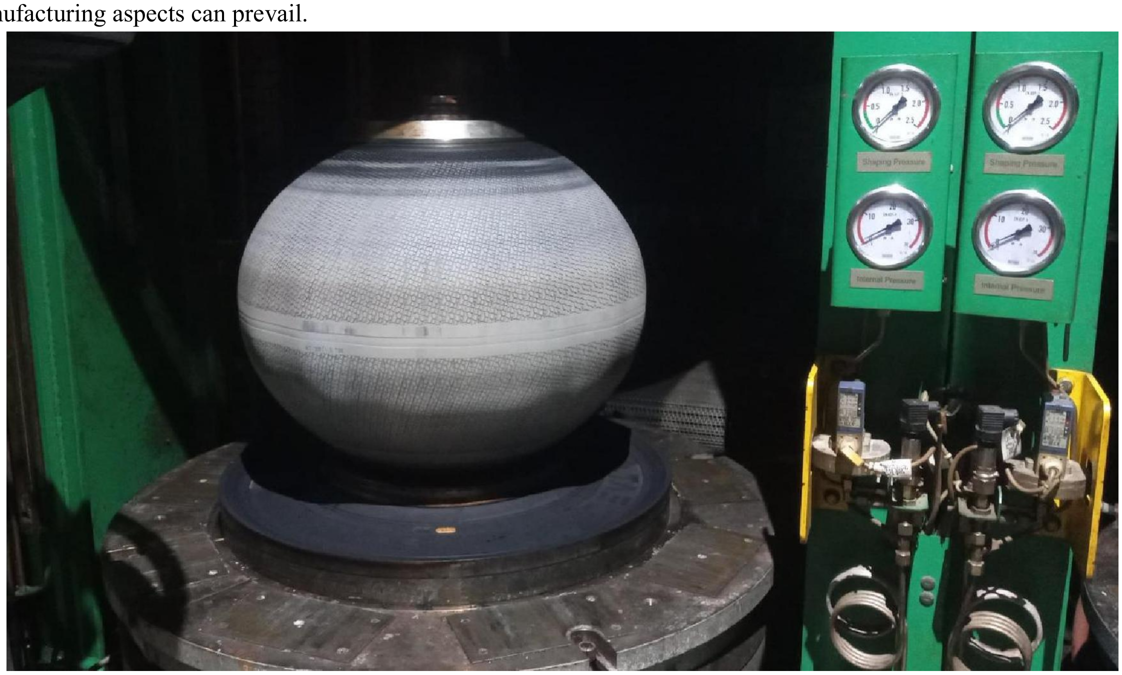

FIG :-10 BLADDER SHAPING OPEN PRESS

REFERENCES

[1]. Wang YS, SU BL, Wu J (2012) Simulation and optimization of giant radial tire vulcanization process. Proceed Eng 31:723–726
[2]. CLAXTON WE, Holden HC (1977) Tire cure and heat transfer sim- ULATOR. US Patent4,044,600
[3]. AMBELANG JC, Prentice GA (1972) Digital method of calculating the flow of heat through a tire during vulcanization. Rubber Chem TECHNOL 45:1195–1201
[4]. Prentice GA, Williams MC (1980) Numerical evaluation of the state of cure in vulcanizing rubber article. Rubber Chem Tech
[5]. TOTH WJ, Chang JP, ZANICHELLIC (1991) Finite element evaluation of the state of cure in a tire. Tire Sci TECHNOL19:178–212

[6]. Han IS, Chung CB, JEONG HG,KANG SJ, Kim SJ, Jung HC (1999) Optimal cure steps for product quality in a tire curing process. J ApplePoly m Sci 74:2063–2071

[7]. Tong J, YAN X (2003) Finite element analysis of tire curing pro- cuss. J Reinf Plast Compos 22:983–1002

[8]. YAN X (2007) A numerical modeling of dynamic curing process of tire by FINITE element.POLYM J 39:1001–1010

[9]. GHOREISHY MHR, Nader i G (2005) Three-dimensionalFINITE element modeling of rubber curing process. J ELASTOM Plast 37:37–53

[10]. RAFEI i M, GHOREISHY MHR, NADERI G (2009) Development of an advanced computer simulation technique for the modeling of rubber curing process. Compute Mater Sci 47:539–547

[11]. ABHILASH PM, Kennan K, VARKEY B (2010) Simulation of curing of a slab of rubber. Mater Sci Eng B 168:237–241

[12]. ZHANG J, Tang W (2013) Rubber curing process simulation based on parabola model. J Wuhan Univ TECHNOL Mater Sci Ed 28:150–156

[13]. Wang DH, Dong Q, JIA YX (2015) Mathematical modeling and numerical simulation of the non-isotherm in-mold vulcanization of natural rubber. Chin J POLYM Sci 33:395–403

[14]. GHOREISHY MHR,RAFEI M, Nader i G (2012) Optimization of the vulcanization process of a thick rubber article using an advanced computer simulation technique. Rubber Chem Techno l 85:576–589

BIOGRAPHICAL NOTES

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