IJERST

International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 1, No. 2
April 2015

2nd National Conference on "Recent Advances in Science Engineering & Technologies" RASET 2015

Organized by

Department of EEE, Jay Shriram College of Technology, Tirupur, Tamil Nadu, India.

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Special Issue, Vol. 1, No. 2, April 2015
2nd National Conference on "Recent Advances in Science, Engineering&Technologies" RASET-2015

Research Paper

ESTIMATING THE EFFECT OF CAD MODEL SIMPLIFICATION TECHNIQUES FOR FEA SIMULATIONS

Subash karan R[1]* and Ravichandran R[1]

Corresponding Author: **Subash karan R ✉ subashr088@gmail.com*

At present, simulation is at the heart of product development cycle. The simulation is currently used indesign and dimensioning of the mechanical parts. We focusing on the dynamics of the microscopic world and on realizing simulations that capture maximum complicity using minimum computation time and cost. FEM becomes the most useful approach in simulation of mechanical behaviour. For that it requires initial CAD model. It is not easy to analyse complex models. So, it is necessary to simplify the models before simulation. In this paper presents an automatic CAD model simplification approaches. First part of this paper deals with a Rule based approach to simplify the features for that the rules are generated with help of expert's knowledge and simplification has obtained in Knowledgeware a special tool available in CATIA V5. Second part presents a Hybrid method approach to simplify CAD model. The implementation of algorithm on Open Cascade Platform is also presented. Finally estimate the effect of using this approach on CAD model. It shows that computational time is reduced with minimal changing the exactitude of results.

Keywords: Simulation, CAD Model, FEM, Rule Based Approach, Hybrid Approach, Simplification

INTRODUCTION

Computer simulations play a vital role in design, research, development, prototyping and validation of mechanical products. It indeed to reduce the risk and inefficient in product testing. For example: UNO III vehicle design, in that when we began the UNO III redesign, for rider safety it was clear that manually tuning controllers and testing on the actual vehicle would be inefficient and risky. Instead they used computer simulation to model and simulate the UNO III mechanical systems.

During real-world test, things move so fast it isimpossible to understand everything that ishappening. In simulations however, we can freezetime and inspect every aspect of the model to get aclear picture of how mechanics are behaving. Wefocus on the dynamics of the microscopic worldand on realizing simulations that capture maximumcomplicity using minimum computation time andcost.

Engineering models today are mainly developed with a 3D computer Aided Design

[1] Department of Mechanical Engineering, Arunai Engineering College, Thiruvannamalai, Tamilnadu, India.

Figure 1: Simulation of UNO III vehicle redesign

Figure 2: Virtual model and Simulation of military vehicle

Software [2]. If we run a Finite Element Analysis (FEA)on a part with hundreds of small feature as oftenleads to computational time will be very large andpoor quality mesh and hence may lead to affectanalysis result. Then, it automatically increased thecost of labour [3].In order to get accurate result in a timelymanner, one must utilize simplified models. Thesimplified models are used in many simulationdomains: dynamic analysis of bogie for forestrymachines [4]; modeling and simulations of dicycle[5]; Thermo mechanical simulation of aerospacestructures [6]; virtual modeling and simulation ofmilitary vehicles [7]; Optimization of vehiclestructure [8], etc.

RELATED WORK

Atul Thakur et al. [9] had studied that theexisting model simplification techniques that areuseful for the physical based simulations and it canbe classified them broadly into four maincategories based upon the type of simplificationoperators used in respective techniques. ie, surfaceentity ,volumetric entity, explicit feature anddimensional reduction.Hamdi mounir et al. [10] had stated that theFinite element method (FEM) becomes mostly usedapproach in simulation of mechanical behaviour.The adaptation steps consists in simplification ofCAD model geometry by eliminating details holes,chamfers, fillets based on a combination ofeliminating details and merging faces .H.Zhu and C.H.Menq [11] had reviewed on BRepmodel simplification by automatic fillet/roundsuppression. The major shape of the primaryfeatures may not be affect fillet and rounds cangreatly change the geometric and topologicalpatterns of the primary features.

R. Ferrandes et al. [12] had proposed anevaluation method of simplification details forfinite element modal preparation. If a shape detailremoved during the shape simplification processproves to be influence on mechanical behaviour, itcan be reinserted on simplified model.Shuming Gao et al. [13] had proposed a featuresuppression based framework to cad modelsimplification. CAD mesh model is segmented intoregions using the improved watershed algorithmand form features are recognized based on regionlevel representation using graph based featurerecognition method.

R.J.Donaghy and C.G.Amstrong [14] use themedial axis transform (MAT) to carry out theadaptation and the idealization of B-Rep geometry.The MAT method builds the skeleton of ageometrical representation in order to obtain themedial axis.

M.Hamdi et al[15] CAD/CAE interoperability,an automatic generation of analysis model based onthe simplification of CAD geometry isimplemented by using CASCADE platform. Inorder to be independent of CAD/CAM system, theproposed algorithm relies on a neutral file (STEP)to recuperate the data of the part to be simplified touse various tools of simulation; the simplified cadgeometry will be also stored in the STEP format.

Oussama jaider et al. [16] had described a newapproach to eliminate the undesirable ininterpretations of features, according tomanufacturing rules and metal removal principals.Automatic feature Recognition (AFR) has played acrucial role linking CAD activities and computeraided process planning (CAPP).

Bob Evans et al. [17] had stated that theinterference of machine learning as decision treeinduction to derive process control rules andparticipation of experts knowledge to do the best.They recently applied a machine learning strategyknown as decision tree induction to derive a set ofrules.

Jiawei Han and Micheline kamber [18] looksat rule based classifiers, where the learned model isrepresented as a set of IF-THEN rules. They thenstudied the ways in which they can be generated;either from decision tree or directly from thetraining data using a sequential covering algorithm.

A.Sheffer [19] reported that, face clustering isa technique to cluster the faces in the input model.The clusters thus formed represents the region ofintersects that may be considered for simplification.There are three main steps followed in thisapproach: face clustering, finding the collapsiblefaces and simplification.

Satoshi kanai et al. [20] had described that theCAD systems and assembly models tend to have ahuge number of parts and very complex innerstructures. For achieving the light weight andstrengthened parts, the inner structures of housingsuch as rib or bosses have very complexgeometries. In order to simplify this complexgeometry: Remove invisible technique is used. In this paper utilizes two different approaches to simplify the cad model. The firstapproach is knowledge based. In this approach theknowledge is gain from experts demo's andencoded that data as simplification rule. It is alsocalled as a rule based approaches. The rules showsthat whether the feature /part that should beconsidered for suppression or not.

The second approach is using hybridmethod of simplification. In this approach consistsof following phases. The phase A consists of stepof pre-treatment of CAD model. The phase Bconsists in identifying details for details forsuppression. The phase C consists of allowssimplification and reconstruction of simplifiedmodel. For this approaches the open cascadeplatform is utilized.

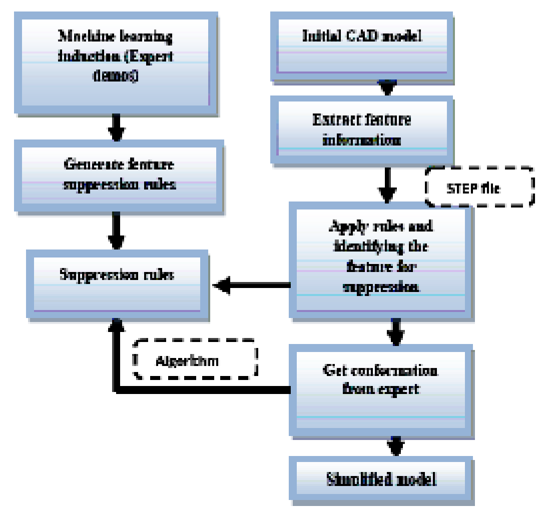
METHODOLOGY

In this session has been divided into twomain phases. First phase consists of knowledgebased approach and second phase leads tosuppression by hybrid approach. The overview ofthis approaches are discussed below.

Overview of knowledge based approach

The proposed approach is to design anautomated tool to identifying the features capablefor suppression. The overall approach forgenerating a CAD simplification using rule basedapproach as shown below.

Figure 3: Overview of Rule Based Approach



First, the experts knowledge is capturedfrom demo and suppression rules are generatedform statistical induction learning techniques[21].The generated CAD model is converted intoneutral format (STEP) and then rules generated areexpressed as a binary decision tree.

The decision to suppress or not, on afeature depends up on the analysis content andapplication. Using that knowledge gained from theexpert and the decision rules are generated forsuppressing the CAD model for FEA simulations.For suppression we considered following.

3.1.1 Machine Learning: Rules for Suppression

Rule 1: Based on feature type only we concludedwhether model is suppressed or not. Feature likeholes, fillets, chamfers are suppressed.

Rule 2: Based on feature dimension only whethermodel is suppressed or not. Small dimensions areleads to suppress.

Rule 3: Instead of absolute dimensions, the relativedimensions of features are considered assuppressed or not.

Rule 4: Boundary and load conditions areimportant factors that also taken to be considerationfor suppression or not.

Rule 5: Feature lies close to the load applicationcannot to be suppressed.

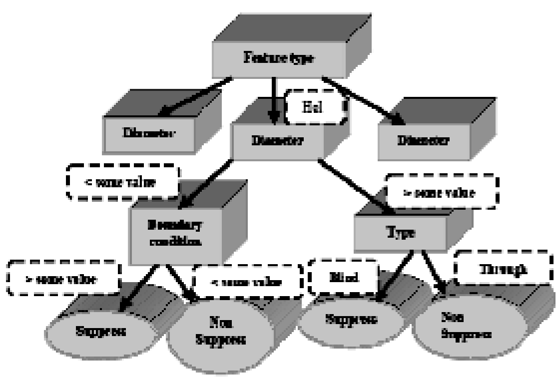
Rule 6: concentrate on feature formed by offset,mirrored and used as a reference, of other features.Because it leads to deleting of overall componentor access denied or redefined over other features.

3.1.2 Inductive Decision Tree

Inductive decision trees have proven to bea successful tool within the numerous fields andthese are proven to be advantageous in improvingthe accuracy or efficiency of the system

The above is an example of arepresentative decision tree for suppressing a holefeature considering attributes diameter, minimum distance to the boundary condition feature, and thegeometric type. The left node is the node

Figure 4: Decision tree for feature suppression



thatshould be executed if the condition is true. Theright node is the node that should be executed if thecondition is false.

Example algorithm for the above flowchart for suppression of holes using decision treeinduction as shown below.

Algorithm for feature simplification

Algorithm: Rule 1

if *feature type ==hole*

get *diameter value (min)*

then *(DIAMETER (D) <5)*

if *boundary condition. Distance (d) <5*

then

The feature leads to be suppressed

Else *The feature could not be suppressed*

End if

End if

Algorithm: Rule 2

if *feature type = = hole*

get *diameter value (min)*

then *(DIAMETER (D) <5)*

if *Hole type = = blind*

then *The feature is to be suppressed*

else

if *Hole type = =through*

then *The feature could not be suppressed.*

End if

End if

End if

Implementation and validation on example

Implementation of approach:

The data processing implementation of simplification approach was carried out on CATIAV5 software. In that the API development's platform: "Knowledgeware". Knowledgeware aspecial tool developed for 3D applications of CADCAMmultiplatform. This platform is installed byusing API toolkit installer and it is based on visualbasic language.

Example of validation

In this section, one example of validation will allow validating the principal functionalities of the simplification algorithm. (Fig 5) presents Bogie SF200. The part Bogie selected because they have a broad variety of mechanical parts in terms of its forms, the boundary conditions and also the details which they contain.

In this first the STEP file format is encoded and details of the feature are obtained.

After that the 3D model is extracted from neutral STEP file in Knowledgeware API platform. Below Fig presents the illustration of the principal stages to pass from a CAD model of the Bogie SF200 (Fig 5), imported CAD model from STEP file (Fig 6), shows that operation performed in rule editor (Fig 7), shows that check editor performance (Fig 8), shows knowledge inspector checks the rules (Fig 9), shows

Figure 5: Imported CAD model from STEP file

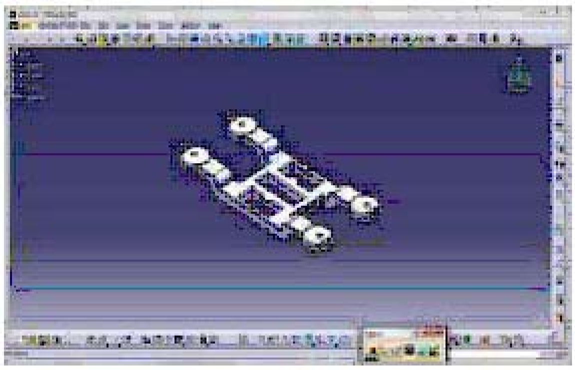


Figure 6: Imported CAD model from STEP file

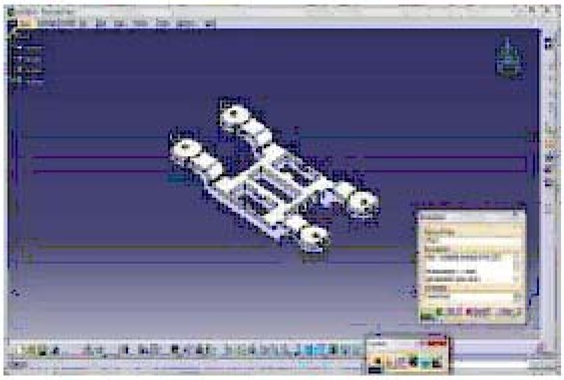


Figure 7: Imported CAD model from STEP file

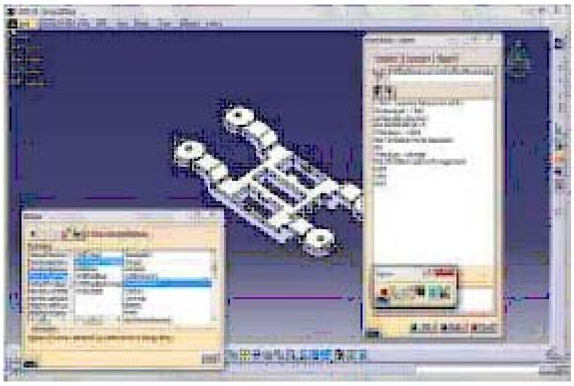
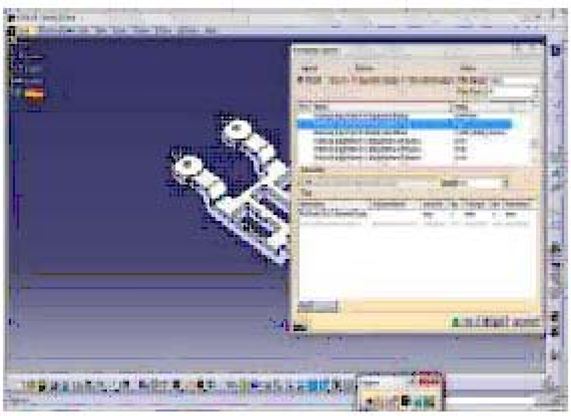


Figure 8: knowledge inspector checks the rules



Remove features language browser and finally (Fig 10), shows simplified model.

Figure 9: Remove features

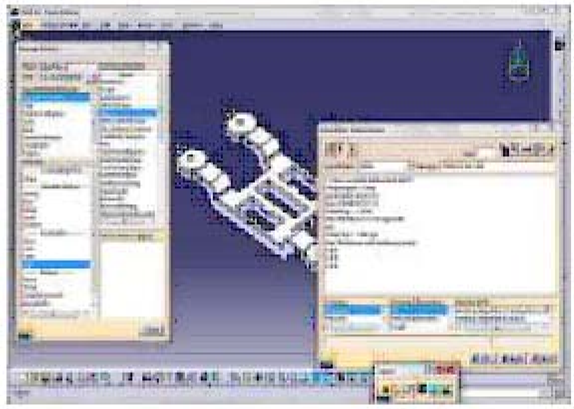
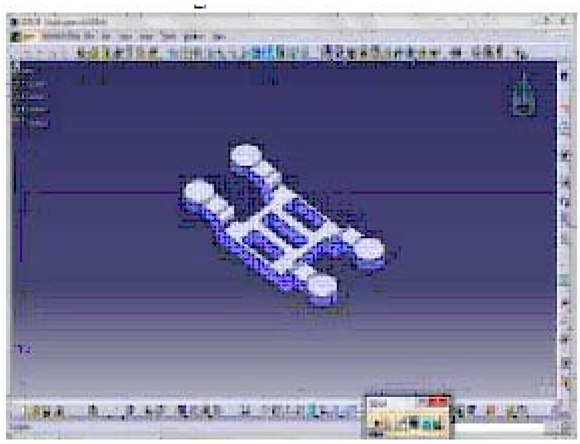


Figure 10: Simplified model

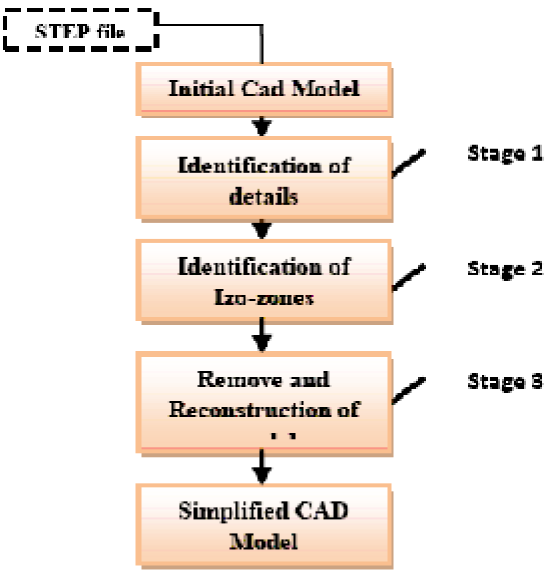


Overview of hybrid approach

In order to be independent of the CADCAM systems, the proposed algorithm relies on a neutral file (STEP) to recuperate the data of the part to be simplified. To use various tools of simulation, the simplified CAD geometry will be also stored under the same neutral format (STEP).

The overview diagram for hybrid approach isshown below. It consists of three main stages insimplifying of CAD model. This original visionenables designer to visualize the least influentialzones (high order of criticality) on the computationresults, giving him the possibility either to interactivelyeliminate the entities which have highorder of criticality, or to appeal to automaticalgorithms of elimination.

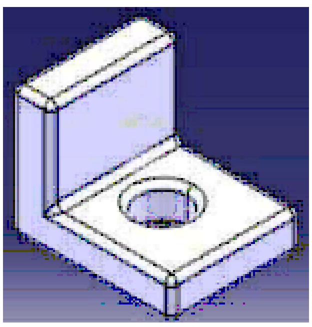
Figure 11: Overview of hybrid approach



Stage1: Initial CAD model

The stage (1) of the algorithm consists of aphase of identification of details. The structured information relates to the faces, wires, the edgesand the vertex which includes the geometry modelof the part.

Figure 12: Initial CAD model



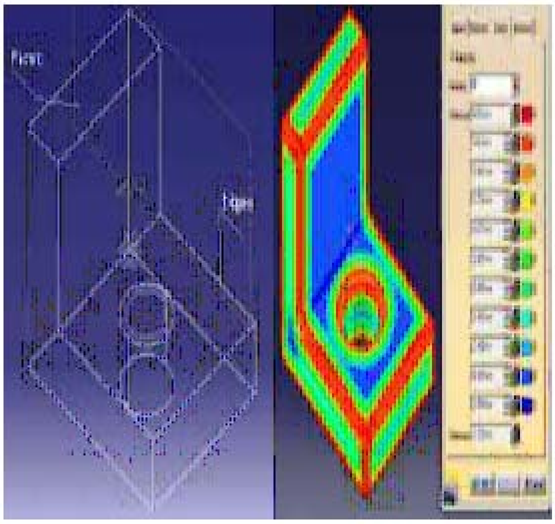
Stage2: Identification of details

The stage (2) consists in identifying theIso-zone for elimination. That implies theimplementation of algorithms of identificationbased on feature recognition. The result of thisphase is a representation of Iso-zones targets forelimination. These Iso-zones are entities (edges,faces, chamfers, fillets, and rounds) coloredaccording to a gradient of criticality.

Stage3: Remove and Reconstruction of model

The stage (3) consists in removing theidentified details, then in rebuilding the geometricalmodel

Figure 13: Identification of details(edges, faces, Izo-zones)



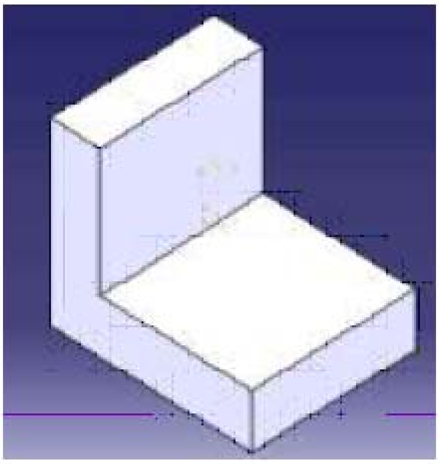
after suppression. The result of this phase isa simplified CAD model whose elementarytopology is valid. At the exit of the algorithm, thedesigner has at his disposal a simplified modelrecorded in format STEP for a simulation by finiteelements.

Implementation and validation on example

Implementation of approach

The data processing implementation of

Figure 14: Remove and Reconstruction of model



simplification approach was carried out on openCASCADE platform. Open CASCADE a specialtool developed for 3D applications of CAD-CAMmultiplatform. This platform available freely inopen source on internet ant it is based on C++language encoding.

Example of validation

In this section, one example of validationwill allow validating the principal functionalities ofthe simplification algorithm. Fig presents BogieSF 200. The part Bogie selected because they havea broad variety of mechanical parts in terms of

Figure 15: Initial CAD model (STEP FORMAT)

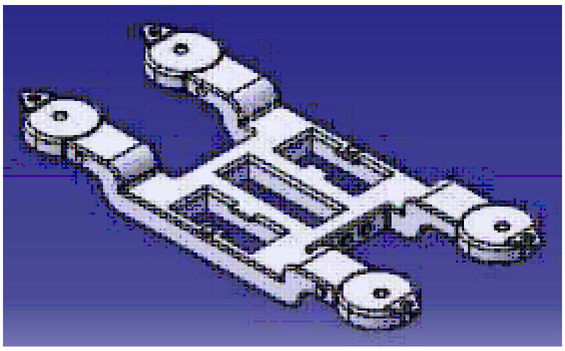


Figure 16: Identification of Izo-zones

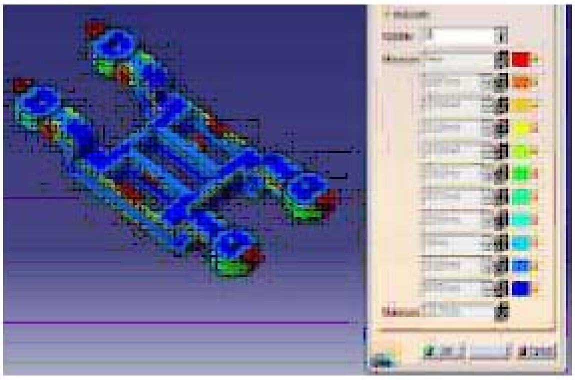
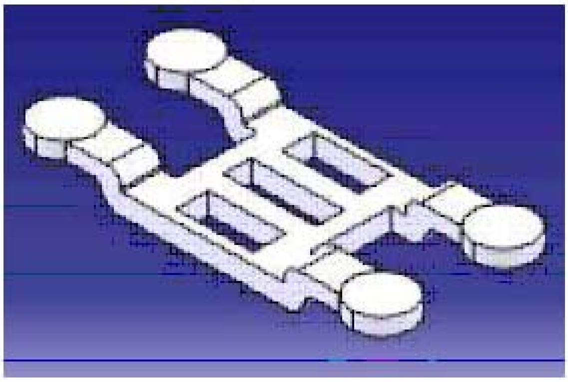


Figure 17: Simplified model



itsforms, the boundary conditions and also the detailswhich they contain.

RESULTS AND DISCUSSION

The below figures shows that the analysedmodels using ANSYS 14.0.Fig (18) shows analysisof original model it has an equivalent Von-misesstress of **1.8745e5 Max** and analysis time taken **as38 s.** Fig (19) shows analysis of simplified modelusing knowledge based approach it has anequivalent Von-mises stress of **1.4891e5 Max** andanalysis time taken as **16 s**. Fig (20) shows analysisof simplified model using knowledge basedapproach it has an equivalent Von-mises stress of**1.4236e5 Max** and analysis time taken as **12 s**.

Figure 18: Analysis of original model

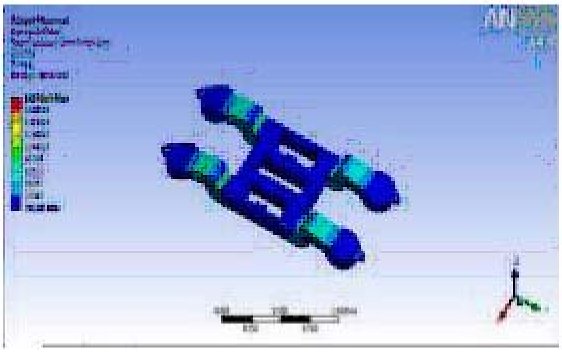


Figure 19: Analysis of simplified model (Knowledge based approach)

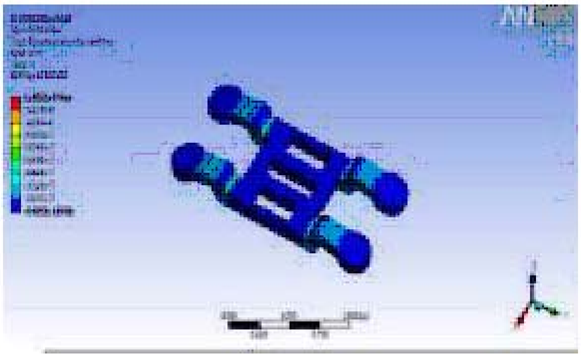
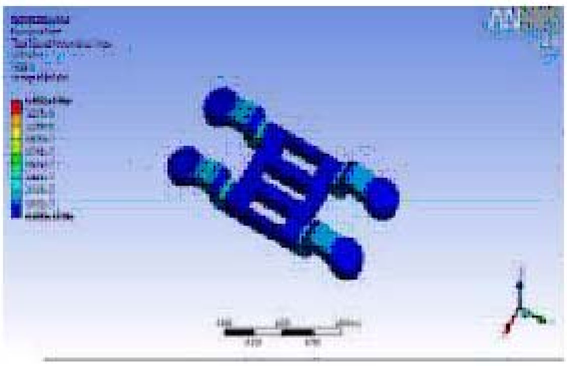


Figure 20: Analysis of simplified model (Hybrid approach)



The below Chart 1 shows that thecomparison of CAD model simplificationtechniques based on Equivalent Von-mises stressand chart 2 shows comparison of computation time reduction.

Chart 1: Equivalent Von-mises Stress comparison

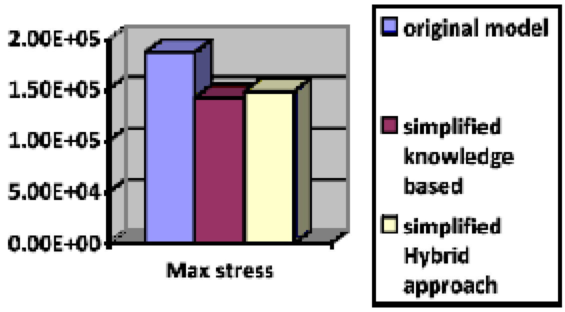
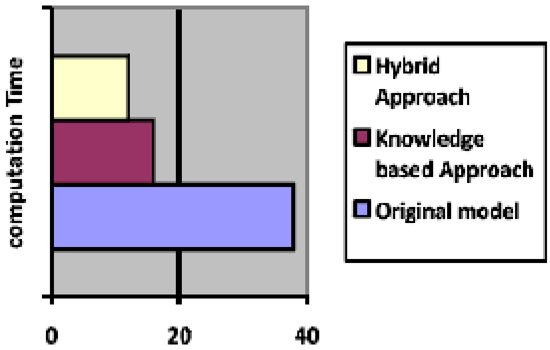


Chart 2: Comparison of Computational Time



CONCLUSION

This paper presents an estimating theeffect of simplification algorithm on CAD modelsfor a simulation by finite element method. Thealgorithm proposed consists on reading the B- repmodel of the CAD geometry in order to identify,then to remove the details considered to besuperfluous for mechanical analysis. The example of validation show that asuitable elimination of the details in a CAD modelallows saving a very important time (up to 69%) inthe procedure of simulation while keeping a highquality of the computation results. Theseobservations were found by doing simulations byfinite elements before and after simplification. Thiswork helps to the industrialists who are interestedmore and more in preparing CAD models forsimulation purposes. Thus the comparison showshybrid approach gives acceptable results withminimum error.

SCOPE AND FUTURE WORK

This work helps to the industrialists whoare interested more and more in preparing CADmodels for simulation purposes. It is fully based onsimplification of features like holes, chamfers andfillets. At short notice, In Future it is important toconsider other criteria of simplification such asvolumes, size and surface entity based with thissimplification technique.

REFERENCES

1. Danaan Metge, "Modeling and Simulating Mechanical Systems on a Transforming Dicycle", BPG Motors, 2013.
2. LEE sang Hun and LEE Kunwoo, "Feature – based multiresolution techniques for product design", Journal ofZhejiang University SCIENCE A 7(9):1535-1543, 2006.
3. Yogesh H Kulkarni, Anil Sahasrabudhe, Mukund Kale, "Strategies for using feature information in model simplification". International Conference on Computer Aided Engineering, 2011.
4. J.Edlund, E.Kermati and M.Servin, "A Long-tracked Bogie for forestry machines on soft and rough terrain", Journal of Terramechanics, 2012.
5. Metge, "Modeling and Simulation of Mechanical Systems on a Transforming Dicycle", BPG Motors, 2013.
6. Erick R. Denlinger, Seffirwin and Pan Michaleris, "Thermomechanical modeling and simulations of additive manufacturing of Aerospace parts",J.Manuf.sci and engg 136(6), 2014.
7. Letherwood M. gunter, "Virtual modeling and simulation of military ground vehicles",SAE technical paper,2000-01-1580, 2000.
8. Wang.H.Maz and Kikuchi.N.Pierre, "Multi-domain topology optimization for vehicle structure crash worthiness design", SAE technical paper, 2004-01-11734, 2004.
9. Atul Thakur, Ashis Gopal Banerjee, and Satyandra K. Gupta, "A survey of cad model simplification techniques for physics-based simulation applications", Computer-Aided Design, 41(2):65- 80, 2009.
10. Hamdi Mounir, Aifaoui Nizar and Banamara Abdelmajid,"CAD model simplification using a removing details and merging faces technique for FEM simulations". Journal of Mechanical Science and Technology 26(11):3539-3548, 2012.
11. H Zhu and C.H Menq, "B-rep model simplification by automatic fillet/round suppressing for efficient automatic feature recognition".Computer-Aided Design, 34(2):109 - 123, 2002.
12. R. Ferandes, "A posteriori evaluation of simplification details for Finite Element Model Preparation", computers and structureVol-87, 73-80, 2009.
13. Shuming Gao, "Feature Suppression based mesh model simplification", CAD Vol-42 1178-1188, 2010.
14. R.J.Donaghy & C.G.Amstrong, "Dimensional Reduction of surface for

analysis", Engineers with Computers, 2000.

15. M. Handi, B.Louchichi &N.Aifaooi, "CAD / CAE interoperation, an automatic generation of analysis model based on the simplification of CAD geometry", CFM, France, 2009.

16. Ousama Jaider, "Manufacturing computer aided process planning for rotational parts". International Journal of Innovation and Applied Studies, 307-319, 2014.

17. Bob Evans, Doug Fisher, "Overcoming Process Delays with Decision tree Induction. Machine Learning", IEEE EXPERT, 1996.

18. Jian-Fengyu, Hong Xiao, Jiezhong & Hui Cheng, "CAD model simplification for assembly field", Int J Adv Manf Technol, 2013.

19. A.Sheffer, "model simplification for meshing using face clustering", CAD-33(925-934), 2001.

International Journal of Engineering Research and Science & Technology
Hyderabad, INDIA. Ph: +91-09441351700, 09059645577
E-mail: editorijlerst@gmail.com or editor@ijerst.com
Website: www.ijerst.com

ISSN 2319-5991