Development of Ansys Automated Macros for FE Modeling & Analysis of Mechanical Components

D S Chetan Kumar, B C Manjesh and Mohammad Farooq Yallur

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DEVELOPMENT OF ANSYS AUTOMATED MACROS FOR FE MODELING & ANALYSIS OF MECHANICAL COMPONENTS

Chetan Kumar D S[1], Manjesh B C[2] and Mohamed Farooq Yellur[3]

[1]9844033826 Sr Assistant Professor, Department of Mechanical Engineering, New Horizon College of Engineering, Bangalore, India

[2]Sr Assistant Professor, Department of Mechanical Engineering, New Horizon College of Engineering, Bangalore, India

[3]Student, M.E Mechanical Engineering Department, New Horizon College of Engineering, Bangalore, India

Abstract *— In today's competitive market, it's become critical to supply items quickly and efficiently. To be able to create dependable and fast goods, the mechanical design process must be altered. Reducing the amount of manual effort by automating repeated processes with scripts incorporated into computer tools is one technique to change the process. AUTOMATION is improving at an increasing rate in our country these days. Higher production rates and productivity, more effective material use, greater product quality, improved safety, shorter labor work weeks, and shorter factory lead times are just a few of the benefits usually attributed to automation. The purpose of this paper is to develop a framework for automating time-consuming and repetitive design procedures. The use of APDL-Ansys Parametric Design Language in ANSYS automates the FE process. Microsoft Excel and Visual Basic are also used to build a user interface. As a result, a significant portion of the work must still be completed by hand, which takes time and is prone to errors, causing significant delays.*
Keywords—*Automation, Product development, Ansys, FEA, APDL, VBA.*

1. Introduction

To be competitive in a changing market it is necessary to deliver reliable products in the shortest period of time possible. Before the advancement of personal computers, only few institutions were able to perform Finite Element Analysis, making the design process extensive and exclusive in the automobile and aeronautic industries. Nowadays the use of this tool has become a routine in different areas of engineering, as stated by Turkiyyah & Fenves (1996). “FE methods have become the standard techniques for evaluating the physical performance of structural systems in various engineering applications”. In the concept realization phase of the mechanical design process, it is necessary to evaluate if the model can resist loads applied to it. In order to analyze the structure, static and dynamic calculations are performed. The time required to evaluate complicated structures is extensive, even though computational tools are utilized.
In order to perform FEA it is not sufficient to just run the simulation in any FE available software, it is more important to understand the method behind the analysis.

There are certain parameters which control the accuracy of the FEA, such as: model simplification, mesh size, element type and accuracy percentage. By understanding the impact of the parameters mentioned above, it is possible to run the simulation efficiently. The main goal of this paper is to automate the FEA process in ANSYS Mechanical and prove the advantages of APDL script automation. This thesis also aims to create macros to automate and evaluate mesh size in order to establish fast analysis without the results being compromised.

2. Overview of Ansys APDL

ANSYS APDL (Classic) is the leading software solution that uses finite element analysis (FEA) for various analyses/simulations using the ANSYS Mechanical interface. It covers an enormous range of applications in the field of mechanical, aerospace, bio-medical, automotive, structural, and much more in 3 phases i.e., pre-processing, solution & post-processing. Ansys Mechanical APDL is also used to model advanced materials, complex environmental loadings, and industry-specific requirements in areas such as offshore hydrodynamics and layered composite materials as well.

APDL is an acronym for ANSYS Parametric Design Language, a powerful scripting language that allows you to parameterize your model and automate common tasks. Using APDL, you can:

- Input model dimensions, material properties, etc. in terms of parameters rather than numbers.
- Retrieve information from the ANSYS database, such as a node location or maximum stress.
- Perform mathematical calculations among parameters, including vector and matrix operations.
- Define abbreviations (short cuts) for frequently used commands or macros.
- Create a macro to execute a sequence of tasks, with if-then-else branching, do-loops, and user prompts.

3. Objectives

The key objective of this project is to create Automation of Ansys by using APDL (Ansys Parametric Design Language) macro to automate the meshing task and post processing the results.

- The future state of macro involves the following:
- Duct or Tube mesh macro, The macro developed just need the component area in display, macros takes all meshing task.
- HTML file for Modal/Spectrum animations extraction
- HTML stress summary table to extract von misses stresses of all components at each mode shape.

4. Literature Survey

- In any Aviation/Automobile/Defense sectors, for stress analysis component's, On various occasion the user might want to repeatedly enter recurring simulation tasks or work steps takes time.
- User has to mesh and report stress summary manually.
- Manual calculations making it prone to errors and reworks, further affecting the project FTY and OTD.
- Time utilization more.
- Odds are more to reduce the nature of deliverables Project OTD & FTY.

Current State:

- In the current scenario, User physically mesh the components, Run the analyses and extract the stress summary and Modal animations for each time, which is tedious task.
- The very next phase after product design is analyzing the design component for many conditions environmental as well as application wise.
- So ANSYS provides a vital platform to test the model for allowable stresses, temperature and pressure conditions.
- It is a tedious task to mesh the model for analysis purpose, since it contains huge number of brackets, ducts and tubes.
- Manually meshing takes more time to mesh the components.
- Also from modal analysis and animation, one can confirm the connectivity of the FE model and Natural

frequencies of modal.

- Once the analysis is completed, to extract the information of stresses and strains of all the required components at each mode a shape is a critical and time consuming task.

5. Automation Of Ducts/Tubes Meshing

The effort to produce a complicated finite element model is expanding rapidly these days, and development timeframes have been cut in order to reduce time to market for new items. There are various solutions to this current state; one of them is to increase the resources of FEA/CAE all over the work, another option is to manage CAE expert knowledge and automate repeated procedures to free the knowledge workers from these tasks and let them to focus on things that add value to the activity. There are a number of advantages to automating task and knowledge management rather than hiring more people: Fixed costs do not rise, expertise is preserved within the company, and engineers are focused on solving issues rather than creating CAE models. This thesis will show how an experienced CAE specialist can increase the efficiency of his or her process by changing the method the finite element model is created.

Rather than spending time and effort running a meshing task, the expert will use VBA and APDL to turn knowledge of the techniques for creating a finite element mesh into custom built applications. The CAE expert will focus more on solving problems rather than creating the finite element models. In the forthcoming future, the CAE Process will alter; the specialist's necessary work to construct a finite element model will be reduced to the point where he or she will only be handling the data generated by servers running commercial or custom-built applications.

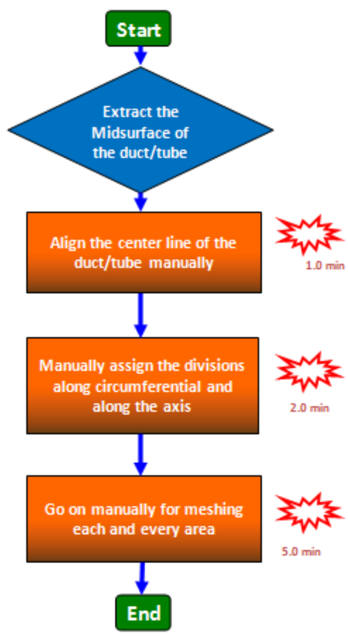

Figure 1. Current State Value stream map

A. Current State:

- In the current state of Duct meshing, user has to extract the Midsurface of the tube component.
- Align the center line of the tube or duct manually by recreating the geometry.
- User has to manually assign the required divisions along the circumference and also along the axis.
- User has to manually go for meshing small portion of the duct or tube surface for quality mesh.

- This manual process will take more time and also prone to errors in meshing as well as quality wise bit poorer.
- To avoid these issues, we can automate the process to avoid waste and improve the process.

B. Total Time required = 8 min / duct

Estimated time = 8.0 * 4 (considering 4 ducts approx. in one system)

= 32 Min/System

C. Future improved State:

The CAE process was enhanced and optimized by converting the CAE expert's expertise into modules for the meshing solution. Ansys APDL is a platform for integrating knowledge into ANSYS, automating repetitive tasks, and avoiding non-value-added processes. The CAE process consists of a series of processes or activities carried out by a CAE/FEA expert in accordance with a set of rules based on the type of analysis required. Traditional CAE/FEA Process entails a great deal of effort, expertise, and understanding on the part of the CAE expert to complete a Finite Element Model driving a pre-processing program.

A controlled CAE Process is depicted in the diagram below, in which the CAE specialist's expertise, experience, and constraints are translated into a set of rules or computer code that requires minimal human interaction. The process can be enhanced by controlling knowledge, minimizing non-value added processes and reducing the effort required to construct a model.

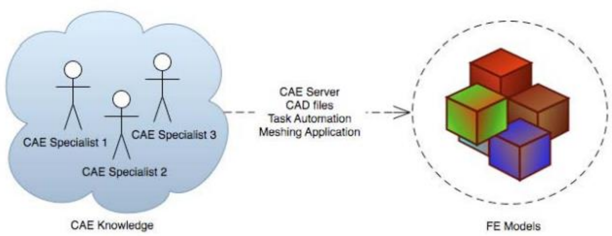

Figure 2. Managed CAE Process Diagram

D. Proposal for Improving the CAE Process

Applications containing the knowledge and experience of CAE specialists were designed to improve the CAE process by eliminating repetitive operations. By automating the processes performed by CAE specialists, these apps handle the production of the finite element model (or mesh).

E. Procedure to follow (Future State)

- Displace the Midsurface of duct area for which meshing has to be carried out.
- Run the macro. Read input from>select the ductmesh.dat file.
- Enter details for circumferential and along axis divisions.

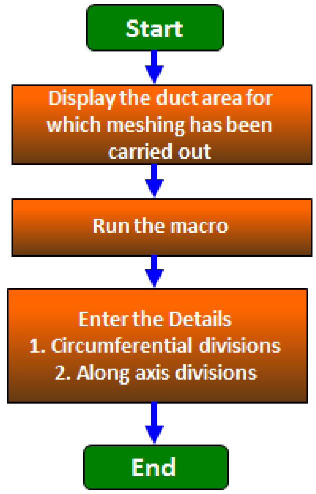

Figure 3. Future State Value Stream Map

F. Total time taken in Current State:

Total Time required = 1 min / duct
Estimated time = 1 * 4 (considering 4 ducts approx. in one system)
= 4 Min/System

6. Results And Conclusion

The use of knowledge and process management could help to improve the CAE/FEA process. This conclusion could be applicable to any engineering process in addition to the CAE/FEA process. Following an evaluation of the methods used and the results produced, the following conclusions were drawn:

- The essential steps to accomplish a given in the CAE process were translated into computer code by managing the CAE specialist knowledge.
- Time-consuming tasks are eliminated and replaced with a more efficient method that practically never requires human interaction.
- Tasks that take time are discarded in favor of a more efficient alternative that almost never requires human engagement.
- The knowledge worker will concentrate on value-added tasks such as setting up boundary conditions and loads, as well as making design recommendations.
- Cutting costs and reducing time to market are two ways that an organization might improve. Because the analysis work to validate the products will take less time, more time will be available for virtual testing.
- The only method to reduce time to market without knowledge management in the CAE process is to increase headcount, which increases fixed costs.
- Avoid rework by having the majority of the work (FE Models) created according to the criteria developed to manage the CAE specialist's knowledge and reduce variance between models created by different CAE specialists.
- The role of the FE specialist will shift in the next 5-10 years from developing meshes and applying loads to maintaining the information (FE models) generated applications.
- The non-added value operations will be completed faster than if the CAE specialist's expertise was managed and numerous sub-processes of the CAE Process were automated.

- CAE specialists could concentrate their efforts on running more simulations in order to create a more robust design. As a result of this work, the quality of the finite element model will improve, and differences between models (produced by different users) will be reduced, resulting in models created by an experienced CAE specialist and a novice user that are similar.

7. Productivity Savings

As Is Process:	
Time spent on meshing one Duct	= 8 min/duct
Time spent on meshing considering 4 Ducts in one system	= 8*4 = 32 min/system.
No. of system runs per month	= 20 No's
Time spend per Month	= 32 * 20 = 640 mins/month or = 10.6 hrs/month
Time required to make the report Yearly	= (10.6 hours)*(12 months) = 127.2 hours per year
To Be Process:	
Time spent on meshing one Duct	= 4 min/duct
Time spent on meshing considering 4 Ducts in one system	= 4*4 = 16 min/system.
No. of system runs per month	= 20 No's
Time spend per Month	= 16 * 20 = 320 mins/month or = 5.3 hrs/month
Time required to make the report Yearly	= (5.3 hours)*(12 months) = 63.6 hours per year

Total time saved: 127.2 - 63.6 = 63.6 Hours per Year

Productivity (hrs.)	**=63.6 Hrs/Year**
Hourly labor rate	**$ 22 /hr**
Project's annualized benefits	**$22 x 63.6 hrs. = $ 1399.2**
Additional work that will be taken up	**Time saved from this productivity improvement shall be used in developing other Value Additions activity and reports.**

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