

BACHELORS DEGREE ASSIGNMENT SPECIFICATION

Student name:	HE	Student P number:	
Programme:	BEng Automotive and Manufacturing streams		
Module:	Advanced Stress Analysis & FEA	Module Level (4, 5, 6):	6
Module code:	M6X00420	Contribution to Overall Module Assessment (%):	50 %
Lecturer:	Kelvin Lake	Internal Verifier:	Rob Goodson
Assignment Title:	Can FEA replace physical testing?	Assignment No (x of x):	1 OF 1
Hand Out Date:	25/02/2020	Submission deadline:	29/03/2020

Referencing:	In the main body of your submission you must give credit to authors on whose research your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have read or quoted in order to complete this assignment (e.g. for books: surname of author and initials, year of publication, <u>title of book</u> , edition, publisher: place of publication).		
Disclosure:	I declare that this assignment is all my own work and that I have acknowledged all materials used from the published or unpublished works of other people. All references have been duly cited.		
Student's Signature:	Assignments will not be accepted without a signature here	Date:	
Turnitin: Lecturer to tick to indicate if an electronic version of the assignment must be submitted to Turnitin. Note: the Turnitin version is the primary submission and acts as a receipt for the student. Penalties for late submission: Up to four weeks late, maximum mark of 40%. Over four weeks late, Refer. Only Year Tutors and the Programme Director may grant an extension.			YES
			NO

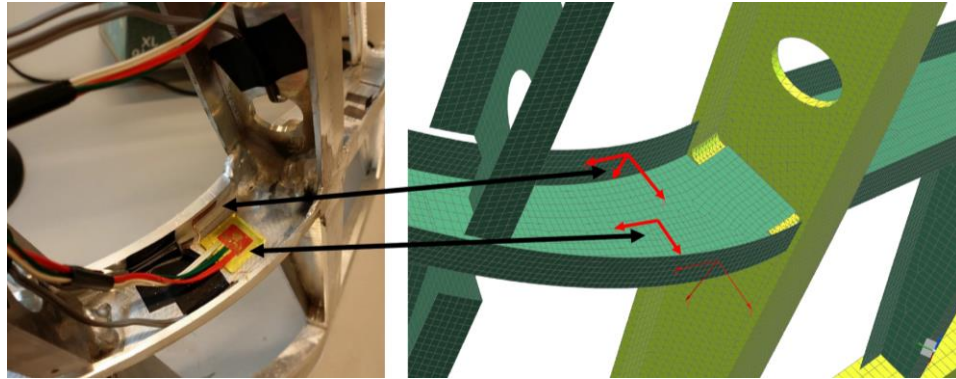
Learning Outcomes tested (from module syllabus)	Assessment Criteria To achieve each outcome a student must demonstrate the ability to:
Demonstrate an ability to analyse a range of engineering problems using advanced stress analysis principles.	

- DO NOT put this form into Turnitin or it will match many similarities with other students' submissions.

TASK DESCRIPTION

This assignment explores FEA and the role that it plays in product development. It is expected that the student will research this topic (referencing any sources used, using Harvard or Vancouver).

GUIDANCE FOR STUDENTS IN THE COMPLETION OF TASKS



The above image shows a component undergoing physical testing and the corresponding FE model. Your task for this assignment is to discuss the following;

1. Why companies typically carryout FE analysis alongside physical testing.
2. How a physical test may be correlated to an FE model.
3. If you think that FE analysis can (or should) ever replace physical testing.

In order to do this, you should consider a case study and use this to discuss the above tasks.

This report should be 3000 words long and should be submitted via moodle

STRUCTURAL SECTION MARKING CRITERIA AND STUDENT FEEDBACK

This section details the assessment criteria. The *extent* to which these are demonstrated by you determines your mark. The marks available for each criterion are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Common Assessment Criteria Applied	Marks available	Marks awarded
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions.		
(Assessed in point 1)	30	18.9
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.		
(Assessed in point 2)	30	18.6
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence		
(N/A)	0	
4. Practical Application and Deployment Deployment of methods, materials, tools and techniques; application of concepts; formulation of innovative and creative solutions to solve problems.		
(Assessed in point 3)	30	20.1
5. Skills for Professional Practice Attributes in professional practice: individual and collaborative working; deployment of appropriate media; presentation and organisation.		
(Assessed in report presentation and structure)	10	5.5

Assignment Mark Overall (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		63.1 %
	Up to one-week late		
	Over one week late		

COMMON ASSESSMENT AND MARKING CRITERIA

	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
Assessment Criteria	0-29%	30-39%*	40-49%	50-59%	60-69%	70-79%	80-100%
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions	Little or no evidence of reading. Views and findings unsupported and non-authoritative. Referencing conventions largely ignored.	Poor evidence of reading and/or of reliance on inappropriate sources, and/or indiscriminate use of sources. Referencing conventions used inconsistently.	References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.	Inclusion of a range of research-informed literature, including sources retrieved independently. Referencing conventions mostly consistently applied.	Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.	A comprehensive range of research informed literature embedded in the work. Excellent selection of relevant and credible sources. High-level referencing skills, consistently applied.	Outstanding knowledge of research-informed literature embedded in the work. Outstanding selection of relevant and credible sources. High-level referencing skills consistently and professionally applied.
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.	Major gaps in knowledge and understanding of material at this level. Substantial inaccuracies.	Gaps in knowledge, with only superficial understanding. Some significant inaccuracies.	Evidence of basic knowledge and understanding of the relevant concepts and underlying principles.	Knowledge is accurate with a good understanding of the field of study.	Knowledge is extensive. Exhibits understanding of the breadth and depth of established views.	Excellent knowledge and understanding of the main concepts and key theories. Clear awareness of challenges to established views and the limitations of the knowledge base.	Highly detailed knowledge and understanding of the main theories/concepts, and a critical awareness of the ambiguities and limitations of knowledge.
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence	Unsubstantiated generalisations, made without use of any credible evidence. Lack of logic, leading to unsupportable/missing conclusions. Lack of any attempt to analyse, synthesise or evaluate.	Some evidence of analytical intellectual skills, but for the most part descriptive. Ideas/findings sometimes illogical and contradictory. Generalised statements made with scant evidence. Conclusions lack relevance.	Evidence of some logical, analytical thinking and some attempts to synthesise, albeit with some weaknesses. Some evidence to support findings/ views, but evidence not consistently interpreted. Some relevant conclusions and recommendations, where relevant	Evidence of some logical, analytical thinking and synthesis. Can analyse new and/or abstract data and situations without guidance. An emerging awareness of different stances and ability to use evidence to support the argument. Valid conclusions and recommendations, where relevant	Sound, logical, analytical thinking; synthesis and evaluation. Ability to devise and sustain persuasive arguments, and to review the reliability, validity & significance of evidence. Ability to communicate ideas and evidence accurately and convincingly. Sound, convincing conclusions / recommendations.	Thoroughly logical work, supported by evaluated evidence. High quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Strong, persuasive, conclusions, justifiable recommendations.	Exceptional work; judiciously selected and evaluated evidence. Very high quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Highly persuasive conclusions
4. Practical Application and Deployment Effective deployment of appropriate methods, materials, tools and techniques; extent of skill demonstrated in the application of concepts to a variety of processes and/or contexts; formulation of innovative and creative solutions to solve problems.	Limited or no use of methods, materials, tools and/or techniques. Little or no appreciation of the context of the application.	Rudimentary application of methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application.	An adequate awareness and mostly appropriate application of well established methods, materials, tools and/or techniques. Basic appreciation of the context of the application.	A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application, with some use of examples, where relevant.	A very good application of a range of methods, materials, tools and/or techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some innovation and creativity.	An advanced application of a range of methods, materials, tools and/or techniques. The context of the application is well considered, with extensive use of relevant examples. Application and deployment extend beyond established conventions. Innovation and creativity evident throughout.	Outstanding levels of application and deployment skills. Assimilation and development of cutting edge processes and techniques.
5. Skills for Professional Practice Demonstrates attributes expected in professional practice including: individual initiative and collaborative working; deployment of appropriate media to communicate (including written and oral); clarity and effectiveness in presentation and organisation.	Communication media is inappropriate or misapplied. Little or no evidence of autonomy in the completion of tasks. Work is poorly structured and/or largely incoherent.	Media is poorly designed and/or not suitable for the audience. Poor independent or collaborative initiative. Work lacks structure, organisation, and/or coherence	Can communicate in a suitable format but with some room for improvement. Can work as part of a team, but with limited involvement in group activities. Work lacks coherence in places and could be better structured.	Can communicate effectively in a suitable format, but may have minor errors. Can work effectively as part of a team, with clear contribution to group activities. Mostly coherent work and is in a suitable structure.	Can communicate well, confidently and consistently in a suitable format. Can work very well as part of a team, with very good contribution to group activities. Work is coherent and fluent and is well structured and organised.	Can communicate professionally and, confidently in a suitable format. Can work professionally within a team, showing leadership skills as appropriate, managing conflict and meeting obligations. Work is coherent, very fluent and is presented professionally.	Can communicate with an exceptionally high level of professionalism. Can work exceptionally well and professionally within a team, showing advanced leadership skills. Work is exceptionally coherent, very fluent and is presented professionally.

Student Self Evaluation Form

Student name:		Student P number:	
Programme:		Year of programme	
Assignment Title:			

This section repeats in brief the common assessment criteria detailed on previous pages. The *extent* to which these are demonstrated by you determines your mark. Using these criteria, tick the box that best indicates the level of achievement you feel you have achieved with regard to each of them.

Common Assessment Criteria Applied	Level of Achievement						
	REFER		3 rd	2:2	2:1	1 st	1 st
	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
1. Research-informed Literature	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
2. Knowledge and Understanding of Subject	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
3. Analysis	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
4. Practical Application and Deployment	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
5. Skills for Professional Practice	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐

PLEASE COMMENT ON AREAS IN WHICH YOU FEEL THAT YOU HAVE PERFORMED WELL	PLEASE COMMENT ON AREAS YOU FEEL THAT YOU NEED TO DEVELOP

Student's Name		Date	
Student's Signature			

University of Wales Trinity Saint David

School of Engineering

Discussion about the relationship between FE analysis
and physical testing

Course: Mechanical Engineering

Student Name: HE XINXIN

Student number :1904657

Degree: Undergraduate level 6

Module: Advanced Stress Analysis & FEA (M6X00420)

Abstract

The development of computer technology make it more convenient and economic to analysis the products by using finite element analysis software in computer rather than doing physical testing with them.

However, this does not necessarily mean that the FE analysis will replace the physical testing completely in the future. This report will discuss *USE PAST TENSE* about the advantages for companies to use finite element analysis when they develop new products, the relationship between FE analysis and physical testing with a case study of modeling a superplastic process and finally the necessity of physical testing from different aspects.

In summary, finite element analysis is a powerful tool for companies to predict the behavior of products, but physical testing will also be necessary to verify the FE model and show some factors missed by FE model etc. Using these two methods properly can give a company the best result.

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1 Why companies typically carryout FE analysis alongside physical testing.

Usually, there are two functions of FE analysis, designing a new product or verifying the stress of a product.

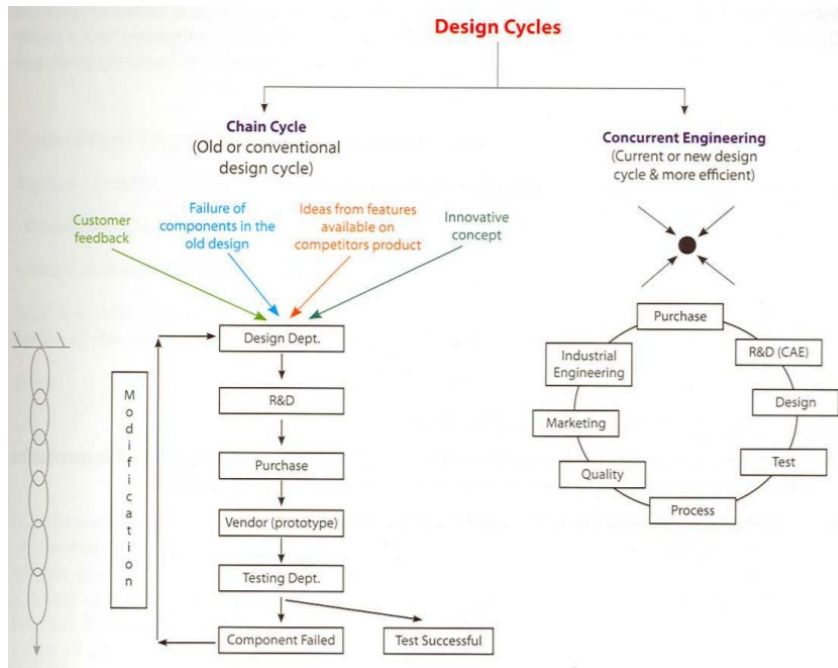
FEA IS CAPABLE OF PREDICTING MUCH MORE THAN SIMPLY STRESS

1.1 FE analysis for New product developing

1.1 .1 Function of FE analysis to improve efficiency

When developing a new product, a lot of testing need to be done to make sure the property of the product. A traditional design cycle is a iterative process of designing, making prototype and testing, where the latter two some times can be expensive and time consuming. And because of the specialization of working, there is some idle time for different apartment in the company in different phase of this process, which causes the low efficiency of the company.

The advantage of FE analysis is that it can change the design cycle into a concurrent engineer. With the help of CAD softwares, represents from different apartments form a group and work together towards a common target. This can keep all members informed about the status of the product design, and reduce the idle time efficiently. And the effective time will also be cut down because of the decrease of number of physical testing, which will be discussed following. (Gokhale and Deshpande, 2008, p11)



Picture 1 the design cycles of different methods (Gokhale and Deshpande, 2008, p11)

1.1.2 Function of FE analysis to reduce the number of physical testing

More importantly, with the FE analysis, the number of prototypes need to be made and physical testings through the entire design process can be reduced considerably. The main purpose of physical testing in the design process is to attain the information about the property of product, such as strength, stability, bearing capacity, or to find the places which prone to failure. And the earlier the information is gave, the more valuable it is, because changing the product early is much cheaper than it is lately. From the aspect, there should be as more tests as possible to avoid the false direction of design. But due to the limit of budget of a project, the time, number and fidelity of physical testing need to be arrange elaborately. (Thomke and Bell, 2001)

Most of aims of physical testing can be fulfilled by conducting FE analysis, which is much cheaper and convenient to do. Because of this advantage, it is comprehensible that many companies today include FE analysis as one of their important tools. And another factor that makes FE analysis prevalent is that given the availability of FE analysis, companies can do more analysis to make sure some properties of the product at the early stage of product developing. They can even do more analysis on other parallel product concepts to optimize their product.

YOU SHOULD NOT START SENTENCES WITH AND OR BECAUSE.

1.1.3 The influences of FE analysis to engineers in the company

Considering the complexity of product performance in reality, which will be influenced by many factors like material, working condition etc, only engineers with lots of experience can be assigned to complete a project independently. However, with the help of FE analysis, novice engineers can gain lots of experience through analyze all kinds of products using software. It also give them the ability to complete a project confidently. And for company, this means that they do not have to hire a lot of experienced engineers, rather, a novice engineer with lots of analytical knowledge can also be a perfect alternative, which can help reduce the expenses on salary of engineers.

1.2 verifying the stress of a product

1.2.1 The function of FE analysis to predict the performance

Physical testing of a product is necessary before it can be launched. One function of FE analysis is to predict the performance of the product in the physical testing, which can give advice about the places that need to be paid attention to. With this prediction, experimenters can then know ~~when~~ they need to paste the sensors in addition to the places that they want to observe already.

REGULATIONS OFTEN DICTATE THIS.

WHERE? YES. FEA CAN BE USED TO DETERMINE WHERE TO PLACE SENSORS.

1.2.2 The function of FE analysis compare with physical testing

The result of physical testing and FE analysis should correlate with each other within a tolerant extent if all the analysis and testing are conducted without any error. In the contrary, if there is any difference which surprise engineers, it is a signal that something is wrong, and it is necessary to find the reason behind this unexpected phenomenon. This process can help engineers to rethink their design and testing process. This may help them to get to know how to model a product better in the analysis software and to make a better assumption about the behave of the product because the reality is much more complex than they thought. During the process of finding the reason they may find the wrong operation during the testing or it is the flaw of the material that causes the failure of product.

1.2.3 The function of FE analysis in some special industries and special testing

There are some industries where it is very difficult to do the physical testing. A typical industry of this kind is bridge industry. In the bridge industry, it is difficult to do the destructive testing because of the enormous expense and the impact on normal life of ordinary people. In order to know the ultimate capacity of bridges, it is a practical idea to build a data base which contains the result of all kinds of physical testings, and then develop the relating FE analysis system to model and analysis these bridges so that other engineers can use the relative design method to design new bridges, which is comparing the new design with the previous model with can work satisfactorily in the field to know whether or not the new design can perform well. (Bechtel and Andrew etc, 2011)

1.2.4 The function of FE analysis in failure analysis

Nearly all products will have a warranty that a company promise if their product fail within the warranty they will take the responsibility for it. If the failure rate of a component in a product is much higher than others, which can only be discovered in the process of using by consumers, the FE analysis can help to model the dynamic load of this component to figure out the reason of high failure rate or to figure out that if it is caused by other reasons like misusing or working condition.

2. How a physical test may be correlated to an FE model.

Physical testing and FE model always need to be used appropriately during the process of developing new product or analysis of the product performances.

2.1 Physical test can provide information to FE model

To demonstrate this assertion, a case study will be discussed in the following.

Superplastic forming is a process to change the shape of steel sheet without heating the steel to very high temperature, and the efficiency of it is much high than other forms of manufacture. To design the superplastic forming dies using FE model, it is fundamental to consider how to model the forming process accurately. In the

article [1], Luckey Jr, Friedman and Weinmann compared the result of experimental and the results of models with different parameters to determine the influences of these parameters.

The specially processed AA5083 aluminum sheet alloy is used in the experiment, and the constitutive model to describe the flow stress-strain rate-strain relationship was the power law equation.(Luckey Jr and Friedman, 2007) There are some questions they need to figure out.

A) Before the forming process, the sheet will be heat up to 2 minutes which will cause the grain growth which may influences the constitutive behavior. Whether this grain growth will cause difference between experiment results and prediction of FE analysis?

B) Is there a significant difference between using explicit FEA and implicit FEA?

C) What is the best mesh size of FE model of this process?

D) What is the influence of strain rate on the thickness prediction?

To find out the answers to these problem, they did 8 different FE analysis as follows:

FEA conditions for experimental correlation

ID	Condition
1	LS-DYNA, rate: 10^{-3} s^{-1} , element size: 4 mm, constitutive coefficients: b
2	ABAQUS, rate: 10^{-3} s^{-1} , element size: 4 mm, constitutive coefficients: b
3	LS-DYNA, rate: 10^{-3} s^{-1} , element size: 4 mm, constitutive coefficients: b , CTE applied
4	LS-DYNA, rate: 10^{-3} s^{-1} , element size: 4 mm, constitutive coefficients: a
5	LS-DYNA, rate: 10^{-3} s^{-1} , element size: 2 mm, constitutive coefficients: b
6	LS-DYNA, rate: 10^{-3} s^{-1} , element size: 6 mm, constitutive coefficients: b
7	LS-DYNA, rate: 10^{-3} s^{-1} , element size: 10 mm, constitutive coefficients: b
8	LS-DYNA, rate: 10^{-2} s^{-1} , element size: 4 mm, constitutive coefficients: b

In this chart, LS-DYNA is explicit method, and ABAQUS is implicit method. The rate means the strain rate in the power law equation. FE model which uses constitutive coefficient did not consider the grain growth because of the preheat, and the others considered this factor. Through comparing results of these FE analysis and

experimental result, it is more easy to see how these factors influence the result of FE model.

A) Compare 1 and 4 and experimental result to see the influence of grain growth. The result showed that condition 4 gave poor prediction to the profile deformation, so grain growth should be considered in the finite element analysis.

B) Compare 1 and 2 and experimental result to see the difference of explicit and implicit method. They found that result of both explicit and implicit method showed good correlation to the experimental result. And considering that explicit method require less time to get result and is more robust, they concluded that explicit method was more suited to industrial simulation.

C) Compare 1, 5, 6, 7 and experimental result to see the influence of element size. It was clear that the prediction capability decrease when the element size increases. They used a correlation coefficient to find form with element size the prediction began to deviate form experimental result. Finally, they gave a recommend element size when the entry radius is a specific number.

D) Compare 1 and 8 and experimental result to see the influence of stain rate. They discovered that accurate thickness profile can be predicted with a target stain rate of $10^{-2} s^{-1}$, which means they can apply a limited velocity scale of the process in FE analysis to improve efficiency without compromise the accuracy of the result.

Apart from giving the initial information to build FE model, physical testing also provides information to improve existing FE models. Article cited [2] provides a method to guide the parameter selection during the the updating existing FE model, i.e. minimise the differences between experimental result and FE analysis result.

2.2 FE analysis gives prediction of physical testing

There are different types testing, destructive testing, testing to get property of product, testing to mimic the possible work condition etc. And when testing a product, there are many aspects which can be measured. FE analysis can provide information about physical testing in several ways.

2.2.1 FE analysis gives a prediction about physical testings

If modeled properly, FE analysis can give a relatively high accuracy about what going to happen in the experiment. Take the physical testing of crane arm for example.

This is a really big equipment, so it is nearly impossible and not necessary to measure the stress of everyplace of this arm. To work efficiently, engineers can use the finite element analysis firstly to figure out the place where the maximum stress will occur approximately according to the experimental load condition. With the prediction of FE analysis, engineers can paste more sensors on these places to monitor the stress and displacements to make sure that they get the data they need.

This process can also work conversely. If engineers want to know what the ultimate load capacity of this arm is, they can try different load in the FE model to find a possible region, and then use this information to organize the physical testing to find more accurate result of this question.

The process of using FE model to predict the result of physical testing and comparing the result of physical testing and FE analysis is a way to check the accuracy of the FE model and any mistake during the execution of physical testing. If any of the situation occurs, the result cannot match each other, which is signal to tell engineers something is wrong.

2.2.2 FE analysis as a complement of the result of physical testing

*USE THIRD PERSON
NARRATIVE*

FE analysis helps engineer to understand the result of physical testing. In the fluid mechanics, there are some areas we do not know what will happen exactly. Take the physical testing of a reducing valve in hydraulic system for example. The valve is usually very small, so it is challenging for them to monitor what happens in the small cavity of the valve. Engineers can only measure the state of fluid outside and use the knowledge of fluid theory to surmise the situation in the cavity.

With the help of FE model, engineers can see what will happen in the cavity in the software and can better understand the state of fluid in this valve, which may help them make improvement to the valve.

Another information that FE model can provide is the ideal capacity of a product. The product produced inevitably have some flaws which can undermine the capacity of the product, but FE model is a ideal model, so it can tell engineers the potential capacity of a product compared with the result of physical testing. Then it is due to engineers to decide whether it is economy to improve the manufacture requirement level.

3. If you think that FE analysis can (or should) ever replace physical testing.

Even there are many advantages to use FE analysis in the process of developing products, physical testing can never be replaced completely. They are not rivals but friends who should work together to maximize the profit. The reasons are as follows.

3.1 To verify the FE model

Usually, the real condition of a product is very complex, so it is impossible to consider all aspects of the product and build a model which is exactly the same as it is in the reality. For example, a company need to design a crane arm, which consists several sectors and the connection between the sectors. In this case, some simplification about connections need to be made to model the crane arm. But even the simplification is made by experienced engineers, there still is a chance that it is not consistent with the real situation because of the state of friction between sectors or other reason which cannot be discovered easily. If there is not any physical testing during the process of designing a new product, chances are that they will discover some unexpected problem when they finally manufacture and test the product before launch it. It will cause a enormous economic loss to the company, because to correct these problems engineers will have to spend more time on this project and the product may miss the best time to launch. According to these analysis, it is clear that it is essential to do some physical testing to justify the accuracy of FE model in time.

3.2 Factors can not be considered in the FE model

There are some factors that the FE model will not include, for example, the flaw of material. The material used in the mechanical industry such as cast iron, steel, may not as perfect as the material applied to the FE model in the software, which can cause decrease of the capacity of the product. And considering the heterogeneity of cast iron, it is necessary to build a prototype and test it to give some guides and requirements to the following manufacturing process. Apart from these situation, there is some surface treatment to improve the quality of products in the mechanical manufacturing industry, for products with these treatments, FE model may cannot reflect their property accurately.

Another important factor that FE model misses is time. During the process of working, the products will go through running-in period, steady working period and

rapid worn-out period. If engineers want to make sure the performance of the product during the whole life-span, they need to actually test it because there is no function like this in the FE analysis.

3.3 The function of physical testing to provide data to FE analysis

Sometimes, the physical testing may not necessary is the testing of the entire machine or new product, rather, it can also be the testing of some components of a whole body to provide the data and property of the component needed to build the model. For example, to make sure the model of a crane, engineers may need to do experiments to find the relationships between the friction force and different kinds of lubricate oil, so that they just need to input the data of friction force applied on the sectors rather than considering how it functions in reality. Similarly, they may do experiments about the property of materials, springs etc whose influence to the model can be describe accurately by data. This is a way to simplify the model without compromising the accuracy and quality.

3.4 The need to fulfill some laws about the product

There are some laws made by government requiring physical testings of new products to make sure that the product sold by the company is safe for consumers to use and consistent with their description.

Further more, even if there is no requirement from government, the competence between companies who produce similar products will force them to do the physical tests because the consumers will tend to choose the products which have physical testing have provides the properties of the products clearly

4 conclusion

This article discussed the reason that why companies uses FE model as a important tool, and the relation between this novel method and the traditional physical testing. Even FE analysis can realize most functions of physical testing, it cannot replace physical testing completely. In the third section, the necessity of physical testing is discussed from different aspects.

5 reference

[1] Luckey Jr, S. G., P. A. Friedman, and K. J. Weinmann. "*Correlation of finite*

element analysis to superplastic forming experiments." Journal of Materials Processing Technology 194.1-3 (2007): 30-37.

[2] Kim, Gyeong-Ho, and Youn-Sik Park. *"An improved updating parameter selection method and finite element model update using multiobjective optimisation technique."* Mechanical Systems and Signal Processing 18.1 (2004): 59-78.

[3] Thomke, Stefan, and David E. Bell. *"Sequential testing in product development."* Management Science 47.2 (2001): 308-323.

[4] Gokhale, Nitin S. *Practical finite element analysis*. Finite to infinite, 2008.

[5] Bechtel, Andrew, Jennifer McConnell, and Michael Chajes. *"Ultimate capacity destructive testing and finite-element analysis of steel I-girder bridges."* Journal of Bridge Engineering 16.2 (2011): 197-206.

• GOOD SECONDARY RESEARCH
& SUMMARY OF THE CASE
STUDY PRESENTED.



• WHILST I CAN UNDERSTAND YOUR POINTS
SOMETIMES YOU COULD BE CLEARER