CAE PROCESS AND AUTOMATION STRATEGY IN BREMBO

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Brembo S.p.A produces mainly braking systems and components for automotive market. Actually, Brembo organization and business are quite complex due to the geographic dimension (Brembo is present in several countries worldwide both with manufacturing and engineering sites) , to the market dimension (Brembo produces for passengers cars, commercial vehicle, motorcycles, racing cars, OE, Aftermarket, etc…), and finally to the customers dimension; infact Brembo designs the braking system on specific customer and car.
This means that engineering is a strategic key for success and that know-how building, managing and distributing is fundamental in order to get competitiveness, time to market, cost reduction and a better and standardized product quality. In the paper the CAE process management strategy is summarized and some examples implemented using Fiper and I-sight are reported

***Keywords**:*

Data and Process Management, Collaborative Engineering, Design Optimization, Multidisciplinary Process, Automotive Component, Braking systems.

1. Introduction

Brembo provides mainly braking systems for automotive, motorcycle and racing markets. It is essentially, both an engineering and a manufacturing company. One of the success key of the company, in fact, was the customer orientated design that is, in the end, the propensity to match requirements and customizations on single customer project and platform in all the different markets in which Brembo is present, from racing to commercial vehicle applications. This is possible only designing and developing each product for the single customer, for each single vehicle. This is the reason way R&D is one of the core business of the company.
During last years the dimensions of markets have pushed Brembo to become a global company, not only in production organization, but also in R&D.
So, at present time, R&D organization has reached a certain level of complexity; Different departments for different markets and different department in different geographic regions. In this scenario, the necessity to manage and distribute design and simulation know-how in real-time, to guarantee the standardization and automation of methods and quality has become a priority. This is way Brembo has decided to implement I-sight through Fiper environment and to invest in process designing and, in general, know-how development and management.

2. Strategy and project implementation

The main goal of I-sight and Fiper implementation in Brembo was to allow to a consistent number of users (potentially all CAD engineers and designers) to have CAE as a ready-to-use tool on their desktop, as a standard design instrument, regardless of their competences, complexity of simulation, past experience. This, of course, avoiding time consuming or complex activities such as meshing or assembling or setting boundary conditions or material laws, and allowing them to work in their standard environment (such as CAD). In the end, the goal was to open to designer the results of simulation (at least the standard simulations necessary in the design and developing process) when necessary, regardless the availability of a CAE specialist. This vision assumes that:

- Inputs of a simulations are just geometric data and generic design informations (for example materials used and reference to the product specifications)
- Meshing technology has to be straight-forward and fully batch
- A CAD-to-CAE methodology has to be implemented
- Launching simulation has to be a very quick and simple action: loading inputs and getting results
- It infrastructure has to be robust
- CAE methods has to be standardized
- A simple post processing tool is necessary to report results in a standard way

I-Sight and Fiper were chosen as main infrastructure because of the distributed enterprise platform and the web user interface which guarantees the easiest way for the final user to manage the "off the shelf" simulation.
The project was divided in different streams and phases:

- CAD-to-CAE methodology
- Process Design
- IT infrastructure Design
- Web user interface
- Tests, pilot, users training

2.1 CAD-to-CAE methodology

In order to get the mesh and correct FEA connections in a complex assembly in a full automated way, it's necessary pushing as much information as possible in CAD assembly file. The methodology basically assumes that standard names to CAD bodies and published geometric items are present.
These standard names and publications are somehow read during one I-Sight/Fiper process and used to build an excel file which is sent back to the designer. In the excel file, through a user interface, the designer indicates which are the types of connection between the different bodies and published geometrical items. This is a very simple and fast operation for the designer who doesn't deal with FEA elements and connections equation. Once compiled the excel file, the full template of FEM model is defined. Material data are previsiously standardized and read.

Modifying the geometry of one part is an operation which doesn't impact in any way on the process, so that once completed this phase, several geometrical modifications can be simulated simply re-running the simulation with the new CAD files.
One possible improvement, for future development, should involve the interoperability between the process and the user through the web-top. This would avoid creation on the fly of an excel file.
The excel file, once compiled, is uploaded to a new process which actually build the FEA model, run the simulation, post-process results.
In the picture 1 the flow of operations that designer has to implement in order to build the first model and running different versions of it.

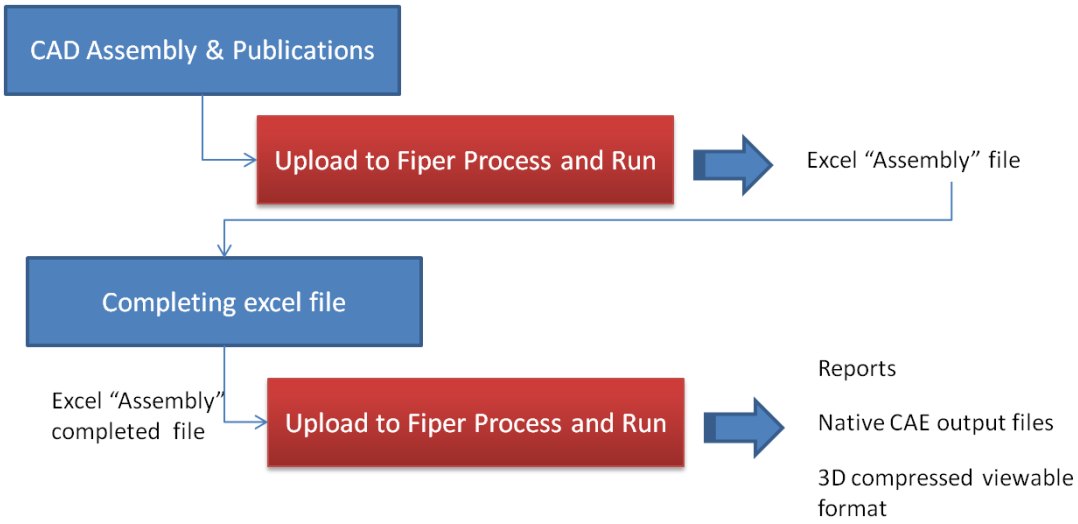

Fig. 1: Operations Flow

2.1.1 Process Design

For complex assembly, the overall operations are divided into 2 different I-Sight/Fiper processes: the first has, as input, the CAD data and produces the connections excel files.
The second process starts from the compiled excel file and actually build the model, run the simulation, generates reports.
In both processes, in order to simplify the "look and feel" of the process, all the inputs and outputs are at root task level. The designer interacts with the process only at that stage.
In Picture 2 is shown the layout of the first I-Sight process (which is the same for all the complex assemblies) and in Picture 3 the actual process for the brake squeal FEA calculation.

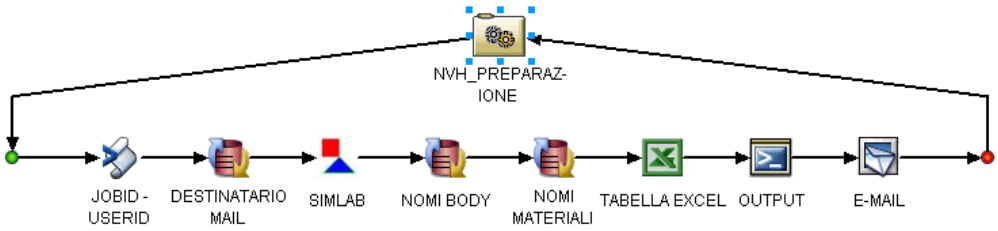

Fig. 2: First Process; brake squeal FEA calculation with Isight

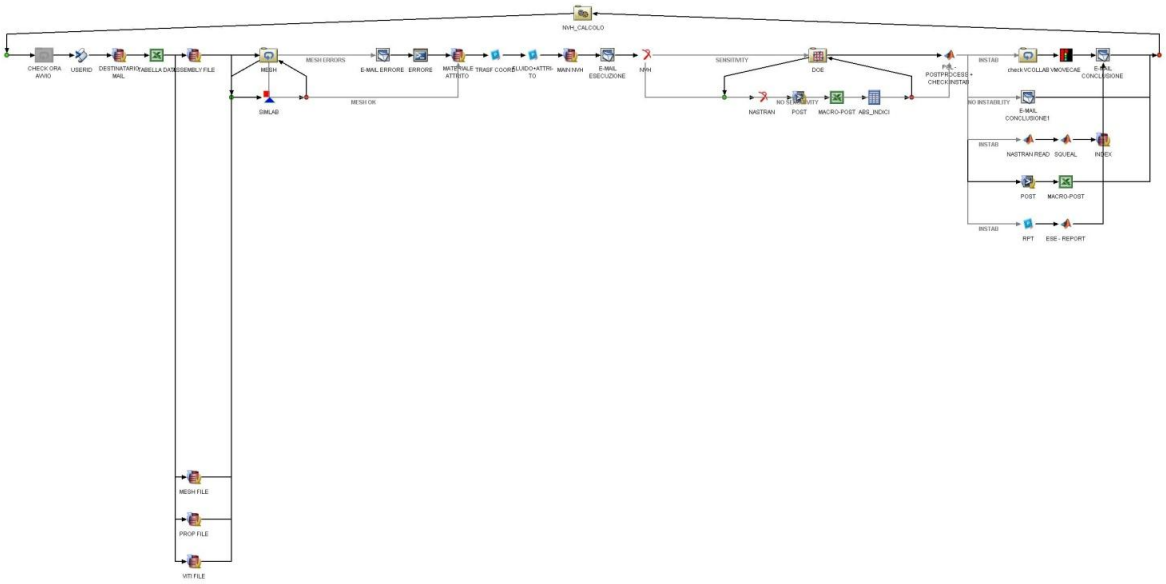

Fig. 3:Actual Process; brake squeal FEA calculation with Isight

In the Brake Squeal process, the full braking system and suspension model are built completely in batch. After the first run a DOE on the main model parameter is executed. Finally a custom post-process phase is executed. The final outputs are some office documents (Excel, word, images) and a compacted format file containing 3D viewable file with principal FEA results (displacement, strain energy, etc…), and , of course, the native FEA result file.

2.1.2 IT infrastructure design

About the currently installed Fiper/I-Sight version, for an extended use, some considerations have to be done:

- Reliability & Robustness → Can be accomplished for an enterprise implementation?
- Queuing fiper jobs → in case of enterprise implementations, users from different departments have to submit fiper-jobs using the web-top without a "trial and error approach" until a license is checked out.
- Queuing tasks → Tasks which execute a licensed tool (pre-post processing, solvers, etc…) and/or that are resources consuming, has to be scheduled on a queue batch system on a cluster of nodes.

About the first item, reliability and robustness of the Fiper environment, some improvements are necessary and some other are planned for future releases. Of course, the possibility to restart ACS services, databases and stations avoiding the crash of the jobs is a priority. The desired level of reliability and robustness is an in-work stream and most of it depends on Fiper native robustness.
In order to queue Fiper jobs, in 3.5 release no "out of the box" tool was available. This is way Brembo has developed a custom web top which communicates with an external database. Here are stored Fiper jobs-id, the status (related to the current availability of jobs' licenses) and the priority of the jobs. In the next paragraph some details will be explained.
In order to queue tasks on a batch queue manager, a simple i-sight component has been developed in collaboration with Exemplar s.r.l. The set-up of the queue submitting is simply executed in a g.u.i. in I-Sight environment during the process design phase.
The IT infra-structure of I-Sight/Fiper environment in shown in picture 4

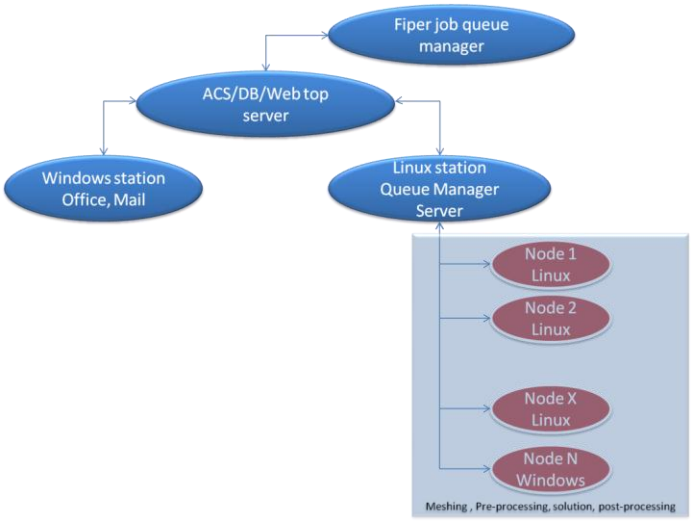

Fig. 4: IT infra-structure of I-Sight/Fiper environment

The ACS has basically 2 stations, one on a windows server, which basically runs office applications and communicates with our mail server, the other on a linux 64 bit server which is also the queue manager server (the front-end of an high performance cluster). This station submits jobs to the queue manager with the proper flags, parameters, priority. The task waits for job execution monitoring the queue. The jobs are actually submitted to the cluster.

2.1.3 Web user interface

A custom web top has been developed. The main necessities were 2:
1 – Simplifying the user interface, allowing the user to simply upload and download at the root task
2 – Integrating a sort of queue manager, in order to queue a fiper job in case of lack of licenses. In this case the web top creates the fiper job and communicates job id and name to a server which stores these informations in a database. A service check available jobs license and update the status of the job, indicating which jobs are runnable. Finally the web top checks job status and, if the job is runnable, actually submits the job, otherwise enter in a loop.
This functionality is fundamental in order to reach a sufficient level of usability. Some improvements are necessary; this is not a native integrated tool, so that robustness and reliability are not guaranteed. In particular if the ACS or the custom web top need a restart, the queues are canceled, and the user need to submit again the job.
A native and integrated Fiper jobs queue manager should be implemented. Important features would be the possibility to define server-level resources, job-level consumable resources and job priority (based on model name and/or user-id)
In picture 5 the custom web-top is shown

Fig. 5: Fiper custom web-top

The custom web-top has been implemented in collaboration with Exemplar s.r.l

2.1.4 Test, pilot, user training

The implementation project required different level of test activities, some of them have required CAE skills, some other IT skills:

- Testing the single tasks. This could require time if the task run the mesh and assembly of a complex system. The CAD-to-CAE methodology has to be robust enough to geometric modifications, different assembly configurations, etc…This is, typically, a CAE specialist task.
- Testing the process standing alone: file and parameter matching, results post-processing, etc..This requires both CAE and IT skills.
- Testing single ACS published process: it's an IT task.
- Testing a stressed server situation: The IT infrastructure has to be tested, simulating simultaneous access, simultaneous submissions, access rules and so on.

Even if getting a full batch FEM model is a challenging goal, getting an IT robust infrastructure is sometimes more complex.
All the tests have been implemented in a pilot project. During the pilot, the AS-IS scenario of the brake squeal CAE activities have been described, and a TO-BE has been defined.
During the pilot project a team of brake squeal CAE specialist has been selected. They had provided modeling specifications, defined test models and benchmarked the results.
After the validation of the process and the infrastructural tests, the Brake Squeal process has been deployed in two phases:

- In the first phase the process has been distributed only to CAE specialists
- In the second phase the process has been distributed to a team of selected CAD engineer

Since the user interface in really simple and the methodology is mostly at CAD level, the training for CAD engineers was really straight-forward and quite obvious. Not so easy, instead, supporting them in verifying output models and interpreting results. This is way the support of a CAE specialist to the result approval and check phase is so far, and probably in future, necessary.

2.1.5 Possible Improvements

There are 3 streams of necessary improvements:

- Reliability and robustness of Fiper environment in a enterprise approach; As formerly mentioned, the possibility to restart the ACS , database or stations service avoiding the crash of the running jobs is a priority

- Fiper jobs queue manager: a native integrated queue manager for Fiper job is a very important feature; in an extended usage, several users should submit their Fiper jobs simultaneously.

- Web-top and process interoperability: the native possibility to interact with the process after the submission of it through the web-top, is, at the moment, absent. Fiper workflow isn't a transactional workflow at all. A certain level of interoperability would help to solve some technical problems regarding handling of process inputs (all inputs has to be pushed at root level and completely defined before job submission) and allow the results approval process.

3. Conclusion

Process management and automation is, of course, the ultimate challenge in CAE world. And the reasons are quite obvious: since a CAE template and process distribution vision has been implemented, the number of simulations is tremendously increased. In the last 4 years at least an order of magnitude. This has impacted in R&D processes deeply and led to the considerations that know-how management is a key point in innovation strategy.
In addition, the traditional cultural differences between R&D and IT organizations have reduced. Historically, CAE specialist was considered a sort of bookworm closed in the basement. In recent years, instead, simulations are became, like common office instruments, a standard tool that each role of product development deals with.
This revolution have led also to organization consequences: process designer and manager are new roles which require new competences, between IT and traditional CAE skills.

4. References

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5. Acknowledgment

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