ITAINNOVA EXPERIENCE AS A MATERIALS MODELLING TRANSLATOR

For EMMC TRANSLATORS GROUP

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ITAINNOVA
INSTITUTO TECNOLÓGICO DE ARAGÓN

Contents

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01. ITAINNOVA

Public Technological Centre with the objective of fostering competitiveness and industry development by means of generation, transfer and dissemination of knowledge, helping companies through technological research, development and innovation.

We are a clearly industrially oriented R&D and innovation centre were approximately 60% of our budget is directly from private contracts with industry, 30% is from competitive public funding, where we are also accompanying with R&D activities to industrial partners, and only 10% is from non competitive public funding.

02. EXPERIENCE AS A MATERIALS MODELLING TRASLATOR

Although the ITAINNOVA is quite horizontal in the technology, one of the biggest groups is the Materials & Components technological area, where approximately 60 out of 220 people work in the following R&D lines:

- Multi-scale analysis and simulation of non-conventional material forming processes
- Design and development of composite materials and nanocomposites
- Advanced characterisation and functional simulation of materials
- Multi-physics and multi-domain simulation
- Structural Integrity

The Materials & Components technological area is composed approximately by 50% of material modellers and 50% of experimentalists. Material modelling

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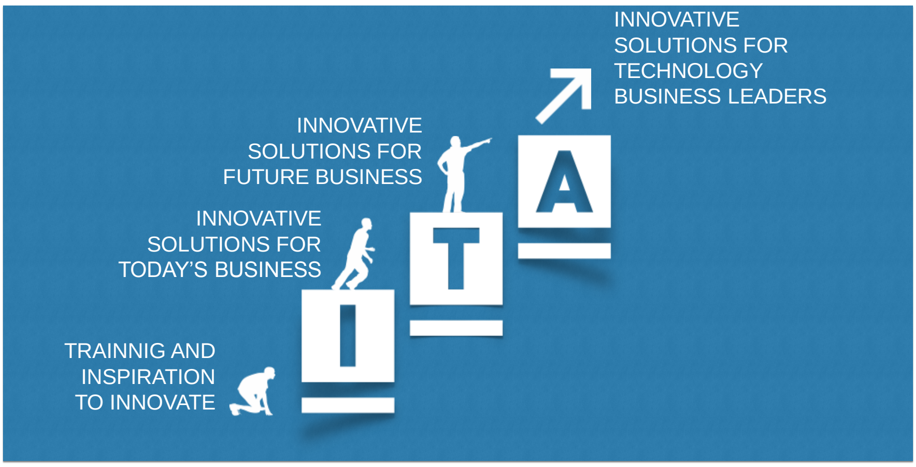
activities for the industry have been one of the key lines of activity from ITAINNOVA foundation in 1985, allowing us to build expertise covering the development, implementation, characterization and validation of material models for different types of materials (metals, plastics, elastomers, paper,...) and behaviours (elasticity, plasticity, viscoelasticity, hyperelasticity, damage, fatigue...). These models are used in the day-to-day work to analyze material transformation processes and the functional behaviour of components at the macro scale in hundreds of industrial applications.

This document tries to give our vision in the translation role to bring together industrial needs with modelling capabilities.

03. NOT ALL THE CLIENTS HAVE THE SAME NEEDS. CLIENT SEGMENTATION

First aspect before defining a project, in particular a material modelling simulation project, is that not all the industry interlocutors have the same technical background and for sure their companies have different needs. That is why we use a conceptual classification of the type of clients, with the stairway of innovation.



Innovation stairway

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On the basis are located companies that demand training services to update their knowledge in some fields. For this we have a training area in order to detect client's knowledge needs and to organize training courses, in a regular basis or under particular clients demand.

Next steps in the innovation stairway are companies that demand innovative solutions with the current technologies, whether to support the today's business or tomorrow ones. For this type of clients we develop solutions applying our knowledge to help them in the innovation process in their products.

Finally, in the top of the stair are companies that are technological leaders in their field and that demand to support them in going ahead of the current technologies, fostering oriented R&D to make technology to evolve.

So the first aspect to be considered when collaborating with a company is to analyze in which category can be classified, since the solutions ITAINNOVA will provide are different depending on the type of client, being tailored to their needs.

04. CLIENT ORIENTATION

Industry requires a specialized interlocution. This is achieved at ITAINNOVA with a layer of people between the client and the simulation experts, the client managers. These people, who have also technical background, are in charge of being updated of an industrial sector of activity, for example automotive, aeronautics…

They have wide enough knowledge about the general capabilities of ITANNOVA and they are in charge of keeping the first contacts with a potential client. During the first conversations of the client they develop several functions:

- First, to collect the needs of the client, that is, to understand the client´s problem and to give a first impression of what can be done. This

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information is then dropped to an internal document called “client expectations form”, which will be basis for the project definition. They also identify any potential conflict of the new client with the existing ones. Most of the times, working for a company is regulated with DNA documents, then this adds some restrictions when building the project team or, in some special cases, bring us to communicate the new client we cannot work for him.

• Second, the client manager knows which technologies should be involved and then discuses with the technology coordinators, which select the technicians to define the project details, being one of them in charge of the proposal elaboration. Usually this step is initiated with face to face meetings involving the client, the client manager and one or several technicians, preferably at the client’s location.

As a result of this, a proposal or “project specifications” is prepared by the proposal responsible, including the technical description of the activities, milestones and deliverables, timing, budget, etc. This is the document that, once accepted drives the contractual relation with the client.

Once the project is launched, the interlocution with the client is made mainly by the technicians, although the client manager is kept informed and follows the general progress of the project. It is also important to improve continuously, that is way client managers make satisfaction surveys to our clients in a yearly basis.

05. CLIENT ENTRY CHANNELS

Several are possible:

I) New projects from current clients. ITAINNOVA have a high level of client loyalty. This is achieved by our clear client orientation and previous successful projects for that client.

II) Word of mouth. Clients sometimes acting as prescribers, bring us in contact with their providers, partners or clients.

III) Active presence on clusters, associations, platforms.

IV) Web site & Inbound Marketing.

V) Congress and scientific publications. When working for industry, dissemination is not usually allowed, but in some cases it is and collaborative ITAINNOVA-Client contributions may be presented.

06. SIMULATION vs EXPERIMENTAL APROACHES

A common question is which is the right development process, numerical or experimental, and the answer is that most of the times, the optimum is the combination. One of ITAINNOVA strengths is that we have an equilibrated distribution of modellers and experimentalists, then we are able to supply complete solutions and we minimize the risk of trying to force applying not the very best technique.

From our experience, in the range of projects and clients we have, the combination depends on the scale you are situated.

For new material development projects, usually the work is predominantly experimental, such us in polymer modifications by adding nanoparticles to extend performance or to include multi-functionality. In this type of work, modelling is introduced, for example through atomistic models, to help understanding the origin of the intended behaviour, perform sensitivity analysis to some aspects and to estimate the effective properties.

When the material is already an existing one (commercial) and the objective is to analyse performance in certain application, the right combination is something around 50-50%. Usually a material characterization campaign is required in order to adjust material models: elasticity, viscoelasticty, elastoplasticity, viscoplasticity, hyperelasticty, etc. So a considerable effort is required to calibrate the material models. Then simulation takes its advantage when analyzing the product performance, optimizing geometry, material changes, studying different loading cases, etc. In the end, of course, there is always an experimental validation step.

When material behaviour is driven by the morphology development during the processing, then modelling is usually the only choice to try having a closer material description. For example, in injected plastics reinforced with discontinuous fibres, processing induces local fibre orientation, fibre breakage, etc. The result is that in a part or component, every point has different properties since local morphology is different. In this case simulation of the process in combination with mesoscopic models for the morphology development allow estimate the final morphology, then with the help of micromechanical models local effective material properties (homogenization) are estimated and then used in the performance simulations.

A typical application where simulation is used almost alone is in stress analysis of steel structures. Usually linear elastic calculations are performed and safety factors introduced for the deflection and the strength. Buckling analysis for the natural frequencies determination is used. This type of structures is built once and then there is limited possibility to test it (proof of charge).

07. SIMULATION SOFTWARE CHOICE

There are many software codes available for performing different type of analysis and an increasing tendency that big software companies try to cover wider ranges of simulation tools, by developing new solutions or purchasing other smaller software developers to cover the gaps.

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For an independent translator such as ITAINNOVA, we have freedom to select the proper software code, although it is impossible to have the best software tool for every particular simulation we have to perform. Then we have licenses for many of them, based on our accumulated experience and the volume of use we typically have. When we have different codes available to solve a problem the choice depends on the modeller experience or preference. In many cases, what the client want from us is, not only to perform a simulations, but to develop simulation methodologies that can be integrated in their simulation departments, then we can propose which software they will use in future, or in the other hand, we have to use the same software they are currently using. In the later case, we have arrived to situations where we have needed to hire a new software license, get trained and then apply to a single project. Of course, this only makes sense for big projects, usually multiannual, where the training effort is small with regard to the project development effort.

08. CONVICING CLIENTS FOR THE SIMULATION USEFULNESS

This is something it was an issue in the past decades, when simulation activities were quite rare and limited, but now a days is not so difficult because in many cases the clients ask directly for simulations, or assume that simulations will take part of the solution. In any case, gaining the client's confidence in simulations begins in the project definition, not bringing false expectations to the client.

First, there may be a modelling background difference that sometimes leads to a language problem. If the modeller directly speaks in the "modelling argot", like for example "viscoelatoplasticity with strain rate dependence", it may be lost. It is usually preferably to speak about material performance aspect we want to analyze, “material plasticity depending on the loading rate” and keep the mathematics only for skilled clients who really are interested in such details.

Second it is useful to put simulation in contrast with the experimental development, what will be required if we do not use simulation. Showing the client that you can help in both ways and you, not only do not try to force in one or the other method, but you propose combined approaches. When possible it is also interesting to introduce validation activities, to get the degree of approach of the modelling activities.

It is important to honestly recognize that the very expert in the product/process the client wants to analyze is the client itself. From the very beginning we, the modellers, like to mention that we are simulation specialists that have experience in using and adapting the simulation tools to solve the problem we want to analyze, but it is important that the client is involved in the project execution, making participant of some decisions in order to take profit of his experience and to get sure obtained results are really useful for him. This is not incompatible with the idea that a translator, having performed many projects, ends accumulating experience in some applications, processes, sectors, etc. which it is also valuable for the clients, in order to have other point of view or to bring experience from a different sector.

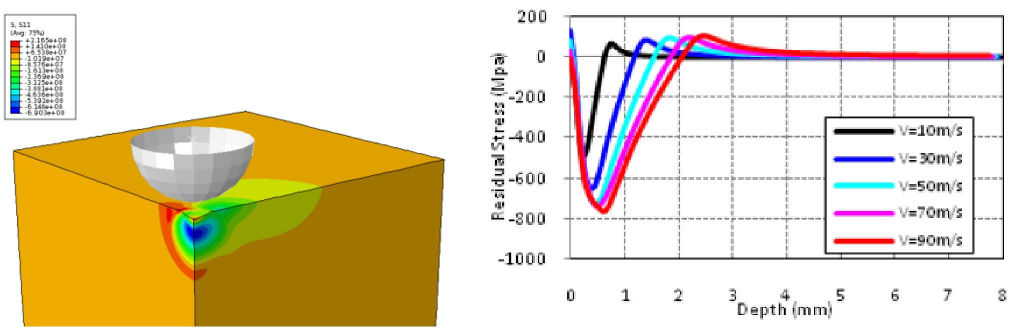
09. CASE STUDIES

09.1. Case1: Simulation of Peen Forming Process of Aluminium Aeronautic Panel

Source: M. Laspalas, J. Gómez, F. Martín de la Escalera, R. Sánchez, M.A.Jiménez. Simulia Customer Conference - Barcelona 2011. Study performed by ITAINNOVA for AERNOVA group.

The shot peen forming is a cold work deformation process consisting of treating the surface of a work piece with a stream of round shots (usually made of steel) with high enough energy to deform plastically the surface. This plastic deformation causes compressive residual stresses under the surface that are able to create a curvature on the component. This process is increasingly being used to create smooth curvatures in large pieces, for example, in the manufacturing of aerodynamic panels in the aeronautic sector.

In collaboration with AERNOVA group, a methodology to simulate this process by the FE method has been developed. First, the methodology includes material characterization, the transient dynamic simulation by means of Abaqus/Explicit of the impact of an isolated shot against an aluminum plate, including validation of the generated dimple with experimentally measured data.



Stress distribution and profile on a single impact as a function of the shot velocity

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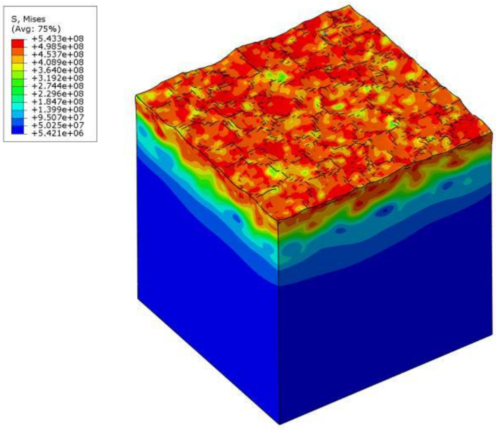
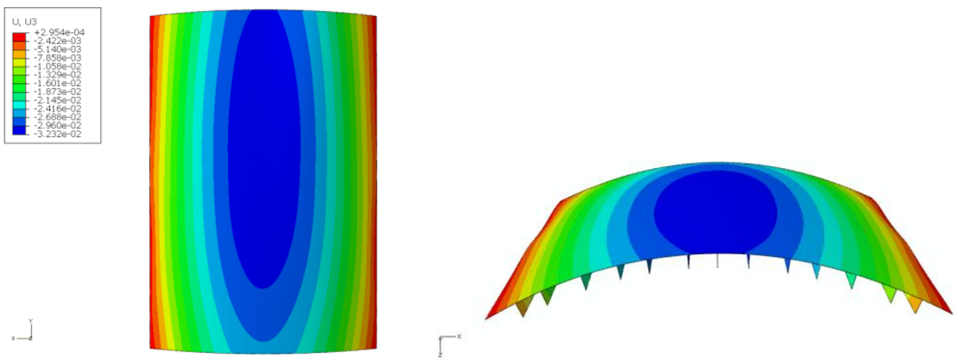
Next, the simulation of multiple impacts is performed, were residual compressive profiles are obtained as a function of the percentage of surface impacted or coverage. The determined profiles are imposed to simulate with Abaqus/Standard the deformation process of initially flat plates in different processing conditions, correlating the results against measured deformation data from validation tests.



Stress distribution after full coverage

Finally the model is applied to the simulation of the peen forming process of a complex panel, including the geometrical features typically found in aerodynamic panels, thickness variations, stiffening ribs, etc.

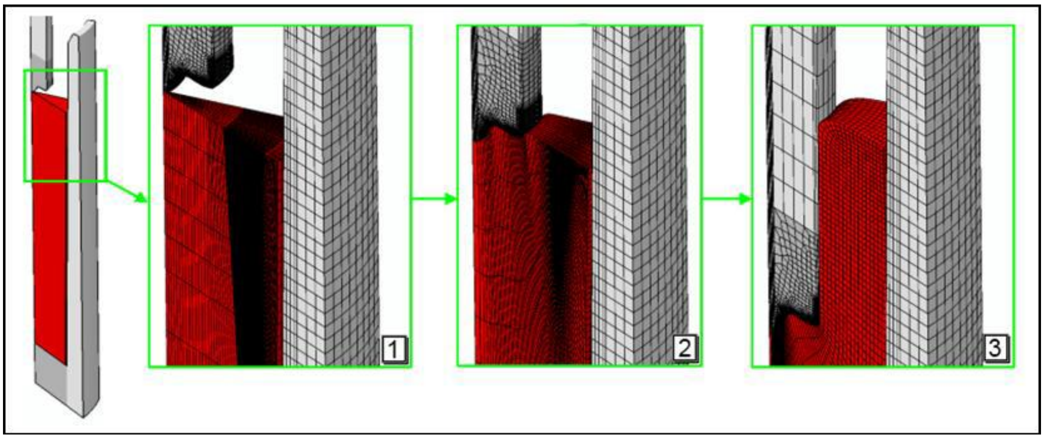


Deformation of the aeronautical panel by peenforming process

09.2. Case 2: Thermomechanical Fatigue FE Analysis Applied to High Temperature Metal Forming Processes

Source: A. Escolán, J. M. Bielsa, M. A. Jiménez, R. Allende. Simulia Comunity Conference-Vienna 2013. Study performed by ITAINNOVA for PTSAU - Productos Tubulares.

In high temperature metal forming processes strong mechanical and thermal gradients in the formed material and in the tooling coexist. Such gradients have a negative influence in the tool life cycle. That influence occurs due to mechanical and thermal cyclic loads undergone during the production process. This factor leads to the appearance of cracks on the tool surface because of thermomechanical fatigue phenomenon. The presented work is focused on a specific manufacturing process of seamless steel tubes which includes three basic steps: backward extrusion, perforation and Pilger rolling mill. This process transforms a blank or ingot into a final seamless steel tube with specific dimensions and characteristics depending on market requirements.



Backwards extrusion FE simulation

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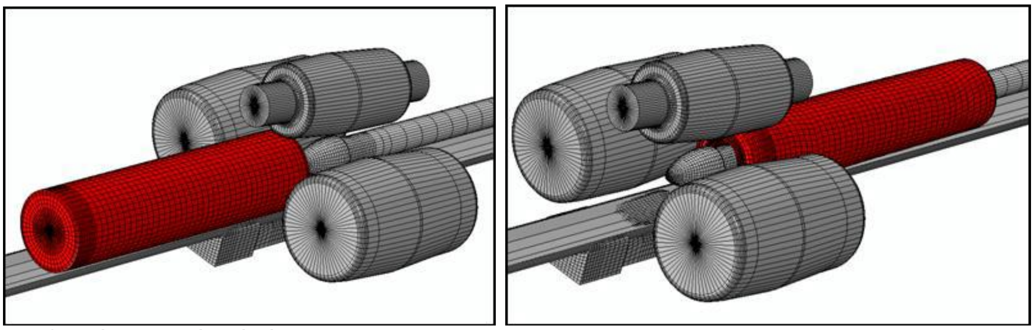
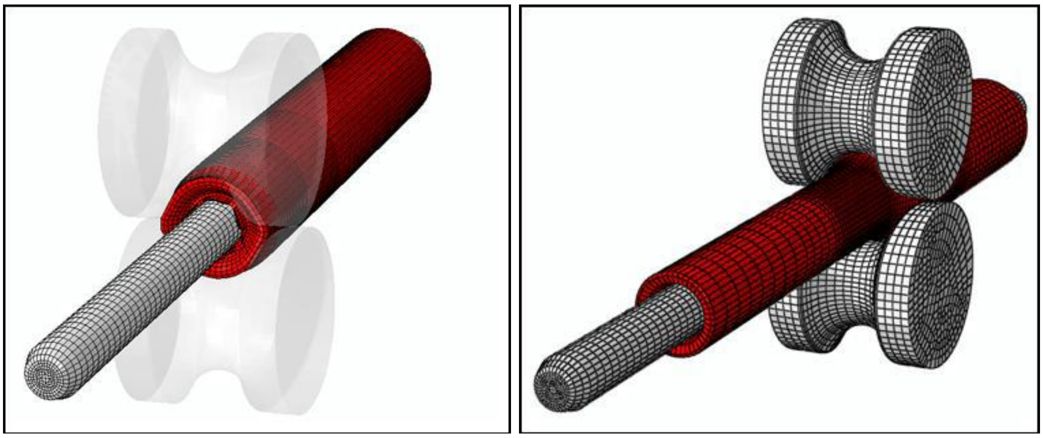
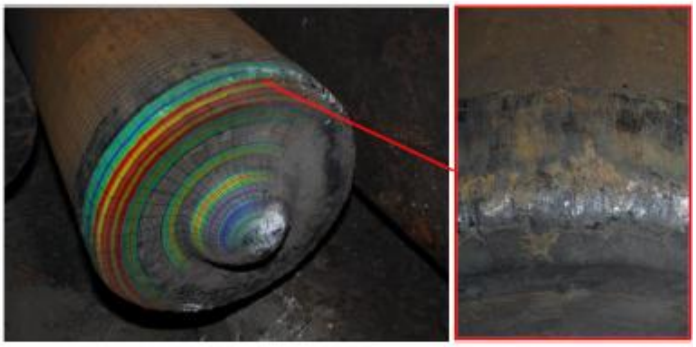


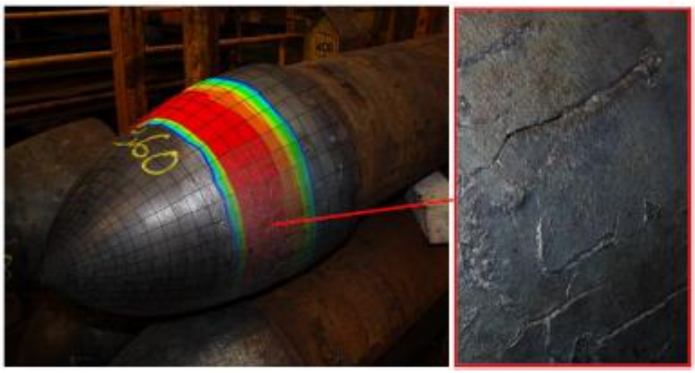
Perforation FE simulation



Pilger rolling FE simulation

The objective of this paper is to present thermomechanical fatigue FE analysis. These studies have been carried out in order to improve tool life and to know the effect of some key parameters of the main manufacturing process. For this end, it has been done several series of coupled thermomechanical FE simulations of the three analyzed conforming steps using ABAQUS/Explicit solver. Moreover, it has been incorporated a post-processing subroutine which enables to predict the number of cycles until crack appearance (tool life). This subroutine includes a cumulative thermomechanical fatigue damage method of analysis where the damage is treated as a combination of three factors: multiaxial fatigue, oxidation and creep. In the multiaxial fatigue, it has been studied, for each element which belongs to the surface, the critical level of crack initiation and propagation; in the oxidation and creep phenomena, it has been evaluated the ratio between mechanical and thermal cycles dependence (i.e. in phase or out of phase).


(a)


(b)


(c)

TMF prediction in the reverse extrusion plug (a), perforation plug (b) and Pilger rolls (c)

09.3. Case 2: Application of micromechanical models for elasticity and failure to short fibre reinforced composites. Numerical implementation and experimental validation

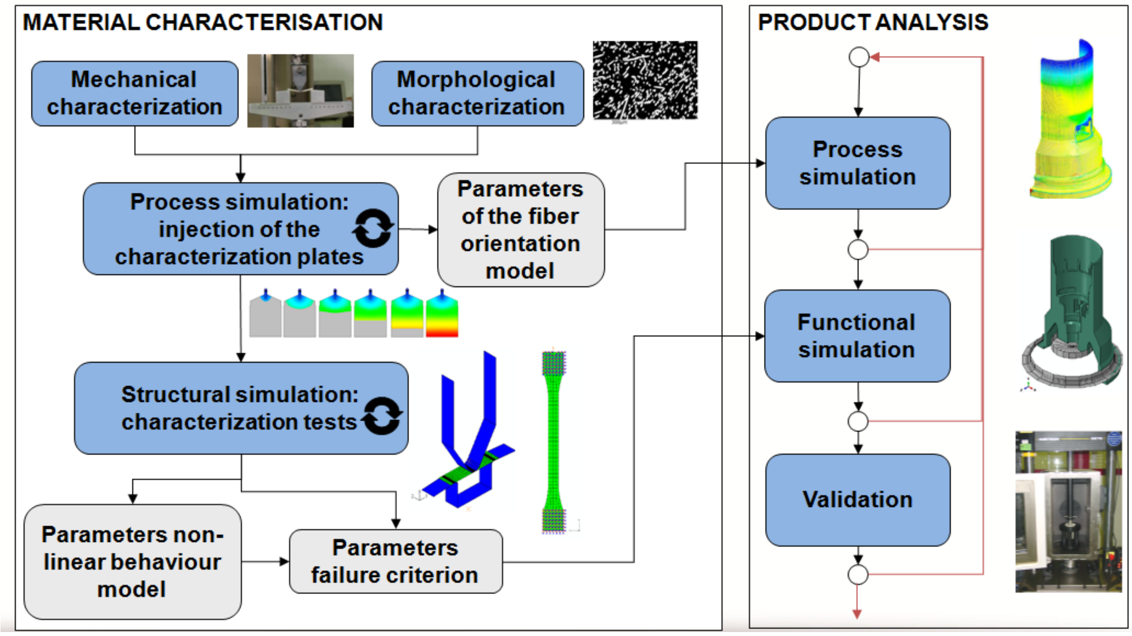
Source: M. Laspalas, C. Crespo, M.A. Jiménez, B. García, J.L. Pelegay. Computers and Structures 86 (2008) 977–987. Study performed by ITAINNOVA and applied for TRW Automotive.

This paper deals with numerical modelling of the mechanical behaviour of short fibre reinforced plastic composites manufactured by the injection moulding process.

First of all, an experimental program has been carried out in which the local fibre orientation distribution has been measured in an 80x80x2 mm injected plate by means of polished cut sections, analysed with SEM and image processing software. Tensile and threepoint bending tests have been performed to obtain the elastic and strength response of the material in different locations along the plate and at two directions (parallel and normal to the flow direction).

Analytical micromechanical models and averaging procedures have been implemented to relate the local fibre orientation distribution with the effective local anisotropic response of the material (elastic and strength). The models are validated by means of the finite element simulation of the performed characterisation tests.

Finally, the methodology is applied to an injection moulded component with complex geometry. Fibre orientation data predicted with mould-flow software has been used to determine the local effective elastic stiffness and strength coefficients. A FE simulation of the functional behaviour of the component has been carried out. Results indicate that the proposed variable stiffness/strength anisotropic model predicts a lower load for onset of failure than when applying an equivalent isotropic material model.



Integrated methodology for simulation of short fibre reinforced plastics

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