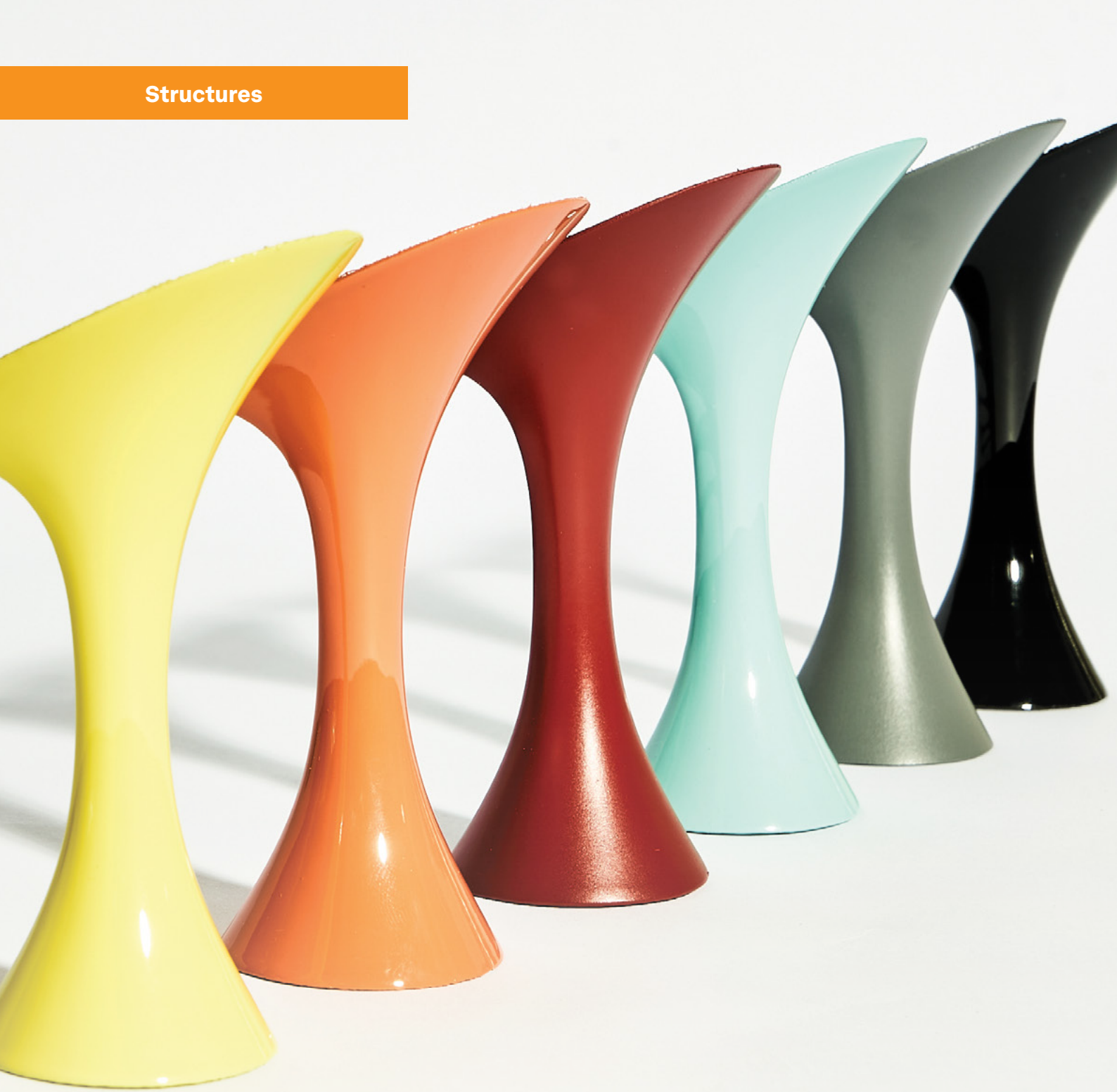


Marc software's dual role for high heel perfection

Hexagon simulation ensures fashion shoe heels won't break under pressure

Picture 1: The R & D division applies a combination of simulation software, laboratory tools for the characterisation of materials, and physical tests to get the best possible results.

A leading heels manufacturer for several global high fashion shoe brands uses Marc software to perform structural analysis on its products. The simulation means Tacchificio Villa Cortese can design perfectly optimised prototype geometry at the beginning of a project, saving time and money.

The software, from MSC Software, also assists the company to identify which more eco-friendly alternative materials are suitable for their highly specialised products.

Founded in 1961 by Luigi Gazzardi, three generations of the family now work at the Italian-based company, and the craftsmanship acquired in the '60s and '70s with the production of wooden heels, still provides a wealth of knowledge that allows them to adapt flexibly to the most varied demands of customers and the market. The high fashion industry relies on expertise and knowledge to produce shoes of the finest quality, that push materials to their limits to create highly desirable and new shoes.

Today, making truly stand-out shoes requires balancing craftsmanship with the latest techniques, materials and a touch of science. Originally tests were done manually; several prototypes were printed and fitted on shoes and given to a person to try them. After that, physical-mechanical tests were developed. And now, they're becoming increasingly reliant on structural simulation – which is where Marc software comes in.

Marc is a 'nonlinear finite element analysis software' which simulates how complex materials behave and interact under large deformations and strains, making it perfect for exploring how materials like plastics perform structurally. Automatic two-dimensional and three-dimensional remeshing allows the heel maker to analyse structures as they undergo substantial distortions, and understand how cracks propagate.

"We need to understand why shoes break, so, as designers, we can push materials to their limits to make more intricate heels, both higher and thinner, with confidence that they are ready to wear, and will last," says Davide Carminati, R&D manager in Tacchificio Villa Cortese.

"By virtually testing shoes in this way with Marc, we can try more design tweaks to balance craft and science, giving us confidence in quality, and the flexibility to experiment more to make better products before a single part is produced."

From a technical standpoint, heels can face several critical issues:

- Damage or breakage under static load, such as when the wearer is standing still
- Breakages that occur while the heel is fixed on the shoe
- Susceptibility to damage from metal inserts; as inserts can lead to stress intensification phenomena that acts on the plastic component of the heel
- Breakage due to fatigue, either when a defect generates a break or by viscoelastic effects that can occur when the shoes are worn

Simulation allows Tacchificio Villa Cortese to understand how to improve their products, and how to optimise the material used for each heel. Prior to using Marc, they were unable to identify issues in a product's shape (geometry) before prototyping, and sometimes it was necessary to work on several prototypes to identify the right geometry. With simulation, they can look for, and design, an optimised geometry that balances the desired design outcome with function at the beginning of the project, and avoid producing unworkable prototypes.

For today's high fashion companies, sustainability is an important trend. Even if high fashion is, by definition, more sustainable than fast fashion, more can be done: it is becoming increasingly urgent to introduce sustainable materials and processes.

Also, in the fast moving and highly competitive fashion industry, getting new styles to the reviewers and fashion shows on time is big business. Reducing time to market is crucial because the finished products have to go out in pre-defined fashion seasons; meaning deadlines are extremely tight. Samples are often used for first events and catwalks, but still need to be engineered to be as similar as possible to the final product, to avoid any unexpected issues during production.

Ecological materials that are recycled, hybrids, biobased and biodegradable, are becoming increasingly popular, as are materials with specific properties such as transparency. These materials need to be mechanically validated, so Tacchificio Villa Cortese creates a digital twin to get computational feedback that reflects actual behaviour. In addition, designers sometimes propose new geometries which are different from tried and tested ones, so it is useful to have preliminary feedback through simulation, before making and testing the prototype.

Discovering structural problems in these new heels only after mechanical tests to the prototypes, would be too late in the production process, when cost and material waste had already

Picture 2: Completed heels ready to be assembled to the shoe.

been incurred, delaying the availability of new shoes.

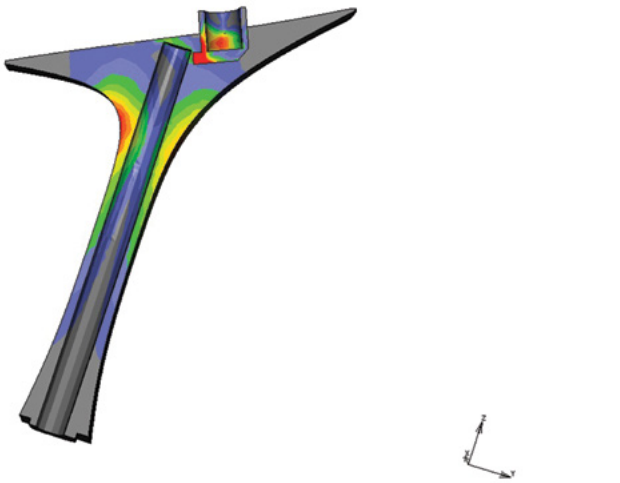
Heel breaks are also a problem for customers; the most frequent issues occurring on high and thin heels, mainly due to the fastening failing or detaching, plastic cracking, and the failure of metal inserts.

Tacchificio Villa Cortese's physical tests include mechanical lateral impact resistance, and fatigue, which are evaluated by an external certifier for ISO regulation. All these tests can be reproduced with Marc software, so that designers can work directly on the Computer Aided Design (CAD) file to make preliminary assessments based on the geometry. The company also plans to carry out additional internal tests considering the effects of impact, and one-off stresses such as stumbling and ankle sprains, along with regular walking simulation.

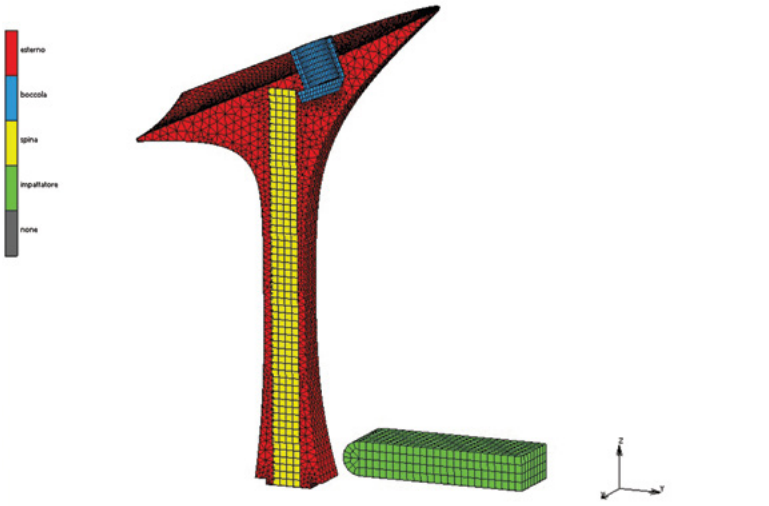
Their goal, using simulation, has been to analyse the geometry of new products before any physical prototyping, to discover issues at the beginning of the production process. This saves time and money because the shoes are put through their paces virtually. "Traditional, manual testing means prototypes have to be physically manufactured first, but testing on a computer screen with the Marc software, means designs can be tweaked to balance craft and science, giving us confidence in the quality before a single piece is made," says Davide Carminati. This also gives us more flexibility to experiment more, and to make better products."

It takes almost five and a half hours to run a full physical fatigue test on a single heel – plus 20 minutes preparation time – costing more than 100€ each, to obtain the relative test certificate. At least three tests need to be carried out, bringing the total time up to around 17 hours.

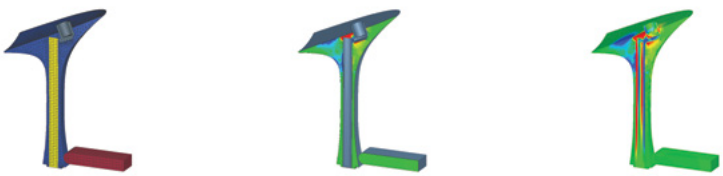
Furthermore, creating moulds for sample production takes at least four hours, and uses 15kg of raw metal on average. "And, of course, this is all wasted if the tests are unsuccessful," says Davide Carminati.



Picture 3: Stress analysis in Marc software.



Picture 4 Impact analysis with Marc



Picture 4 and 5 and 6: Impact analysis in Marc software. The heel of the shoe is made of an exterior, connection and spine which is impacted by a blunt object.

While simulation times vary considerably depending on the individual heel, and the level of detail required by the analysis, to simulate the static equivalent of a fatigue test on a moderately complex model, generally takes around 30 - 45 minutes. But Davide Carminati says even the slightest difficulty can greatly increase the time, and accurate analysis can require more simulations. "The real advantage is evaluating problems early on, which avoids the need to perform further tests on more variants. Even if an optimisation analysis takes a full day, we can avoid tests with specific moulds or specific inserts, which would take more time and resources, and could still be unsuccessful."

The design from their brand customer has to be evaluated to create the desired shape, but at the same time ensure it's strong enough to withstand use. To do this they need to understand the strength of the material in all the ways it's used. Simulation allows them to explore each of these so they can balance the shape and thickness with the design requirements, to find the optimal 'best fit.'

The results of the analysis are used to rectify or rework the CAD model if necessary, which is then sent to the customer for approval, with a detailed analysis report. If requested, an Additive Manufacturing prototype is also produced and delivered with the geometry.

Simulation is used during two different stages of the production process:

1. Material characterisation
2. In accordance with the designer's instructions, find the compromise between geometry, material and process, to obtain a structurally valid shape.

For example, during a new project proposal, Tacchificio Villa Cortese were provided with a design of a certain thickness, and specific restrictions on the method of fixing the heel to the shoe for aesthetic reasons. The proposed fixing methods made it susceptible to high stress, so it was essential that the design and fixing were as robust as possible. Through simulations in Marc they were able to make the inner part thicker by keeping the outside profile the same dimensions, while at the same time investigate, and preliminarily validate, different fixing strategies. In this way they found a trade-off between the finest and thickest profile, and selected a suitable fixing strategy. "Indeed, the final shoe tests matched the foreseen critical aspects," says Davide Carminati. "So we saved on waste and time by identifying where to focus to solve the structural problem before manufacturing any prototypes."

In cooperation with IMT School of Advanced Studies based in Lucca, simulation was used to not only study the final product, but also to refine the material model by matching the physical and virtual response of the specimens. In addition, this helps to characterise the more sustainable eco-friendly materials:

- Ecological alternatives: materials that can have comparable properties to traditional solutions, but save resources and energy during synthesis and transformation
- Recycled materials from post-consume or industrial waste
- Hybrid materials: partly polymer, partly material from waste and/or renewable resources
- Bio-based, biodegradable

All these materials typically exhibit poorer mechanical performances than traditional solutions, and therefore require more extensive mechanical validation to identify possible improvements, and which products they can be used for safely.

Learn more about Marc at:
www.mscsoftware.com/product/marc

About Tacchificio Villa Cortese

Partner of the most prestigious international fashion brands, Tacchificio Villa Cortese has been producing heels since 1961 through a perfect balance between craftsmanship and innovation. Founded in Villa Cortese (Milan) by Luigi Gazzardi, TVC currently sees the coexistence within the company of the second and third generations – this corporate structure guarantees continuity of principles and values making TVC a paragon within the market.

In order to follow with adequate means the entire production cycle of the heel, TVC was joined by subsidiary companies: Teknostampi S.r.l – a company specialising in moulds for plastic materials; Villa Cortese Finishing – a firm specialising in lacquering finishes and special processes; and a new Modelling Office in Scandicci (Florence).

With its major investments in Research & Development, modernising flows and processing plants, and continuous enhancement of human capital - a strategic asset for the company - Tacchificio Villa Cortese strives to prove its pre-eminence as an industry leader. With its commitment to quality, TVC wants customers to recognise it as an essential source for quick and efficient service. And in the public eye, the company strives to uphold its position as an important player in economic and social development.