Certifying Mass Customised Products

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Mass Customization shines new light on certification. Before products can be sold, they need to conform to norms and standards. Currently, certification is usually done by means of physical testing: A small batch of the products is assumed to represent the entire production series. If the sample passes the tests (type approval) and if production applies to standards for consistent quality (process approval), the series is considered to be certified. For MC products, testing some samples does not cover the complete production series, because every product is unique. Computer Aided Verification can certify all designs before products are made. Besides technical challenges, this requires a change of attitude of consumers and legislators. In future designs for MCP, standards may be incorporated. Instead of certifying products or production, the entire chain, including the automated design processes could be certified. BPO is studying various ways of certification MC products by Computer Aided Verification, as well as the implications for development of norms and the design processes. At the latest World Conference on Mass Customization & Personalization (MIT, Boston October 2007), BPO presented their latest results.

Most industrial products conform to norms and standards (ASTM / ISO / NEN / BIFMA / DIN / BS). Certification often requires physical tests of product samples, destructive tests to asses the maximum strength are not unusual. Also the tests involve one or few test dummies to represent the 'average user'. For mass produced products, passing these tests yield to a 'type approval' which covers a complete production volume.

In Mass Customisation every product is unique, traditional 'type approval' is no option: each product is unique, thus several copies of each individual product have to be produced: one for the customer and numerous others for the physical (destructive) tests. It is not hard to understand that this is not economically feasible. Mass Customisation therefore calls for new methods to guarantee in the first place that each produced product automatically is in accordance with the applicable standards and regulations and also that only one copy of each unique product has to be made (the one for the customer). The new technology called for is found in state of the art Computer Aided Engineering (CAE) techniques. Not only have these proven to produce accurate and reliable results, but on certain occasions these provide an even better prediction of the performance of a product than corresponding physical tests. Computer Aided Verification will make the approval of Mass Customised products possible.

Numerous cases demonstrate the value of CAE for the development of reliable mass products. The technical challenges to apply these tools to Mass Customisation are serious, but solvable. In some cases laws and industry standards should be rephrased to achieve a high level of certainty without having to rely on physical tests.

Besides practical challenges, relying on Computer Aided Verification requires confidence and support from public and legislators. Being technically right may be enough for the engineer to make a product, but in order to sell it, credibility is just as important, to state the least.

Eventually Mass Customisation will urge product developers to rethink the entire value adding chain. Not products, but designs will be mass produced. When designs are mass produced, traditional 'type approval' can make its comeback on a higher level. It is conceivable to certify the entire process including the general design formula; covering every possible distinct design and all customized products that may come out of it.

Detailed simulations leading to reliable products.
For over 20 years, BPO has been simulating the mechanical behaviour of complex plastic products by means of CAE, and turning CAE results in to reliable products. In numerous cases Computer Aided Verification has proven to be accurate enough to optimise designs for international regulations and industry standards. The actual physical testing in these cases is nothing more than a formality required to obtain the official approval. This has led to the sense that simulated tests are a valid substitute for physical tests. For particular situations CAE is preferable above physical tests, for example if the long term durability (creep, fatigue) has to

be judged. Furthermore simulations give a far a more profound insight than a simple 'pass' or 'fail' of the test.

Currently, in the Netherlands subterranean water tanks are certified with the aid of computer simulations (Finite Element Method). Simulations asses the performance of the tank over the entire projected lifespan of 30 years. (KIWA, BRL-K22002 Kunststof behuizingen voor IBA-systemen, 2003)

Challenges in Certifying Mass Customised products
If every product is unique, 'type approval' is not possible. Physical testing MC products in the traditional way is not feasible. Subjecting every individual design to a program of (destructive) tests, would take endless process time, unlimited amounts of money and serious logistical problems. The logical thought is to use Computer Aided Verification to assure that in a Mass Customisation production system, only safe and functional products will be manufactured. Currently, this concept is under development in the European Framework 6 programme Custom Fit. Until now, this research has shown us distinctive paths that can be followed to certify MC products by Computer Aided Type Approval and Process Approval.

A considerable amount of requirements in regulations and industry standards can be matched accurately by CAE. When CAE is regulated and accepted as a substitute for physical tests, the common norms and standards can be kept. In some cases reproducing the criteria is difficult, but a reasonable substitute that provides equally reliable judgments can most often be found. In this philosophy, Computer Aided Verification becomes Computer Aided Type Approval.

In some cases it is necessary to adapt norms and standards, in order to guarantee the same level of security for MC products as for common industrial products. Generally it is advisable to reconsider the way norms are stated. It makes sense to use every available method to assure maximum safety and reliability of products. As long as regulations limit certifying to physical testing, the potential value of Computer Aided Verification remains unexploited. Norms and standards should be adapted to accept the certification of automated integrated design and production processes.

Socio- Political Challenges
Today, Computer Aided Verification is a widely accepted tool for engineering, but hardly acknowledged as alternative (let alone improvement) for actual physical testing. Although physical tests do have limitations and disadvantages, apparently the cons of the present are appreciated better than the idea of depending on a product that was certified with a virtual test.

This mind-set can be debated. Do you really prefer to be represented by crash test dummies? Would it not be more valuable to know the performance of a product for your own unique body and your personal habits?

Proving the technical feasibility, accuracy, reliability and economical value of Computer Aided Verification does not sell the product. Lawmakers and consumers will have to be convinced to have confidence. Contact and discussion with the concerned European authorities is in progress to achieve this. Credibility and social acceptance of Computer Aided Verification is an essential key to the success of Mass Customisation.

Changing the chain
In traditional product development certifying a design takes place after the first production samples are available. If the samples pass the test, identical clones of the approved design are mass produced. Passing the test is no trial and error. Experienced engineers put knowledge in to the design, to assure that it lives up to the requirements.

Traditional product development means certifying by physical tests. Only certified products are mass produced

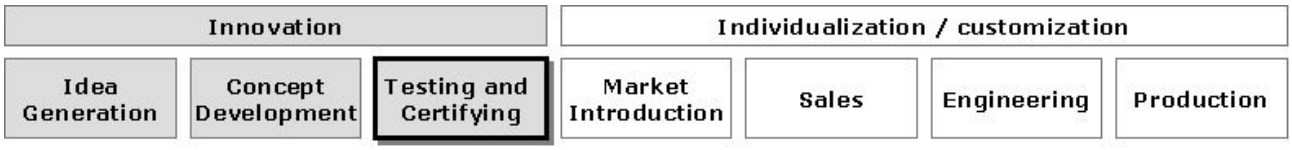
In a Mass Customised environment only one piece of each design will be manufactured. It makes sense to certify the design anytime before the actual product is produced. So independent of the way in which a MC design is created, at some point in the chain, a numerical (computer) model representing the design, will be verified and released (or rejected) for production.

MC product development by means of Computer Aided Verification. Every design is certified or rejected before manufacturing.

It is likely that the development of MC products will be done by advanced knowledge based systems. Based on smart design recipes and analytical formulae, these systems generate customised designs. No identical copies of a specific design are mass produced, but designs are mass produced.

Passing the Computer Aided Verification test will not be trial and error. Engineers will put their knowledge in the master design, to make sure the system only comes up with relevant designs. Laws of nature and legislations as well as personal characteristics and preferences are integrated in master design formulas.

Comparable to a production process that is set up and certified only to produce approvable products. The MC design process will be set up only to produce approvable designs. This is where 'type approval' comes in sight again. In stead of certifying a specific product, the entire chain from design generation until production can be approved. The world will have to set standards for master designs and come up with methods to certify that every conceivable customized product that results from a certain recipe will apply to those standards.



MC product development by means of Chain Approval. Only approvable products are designed

Four methods for certifying MC products
BPO developed four methods for Computer Aided Verification. Two of these are suitable to be applied to Computer Aided Type Approval: the 'channels' and the 'destining' approach. The other two Computer Aided Verification methods (which are referred to as the 'iterative' and the 'analytical' approach) are appropriate for Process Approval.

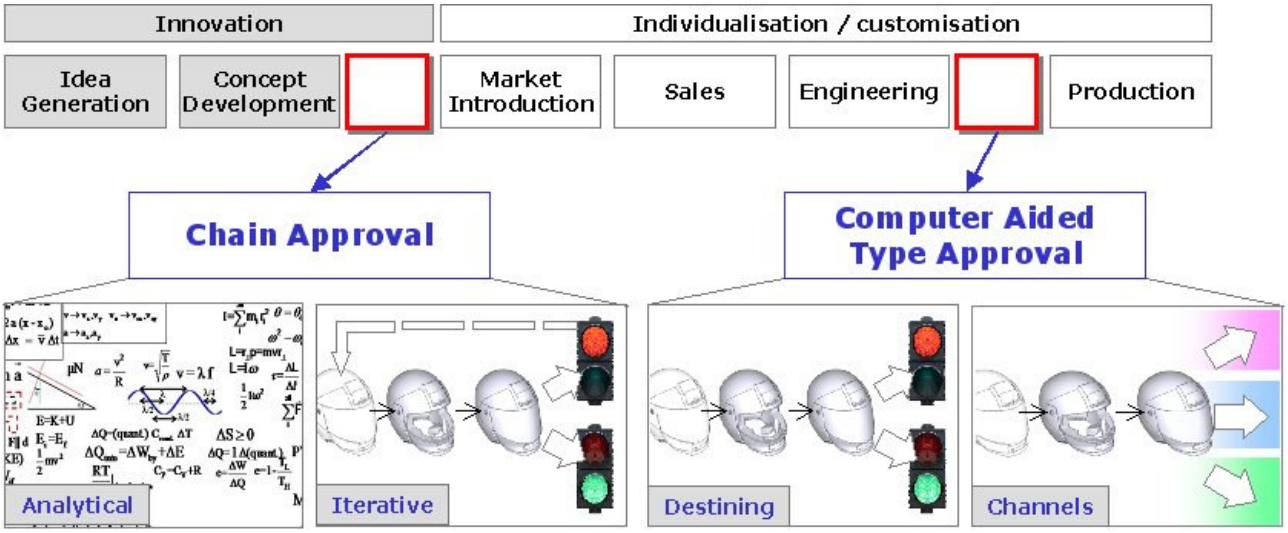
The 'destining approach' is substitution of physical accreditation tests by computer aided verifications. Just before production, the final design is verified and tested. It either passes or fails. Only if the design passes it will be produced. This is the absolute minimal requirement to a virtual validation system. Just before production it filters, and guarantees that only acceptable products are produced.

The 'channels approach' can be compared with the different available sizes in confection clothing (S,M,L,XL). In stead of defining one fixed size, a 'channel' refers to a range of possible sizes or finishes, restricted by certain upper- and lower limits. In between those limits the MC products are allowed to be personalised. Physical tests may be conducted to verify boundary limit cases for some loading situations of each Channel. Computer Aided Verification is not required for every single loading condition. Checking if the MC product is within the predefined limits of a channel is sufficient.

The 'iterative approach' is an automated product design process. The physical tests are replaced with Computer Aided Verification. If the automated design process runs at high speed, the verification result is fed back in the design system to improve the design. Iterations

are repeated until the requirements are fulfilled. This system produces only products that are approved.

The 'analytical approach' refers to the definition of analytical relations between the loading situations, the material properties and the geometry of the MC product. It makes use of knowledge based design methods to describe the product by a mathematical function: f = f(a,b,c…,x,y). In this case, the engineering knowledge is an integrated property of the design and such a design will automatically adapt to the right mix of size, shape and material, depending on individual requests. During concept development, the engineer not just defines shapes, sizes and materials, but feeds the system with design rules, defining the dependency between user specific values, and geometrical or physical properties. The system will only produce acceptable copies.



Steps forward
BPO carried out this research as a part of the European Framework 6 programme Custom Fit. Custom Fit is a cooperation of over 30 European parties, bringing the technologies for personalised production to a higher level. Having defined four MC product certifying methods, the next step is to start working on convincing the legislation institutes. The consortium has defined a couple of test cases, which will be utilised to discuss matters with the legislation institutes and technical committees.

Links:
www.bpo.nl
www.custom-fit.org
www.mass-customisation.de