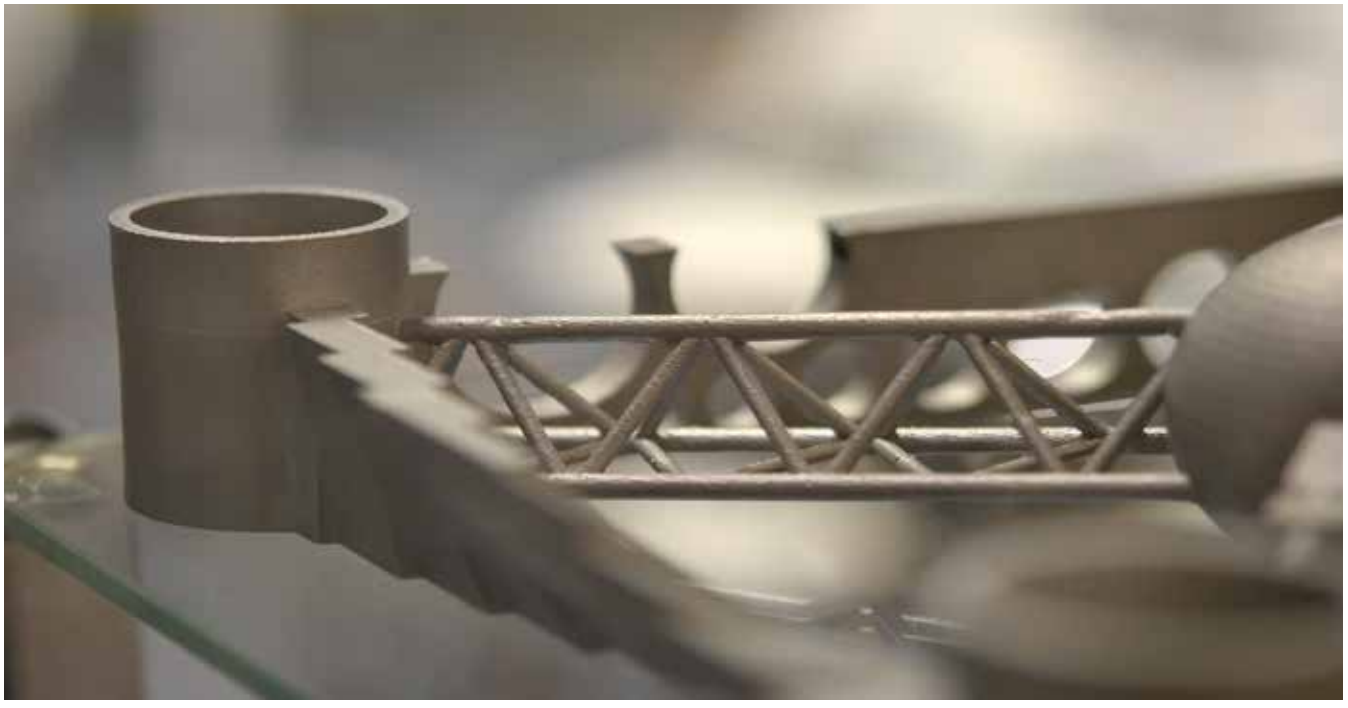

Generative design – Driving force for engineering design

Generative design is a technology that uses Artificial Intelligence (AI) to transform the design process by identifying various design opportunities or design problems by giving a wide range of solutions or design options during design and testing. It will be one of the driving forces in the era of Industry 4.0

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GENERATIVE design is an iterative design process that involves Artificial Intelligence (AI) and cloud compounding that will generate a certain number of outputs that meets certain constraints.

It is an evolution of human-AI collaboration where engineers or designers plug in the design objectives for AI and AI spits out endless iterations of design solutions.

This data-based approach can significantly accelerate companies to move designs forward into production, reduce the manufacturing cost and take something to market at speeds that would be unimaginable. But finally, human intervention is required to make the final design decision, say, for example, aesthetic look, colour, and feel.

Although generative design was introduced in product development a few years ago, it was not successful or not effectively implemented. This is because it was difficult to get engineers and devel-

opers for developing 3D CAD software. And many previous users of the software have been tempted to describe it as a simulation tool or a topology optimisation system. But there has been a lot of progressed since then. Advancement in cloud computing, AI technologies, machine learning, simulation technology, 3D printing, and rapid prototyping enhanced the usage of generative design in the era Industry 4.0.

Early CAD versus generative design

In the past, the creative work all existed in the engineer's brain and the CAD system simply recorded those ideas. In other words, starting a 'drawing' or CAD design is based on what you already know or ideas that are in your head: you could tell a computer what you want to accomplish or what problem you are trying to solve.

But generative design turns the computer into a driving force for engineering design. In generative design engineers first define the design and functional parameters like maximum size depending on the installation or available space, weight, type of material, maximum load, type of manufacturing, and costs. Then the AI takes over, not only giving one improved design alternative, but rather dozens, hundreds, or thousands of potential design alternatives focusing in all possible directions.

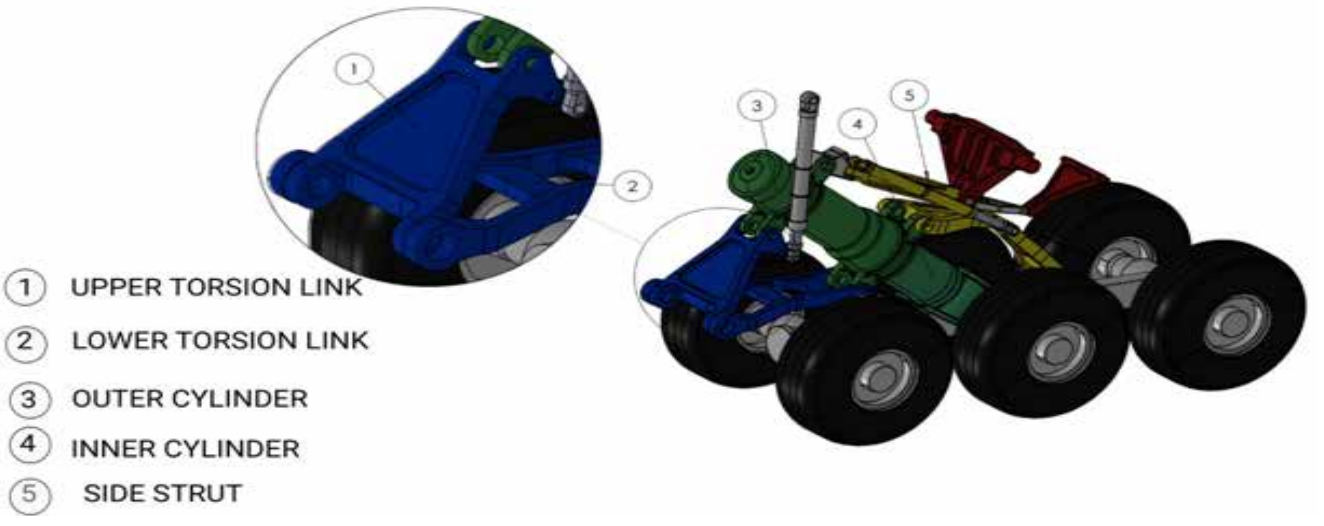
And, unlike traditional design engineering, it does not do this in blankness. The designs can be simulated and tested for performance in real world applications to help narrow down the right options for the design. In addition to the performance, the system generates designs suitable for CNC milling or 3D printing, additive manufacturing and so on.

Topology optimisation versus generative design

Topology optimisation refers to the optimisation of available existing design by using simulation on 3D model. For example, the designer aims to reduce the weight without altering the outer shape. For this, he does not create a complete new design but optimisation of known solutions. But generative design starts from scratch, where designer defines few parameters and obtains optimised design solutions.

CASE STUDY – UPPER TORSION LINK IN LANDING GEAR

Figure1: 3D CAD model of landing gear assembly and magnified view of upper torsion link



The objective of this case study is to give insight to what generative design all about.

A torque link subassembly is selected to explore the feasibility of this generative design. **Figure1** shows 3D CAD model of complete landing gear and magnified view of upper torsion link. During CAD modelling the designer just tells a computer what he want to accomplish, hence all dimensions are inputted to the software without giving any functional parameters and manufacturing methods. To optimise further, designer wants to use other optimisation techniques and subjected to various testing and simulation work.

But by using generative design we obtain the optimal solution. For this case study we used Autodesk Fusion 360 software (Generative Design).

The steps involved in generative design are–

1. ***Creating preserve geometry***: 'Preserve' selected geometry defines the loads and constraints associated to the case study. The green textured parts indicate preserve geometry as shown in **Figure2**.

2. *Creating obstacle geometry*: This constrains the software to not put any material in between. Outside of that obstacle, generative design can work around it, as needed. Red textured part in **Figure3** shows obstacle for the torsion link.

3. *Setting up a design problem*: Use the constraints to define interfaces between design and the surrounding environment. Apply structural loads to simulate pushing, pulling and twisting forces that the design should withstand. Along with one can specify the optimisation objectives such as factor of safety, stiffness, mass target, manufacturing process. A load of 4.48 KN is acting axially on the torsion link as shown in **Figure4**.

4. *Explore outcomes*: Software generates outcomes that satisfy the design requirement specified in the generative study. Once the processing is done design alternatives called outcomes can be explores along with their properties. Generative design gives you the ability to select multiple manufacturing methods, from additive to 3 or 5 axes milling and more, to quickly explore numerous solutions for your design and engineering challenges. Presenting you with a range of solutions that meet your goals, the generative design software gives you the option to explore the various outcomes and even bring the solutions back into your CAD program to refine the design.

Figure5 shows the few design iterations by using generative design. This case study successfully demonstrates the potential of incorporating the generative design methodology for aircraft landing

Figure2: Preserved geometry and starting shape

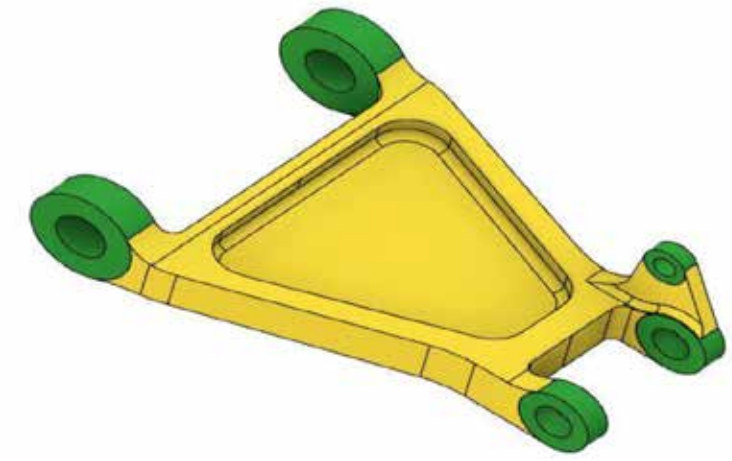


Figure3: Obstacle geometry

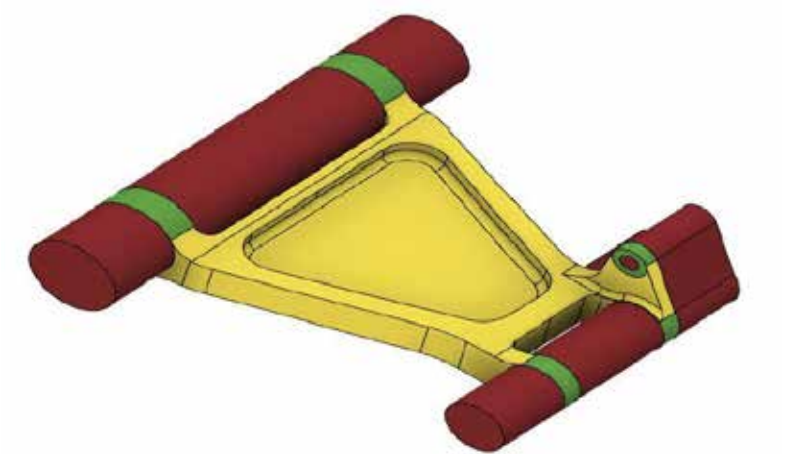


Figure4: Load acting on torque link

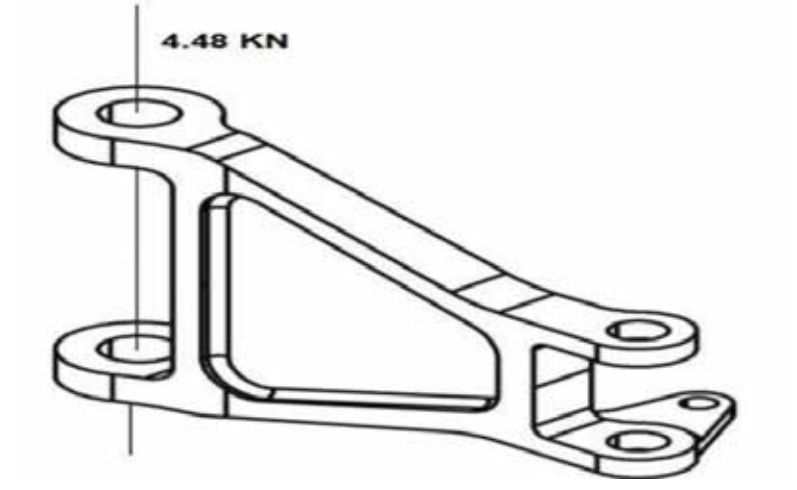
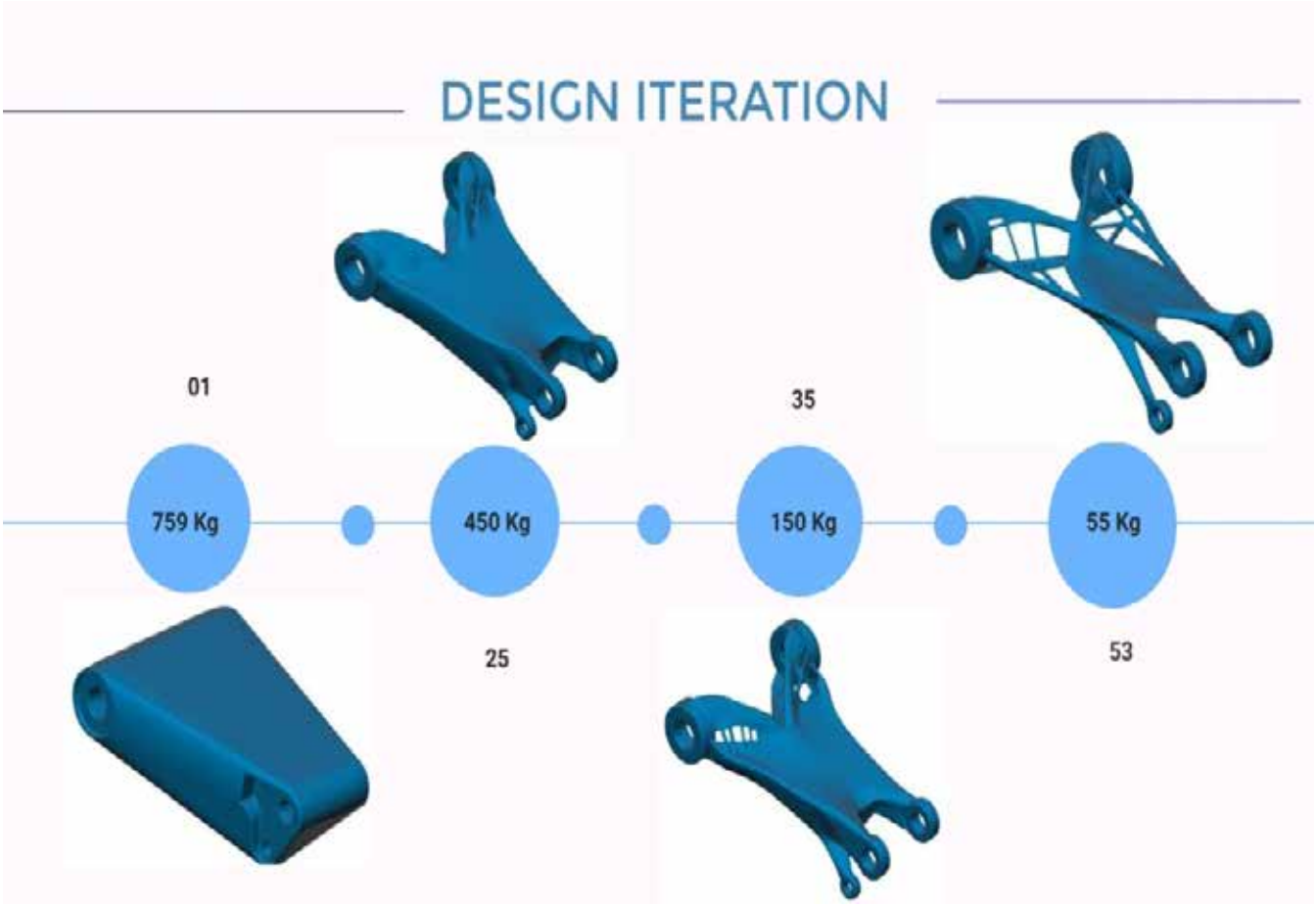


Figure5: Design iterations from initial to optimal solution



gear subassembly, i.e. upper torsion link. With the use of this process the overall weight, performance, product manufacturing time, and cost of the component will be reduced significantly.

With use of generative design method the Torsion link achieves 48 percent light weight than original design with same performance characteristics.

Conclusion

Using artificial intelligence (AI) software and the compute power of the cloud, generative design enables engineers to create thousands of design options by simply defining their design problem – inputting basic parameters such as height, weight it must support, strength, and material options.

With generative design, engineers are no longer limited by their own imaginations or past experience. Instead, they are collaborating with technology to co-create more, better, with less: more new ideas, products that better meet the needs of users, in less time, and with less negative impact on the environment.

Another benefit of generative design is the ability to consolidate parts. Because generative design can handle a level of complexity that is impossible for human engineers to conceive – and because 3D printing can enable the fabrication of the complex geometries that generative algorithms often produce – single parts can be created that replace assemblies of many separate parts. Consolidating parts simplifies supply chains, maintenance and can reduce overall manufacturing costs.

About the authors

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