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A Generative Design Method to Optimize Weight & Performance to build a sustainable product

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ABSTRACT

A generative design is a exploration of CAD design model. The approach of Generative Design is applicable for the complex multi criteria design problem where performance criteria are un-computable. The fundamental base of this method to building a genotype of the design within a history of parametric based CAD system & prepare a sustainable product then further explore the design by its varying parameters randomly within the constrained and its objective function to develop a set of distinctive design sets. Afterward Generative design filtered through various constrained envelopes which representing geometric viability, manufacturability, cost and other performance criteria. Then by this method designer able narrower their area for selecting a appropriate design from vast spaces. Its ability to work seamlessly with current CAD based design practices from early conceptual to detailed design is demonstrated. As machine Structure is a vital of a machine because 50 to 60 percentage weight will be concentrated or consumed by a machine structure. So, for exploration of Generative Design Approach Structure of machine selected for optimize it's weight and performance.

Keywords:- Computer Aided Design (CAD), Generative Design (GD), Cloud Computing, FEA

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Keywords: *Keywords are your own designated keywords separated by commas (","). Keyword 1, Keyword 2, Keyword 3, Keyword 4.*

1. Introduction

A recently newly design concept developed is Generative Design approach. Generative Design (GD) is an evolutionary approach which use a cloud computing method. Generative Design (GD) approach generally make freedom to designer for selecting a many design solution for one engineering problem. So one can also said that generative design approach is a many to one design solution of an engineering problem. With the developing a new edge technology in a computer science and due to availability of more powerful computing software the GD is give leverage to the designer for creating a fast conceptual design.

Generative Design uses a mathematical optimization model to solve an engineering problem. It is also combined with the FEA to create an optimal part Geometries. Generative design creates an many conceptual models in the boundary condition which was defined by a designer like parameters (such as materials, size, weight, strength, manufacturing methods, and cost constraints)

2. Design Phases

Every Design passes through the multiple design stages. But if we broadly classify the design stage in two Phase

1) Iteration Phase 2) Design to production Phase.

If we consider first phase which is iteration phase, So in iteration phase Designer made a conceptual design on the bases of data available like customer requirement or Need. In this phase Designer prepare a various model under the boundary condition such as load, material weight, cost, assembly etc.

After designer made an all-conceptual design the all design are go to the next phase for prototype and manufacturing. In this stages designer check the compatibility to produce a prototype of all conceptual design which they make in iteration phase. After evaluating the manufacturing parameter design go into the validation stage and finally one concept is select and produce the first prototype of product.

3. Traditional Design v/s. Generative Design

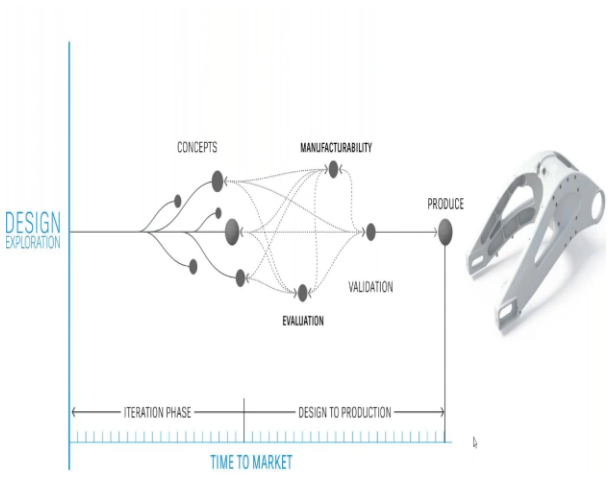


Figure 1. Traditional Design Timeline

After understating the various design phases and their work we will now able to identify difference between in traditional design & Generative design. So for this difference we use a chart with an axis where X-axis shows the Design exploration , Y-axis shows the Product time ready to market. Figure 1 shows the Traditional Design approach while Fig 2 shows the Generative Design approach.

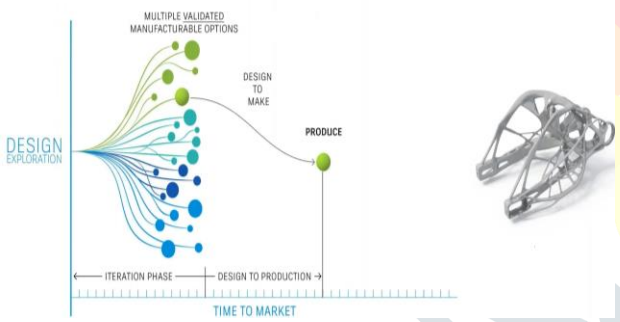


Figure 2 Generative Design TimeLine

So if we compare both the design approach using the above figure 1 &2 we clearly seen that by the using of generative design the product ready to market is faster than the traditional design approach because as we notice that in figure 1 designer take a too much time in iteration phase for crating a multiple conceptual design. Because design make to sure about each and every design model optimize their constrained and work within a boundary condition. So, In tradition design iteration phase take too much time for it's complicated calculation of each iteration. While in generative design it uses a cloud computing technology, so in early iteration phase designer just input an all parameter, constrained & boundary condition, software makes it easy for calculating those things faster. After calculating each conceptual design software gives a many solution of design and designers are able to select a model for their product. Also, now a days availability of additive mfg. and 3D printing technology designer directly make their prototype from selected model of iteration phase. Now a days more software available for creating a generative design one of the powerful software tool is Fusion 360 by Autodesk.

4. Generative Design – Approach

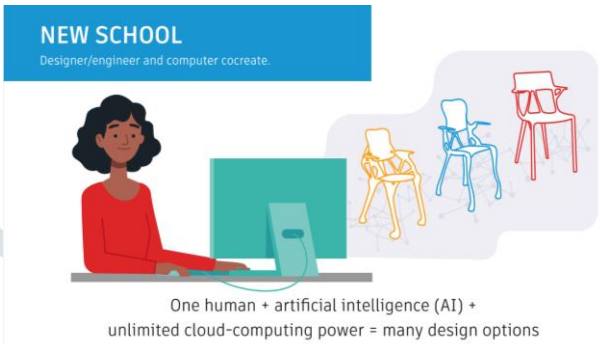
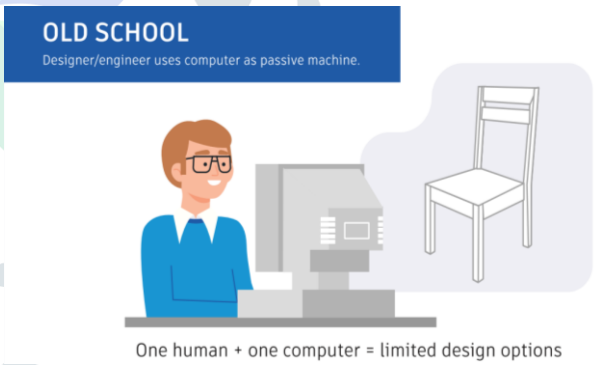


Figure 3 Old V/s New era Design

If we compare an above tow design approach one is traditional and other one is Generative Design approach, so in old era of CAD one can use a computing technology to generate a one model at a time. In that time Engineer or designer uses a workstation as a passive machine while in modern era of Design engineer use a cloud computing technology to concrete the design and build up the Generative Design. As we clearly show the in the figure 3 in old era designer work on the fundamental of one designer + one computer = limited design option, while in modern era as shown in figure 3 using AI technology and cloud computing technology the equation for designer is change like One human + AI + Unlimited Cloud computing Power many design option. So If we take an example of product design of chair we see that using generative design approach we can develop a many option of chair design as shown in figure 3.



5. Flow Chart of Generative Design

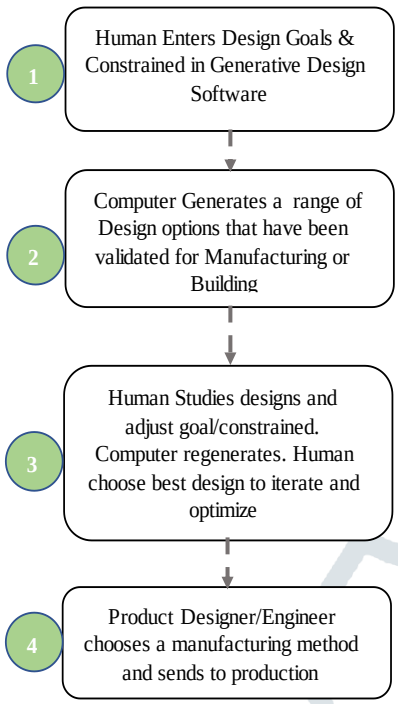


Figure 4 Steps in Generative Design

Generative design passes through the 4-stage as shown in figure 5. If we further show the detail of each stage, In stage - 1 is a input stage of GD. In this stage designer enters their goals to create a design like defining a constrained in this stage. Also, designer set some preserved area in that design which can be fixed for product like holes, bores or fastening area which can be not rearrange by computer so it become fixed. So that after deciding that input criteria in stage -2 the role of computer being introduce and using a cloud computing technology CAD workstation generate a many option of a design where preserved area of design is retained it will not change. So, after ward in next stage -3 which is mainly called a selection stage, in this stage designer studied the various iteration design which was generated by a CAD system in stage-2 & finally selecting a one optimizes design as per their close constrained like load, cost, material, weight etc. Then after in last stage -4 the designer chooses a proper manufacturing method to prepare their prototype which has been selected in stage-3. Mainly the designer chooses an additive manufacturing or 3-D printing process to developed their prototype.

So, GD is giving a leverage to the design to choose many design options for one problem definition. It can be possible with powerful cloud computing technology and additive manufacturing process.

6. Case Studies

6.1 General motors and the seat bracket

The giant automotive car manufacturing company GM (General Motors) also work with same technology of GD and use the design potential of GD to developed a seat bracket of their car. The main objective of their design to reduce the weight of seat bracket without losses their strength. So, for that purpose they developed a first seat bracket and then define their preserved area in model. Afterwards selected a constrained like weight and strengthen to optimize their design. So as a two input of constrained minimize the weight and maximize strength using cloud computing technology of GD they developed a 150 design of seat bracket using a Autodesk Fusion 360 software. The result of the GD which will shown in figure 6 which shows the various design of seat bracket and which actually developed a design up to 40% lighter in weight and 20% stronger in strength.

Figure 5 Seat Bracket output of Generative Design

6.2 Airbus and Cabin Partition

Aircraft manufacturer Airbus implemented a GD philosophy to develop and redesign their cabin partition of A320.According to Airbus after applying the

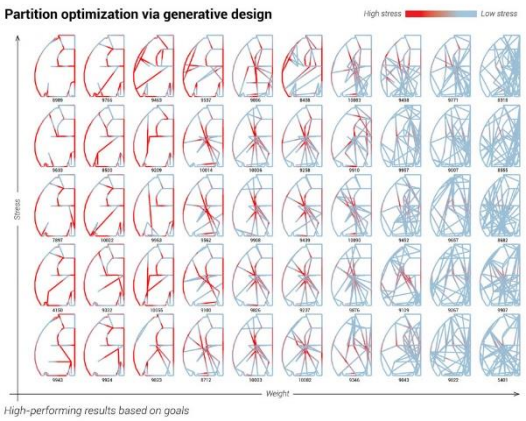


Figure 6 A320 Cabin Partition optimization of weight v/s. Stress

generative design approach to this new part they got conclusive result that weight of the original part of cabin partition it will reduce to half of the original and for the result of the weight reduction they saving a 3,189 kg fuel per part of A320. So reduction of fuel consumption it's lead to a reduction of CO2 emission by 166 MT annually per A320 airplane. Conclusive result of cabin partition of A320 as shown figure 6.

7. Conclusion

After the reviews such design philosophy and studying the case studies, Conclusive evidence of GD is helpful in the area of product design, Assembly modelling, Product development, Geometric modelling, Analysis (like FEA, Structural analysis). If we concluded the GD the following points are summarized in Generative Design conclusion:-

- GD will helpful to generate a design prototype in lightweight with the given boundry condition for optimization & also Quickly Identifying solutions to minimize the mass and material use while maintaining performance and design goal
- It also works on an assembly modelling or a part consolidation where it give an Explore a range of design Solutions that allows you to consolidated multiple components into one solid parts so reducing the part counting finally reducing assembly costs.
- It gives wide range of design solution of given problem definition. So, designer having a various choice for selecting their prototype.
- Also Achieve sustainability goal by using generative design to light weighing products, creating less production waste and helping you select more sustainable materials

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