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Generative Shape Design for Engineering and Medical Equipment

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Abstract: ***The paper focuses on design optimization. The Paper is regarding optimizing the use of 3d object in real work. This directly helps us to optimize the use of design with all physical constrains along with its working and function with topology optimization. In this high demanding world. The manufacturing industries are ready to adopt new technology that will increase the manufacturing production along with reliability and maximizing the use of Raw material, machines etc that will indirectly lead to high profit. This technology can be used to achieve it. The Paper is also use to give exposure to the world of optimization where people with minimal use of material will actually use the maximum option with the help of design optimization.***

Keywords: design optimization, 3D object, manufacturing, resource utilization, sustainability

1. Introduction

The new era of artificial intelligence and internet of things has opened the door of not only the software industry but also manufacturing industries. With the growing demand for consumption of new products in the market and customer need, the manufacturing industry has adopted new technologies to fulfil the supply demand of market with the help of automation

a) Reuse of a product
b) Use of reliable and environment friendly raw material to avoid damage to the environment

This thing are directly the product of a showroom but, what we could also do the things require to manufacture the product. One such new technology is topology optimization or generative design.

Topology optimization is the reduction of unwanted material that causes no effects on the parts of the body even while they are in an operation or not. This optimization technique was introduced in 1970's where it was difficult for industries to adopt this thing as their where no analysis software or technique that will give a final optimized product to be adopted by industries. Topology optimization reduces the gap and makes it easier to find a sustain friendly solutions to that problem. Topology optimization and generative design are the faces of the same coin the only difference is generative design focuses more on;

- Pressure, loads
- Working conditions
- Material to be used and their behaviour

And accordingly, the software use to give the output making the reduction of unwanted material in consideration the paper also us to give high attention to

1) Shape optimization

Maximum possible use of a particular product in terms of shape is called shape optimization.

2) Size optimization

Reduction of unwanted material in order to work within the set constrains is known as size optimization.

3) Design Realization

Designing the product in such a way that it will be able to manufacture in real world along with cost.

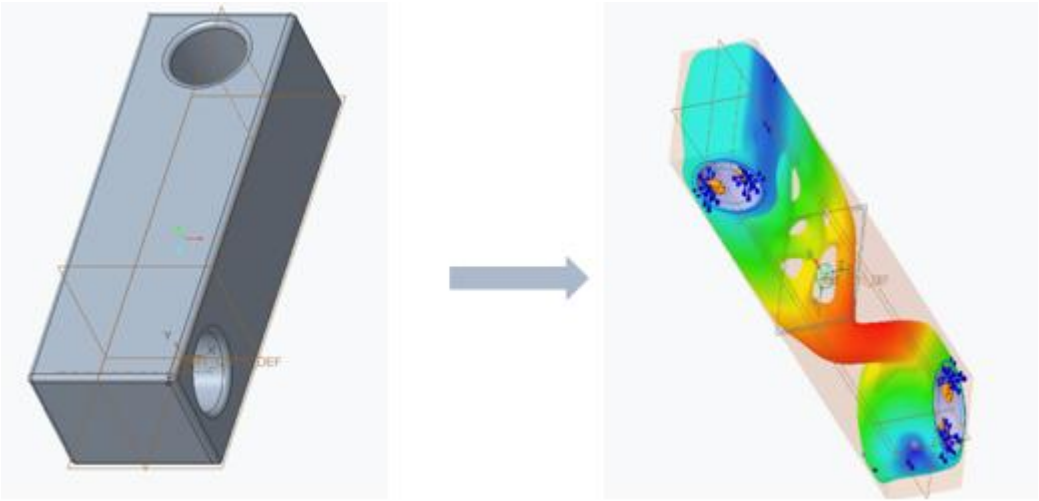
4) Topology optimization

Over all reduction in material in order to reduce the weight and proper functioning of the part.

2. Previous Work

Topology optimization was introduced in 1980's in the world. The purpose behind its introduction was not only to find the best suitable shape but to reduce the unwanted material where there are no loads and neither will it affect the working of existing solution. Topology optimization needs only basic type of computer to run it.

Generative design it was introduced in 1990's and needs a high end configured computer to process it stimulation. Generative design and topology optimization are the faces of a same coin but the only difference is in today's world we say generative design. It can give many solutions to a particular constrains.



3. Problem Identification

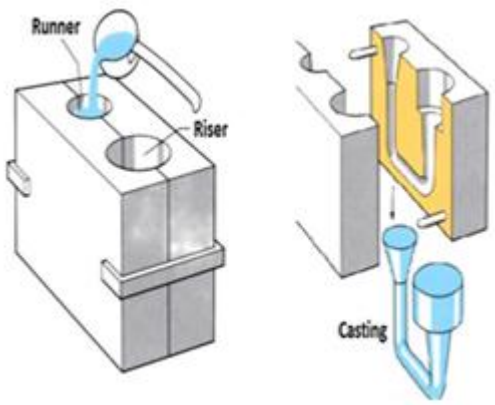
This object are difficult to manufacture as they are complex in terms of design and thus design realization is used to manufacture the things in real world with respect to optimization.

In today's world the manufacturing sector is ready to adopt new methods and technologies after the era of industrialisation and this new era also includes max possible use of an object which is optimization. The manufacturing behaviour is also a very important fact often the whole design process as the molecular structure may get a different behaviour as compared to original.

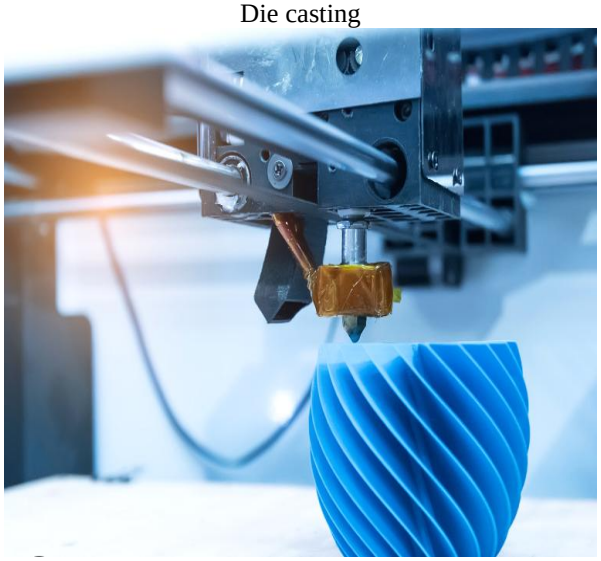
The testing of such material is also very important as the optimization as reduced the size and shape along with material so, testing its capability is one of the crucial points.

Also, the manufacturing method selection is very important

Manufacturing optimized product can be done by the following processes.



Die casting



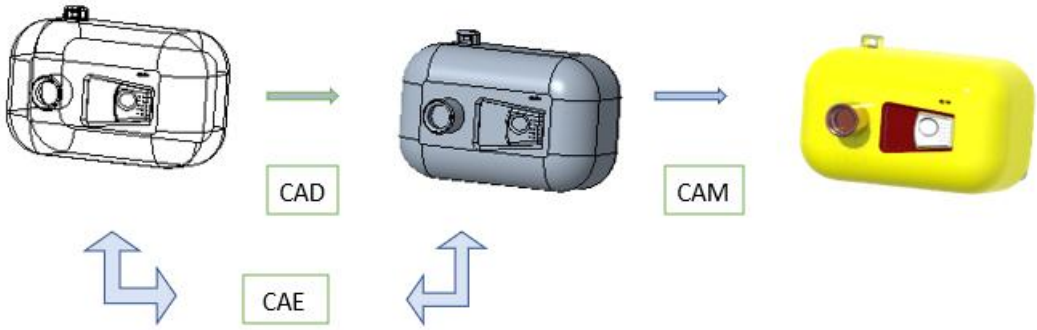
3D Printing

4. Existing Method

The most convenient method to produce a generative design is through

1) 3D Modelling
2) Die Casting

But, to manufacture this we will need to identify the perfect shape and size for an optimized design and for this the following process has to be undergo for through the given process



1) CAD (Computer Aided Design)
The first and the foremost thing for making a product is to make a suitable design for that particular task. Within the market there are number of software available for 3D Modelling(e.g. CREO, AUTOCAD, ANSYS etc) which are able to make 3 models in different format types.

2) FEM (Finite element analysis)
Finite element analysis is a type of analysis in which the component is divided into many small parts clubbed in together and is known as meshing. So, While performing any activity with respect to loads, pressure etc, the performance behaviour is determined (Buckling, twisting etc) and further can be modified accordingly.

3) CAM (Computer aided manufacturing)
In this the method the manufacturing of 3D Model part is determined. For Generative Design purpose CNC, VMC Machines can be used as they are presized and accurate while manufacturing a particular part.

4) CAE (Computer aided engineering)
In this method the product undergoes again through design as their can be a scope of improvement (In terms of aerodynamics, performance etc) and the same cycle of product development is repeated. Thus, Making a more reliable product then the previous model.

Construction
Constructure of replacement of plaster for body in against of light weight, Reliable and convenient to use objects, things for the same objective

In medical field, Whenever a bone of human body fractures, The doctor use to apply plaster for the recovery of the body which is

- Very much Bulky
- Not convenient to use along or taking with it
- We cannot wash the fractured part properly

The person along with fracture plaster has to bear all this thing but, what if we can just reduce the shape, size and design to overcome such problem

Topology Optimization use to do all such kind that will make an impact over medical industry by applying it over the equipment.

We have applied the constrains of a fracture plaster to a plastic material …… and started doing the analysis. With this analysis we found that the

- Shape
- Size
- Design

Can be optimized. Further more the manufacturing cost of this thing is also low

The Design can be altered keeping in mind the focused objective.

Robotic Arm

Name :	Robotic Arm		
SR NO.	Criteria	Experiment model	Transformed
1	Material	Cast Iron Malleable	Cast Iron Malleable
2	forces	X-150, Y-350, Z-100Nmm	X-150, Y-350, Z-100Nmm
3	dimensions	145x140x800mm	145x140x800mm
4	weight	50 kg	30.5 kg
5	No. of constrains	1	1
6	fixes	2	2

Robotic arms are the part of machine which use to work like an arm. The key operation of robotic arm is to rotate with respect to the axis and direction which is performed by motors. So, arms can be optimised as the operation is only moment. With the coming of AI, The future is going to be robotic very soon and all the work will be carried out by just instructions. The current growth of robotic arm is 45% and around 3gets manufactured daily. The space research institutions are also finding out ways to performed different operations in the space and for that they are using robots as a to tool. Generative design has an immense scope coming future. The cost of getting 1 kg in the space is huge and for this reduction in mass can be more effective

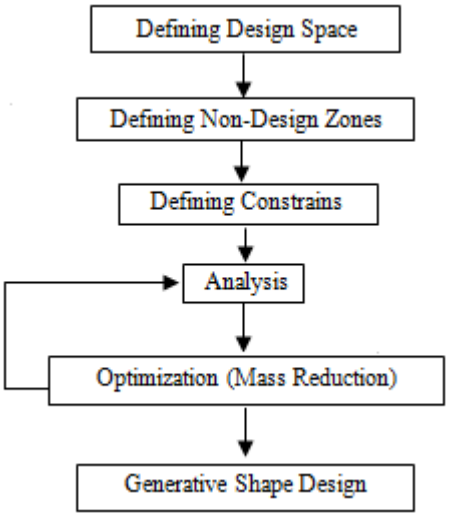
5. Working Principal

Reduce the unwanted material from the part

The only process that a software use to make a generative design product is :

Iteration method
It is the process to make a continuous cycle until the product does not break or discontinue its functionality.
So,

1) We make the product
2) We add the constrains
3) The product is submitted to analyse and optimize
4) The software gives the output based on input
5) The unwanted material is identified while analysis and removed from the product
6) Again, the process continuous for adding the constrain and analyse the product.
7) This continuous the process until the product does not break and just before its fatigue the optimized product is given by the software.



Advantages

- **Light weight**
  Topology optimization is made to reduce the weight. The final optimized produced is always less than the original one. This reduces the overall raw material and increases the efficiency.

- **Convenient to use**
  Light weight will affect the transportation to be done more easily and will also reduce the overall cost.

- **Design optimized**
  Design is more efficient to work and with less self weight along with the shape.

- **Size optimized**
  Maximum possible use of the size of which it is constrained.

- **Low cost**
  The raw material required is less so, the transportation cost will be reduced along with the energy and thus, will reduces the extra charges applied over it.

6. Future Scope

During the 90's many people were not having car but now, almost each one of the family has a car. Similarly generative design is not adopted by industries but in the

coming future optimization will be the key to become efficient industry and also a gift to the next world. We can easily reduce the size and shape of an object along with the same functioning. We can use topology optimization in the following ways;

- Robotic industry
- Manufacturing sector
- Medical equipment.
- Civil industry

And each one of the industries has immense scope for a particular part because that part can have multiple designs of the same constrains so, when AI will be ruling over the industries, topology optimization will be the part of it.

E.g. A tool (ex. Spanner) of 300g has to be shipped from India to USA in 10,000 quantity.

So, the weight will be 3 tons (3000000g) and if we were able to reduce the weight by just 50g then the quantity can reach upto12000 pieces.

So, the cost to transport from India is around 20$ of 1Kg

That's how Generative design helps in mass production transportation.

7. Limitations

1) High manufacturing cost

The cost to manufacture a generative product is high as the complex design makes it difficult to manufacture with die casting or to 3d print it. But ones the die is made it will cover all the other extra cost added to the product as compared to generative product. This will include;

- Transportation cost
- Extra material cost
- Taxes

2) High modelling cost

The modelling of topologically optimized product is high as the software that are used for this purpose are of high end processors. The analysis of the 3d modelled part is also very essential. As a part that is made of two materials portioned between it affect the design or splitting tool must be introduced between it. Any fracture within the part is also a point of failure.

3) Difficult to manufacture

We can print a generative product but it is limited to the number of products it will manufacture at a time. With the help of die cast me can produce number of similar product but, to model and manufacture die is also a challenging.

4) Have to made with extra material because of design realization or manufacturability

Manufacturing a generative product is very much difficult and time consuming. In order to make this product feasible to manufacture the generative model is to be taken in to consideration for modelling and further more material to be added for machine to manufacture it smoothly.

5) Minute fractures are not allowed in generative design product

The fractures are not considered in the product analysis while 3d modelling a generative product and as a part of it the product must be fracture proof or must be checked with the help of equipment that can detect fractures (ultrasonic machine). If the material to make the part is made of alloy material, then its properties must be added in the software to get the precise model. The partition of two sub parts of a part must be considered with the help of splitting in software.

8. Conclusion

The method to use a product in its maximum efficiency is optimization and generative design allows it to do with the help of software. Software allows to apply all the constrains of and gives the result in few couple of minutes. The coming future is all about efficiency and this technique is the best way to do that for manufacturing sector. The Magic of AI in the competitive world will be fulfilled by generative design. The Software use the use to iterate the given component along with applied constrains to give an optimized product. We can also reduce the volume or percentage reduction in the over all product to the software So, that we will get a product with its maximum efficiency. The manufacturing world is going to get a boon with this technology and manufacturability of a product will be fast and convenient to use just is like that of mobile phone. We will be able to manufacture a component with maximum efficiency and in a faster way that to remotely.

The use of optimization in medical field is vast and fracture replacement is just a start of the optimization journey in the health sector. We can explore more on this in terms of wrist fracture, Robotic arms for the operation propose. With the development of AI and IOT the future of medical industry seems bright as the operations that can only be performed in the presence of doctor, In the coming future it can be performed remotely with the help of Robotic arms and high speed internet connectivity. And this has be convenient to setup along with easy transportation. This can be performed by generative design. Even the production of a particular part of a machine or whole machine can be manufactured and set up by 3D Printing. Over all generative design or topology optimization will add a better part of in terms of efficiency or maximum possible use of a product in the world of manufacturing industry. The upcoming twenty years are devoted to AI and IOT and this thing's will also be included in not only in software field but also in manufacturing world.

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