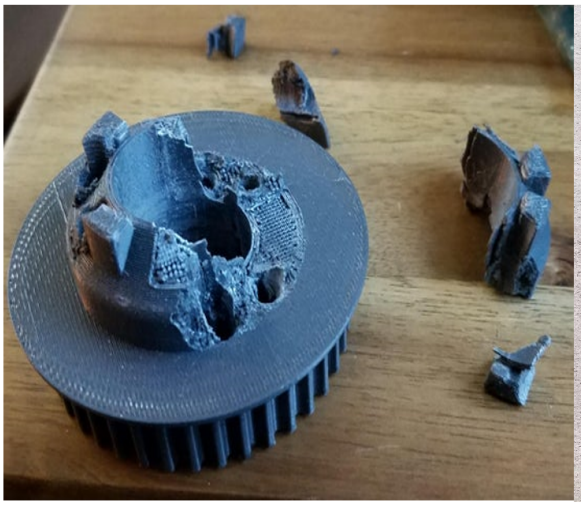
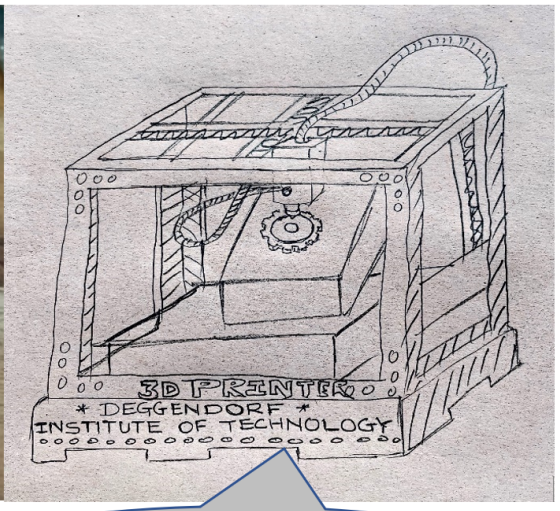
Gear Mechanisms made by Additive Manufacturing

The process of creating the 3-dimensional object from a digital file. Why additive? "Because it involves building up thin layers of material one by one"



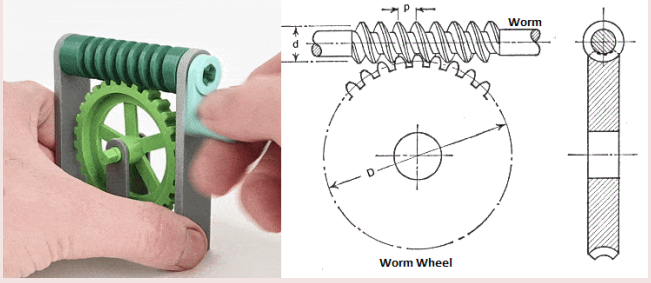


Don't Worry!!
I can print the new one 😊

Advantages

Without using expensive and special tooling, fixtures, moulds, mills, and lathes, only one machine can make accurate kinematic mechanisms which can be powerful at:

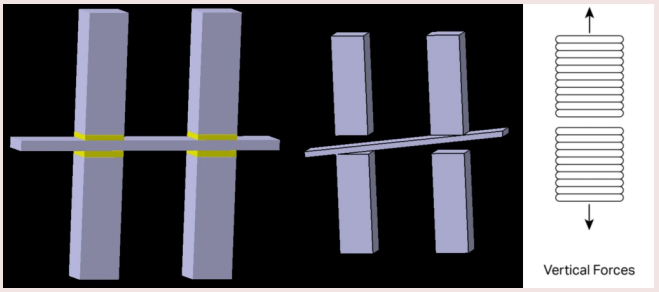
- **Education & Training:** These mechanisms are proved to be extra-ordinary for educating students or training teachers and practitioners. It increases the ability to grasp any kinematic concept for students which is helping them to be creative and solve complex problems. Teacher-student engagement is relatively enhanced.



https://www.robives.com/project/worm3d/

Disadvantages

- **Strength**
  - Orientation of layers: There is an adhesive bond created between consecutive layers. If the force is applied vertically (perpendicular to the print bed plane), the layers can be separated apart or sheared in one another. (See Image)
  - Usually, mechanisms manufactured by additive manufacturing have structural defects like voids and porosity, it results in lower strength near the areas of defects, since voids are likely to increase stress.
- **Misalignment:** Support is required for some structures, but once the support is removed, then it may cause misalignment. (See image)



- **Prototyping:** Exploring mechanisms for the purpose of research, demonstration and modelling provides many opportunities to aid visual and practical understanding across the labs. 3D-printed mechanisms are often used as test models for scientific experiments across different disciplines, including mechanical engineering, aerospace, and robotics.
- **Yes! The complex is printed:** It is only the matter of capability to make CAD model and you are done! Exotic tooth forms and highly complicated mechanisms are pretty well printed and has functionality.
- N**eed it? Manufacture it!** Time to market is short when mechanisms are made by additive manufacturing since it is not required to assemble numerous pieces to form a mechanism, additive manufacturing does it in one go and one machine. It has made it possible to make the Mechanisms once the requirement is foreseen.
- **Artifact conservancy:** Unique and patented mechanisms can be presented in museums or preserved for historical significance.

- **Surface finish:** Gears are made layer by layer hence there is possibility to warp the material while new molten layer is developed, and it is less likely to get the smoother surface finish in case of joints.
- **Clearance:** Unlike the cutting off method, additive manufacturing can not maintain the zero-width gap when printing the clearance between parts having relative motion. It very crucial to consider when tight clearances are required for functionality.
- **Large gaps** produced at clearance and **tooth backlash** can reduce the rigidity of mechanisms and increases loudness.
- **Transferable torque** is relatively low as compared with conventionally made mechanisms.
- **Post-processing:** It is required to do some extra work like smoothing the gear teeth, removing the support material, polishing, surface finish, clearance correction etc.

How to deal?

Pre-analysis

Having everything pre-analysed will result in increased life and performance of the mechanisms and overcome some of the disadvantages.

1.Torque: It is crucial to determine how much torque can each gear handle before permanent deformation.

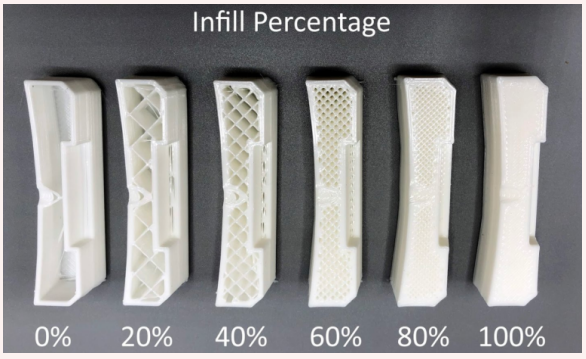
2.On which circumstances does any of the gears fails, if so, note it down. Is it repeated every time? To prevent and take predictive actions, analyse the behaviour of how the failure has happened.

3.Layer-orientation according to the direction of application of force.

Material

Material really plays vital role and decides on eliminating some of the limitations which were previously present.

1. According to the application and requirement, proper material can be selected to have required surface finish, strength, coefficient of friction, temperature to withstand at planned cost. For e.g., Nylon is good as compared with ABS and PLA when subjected to tensile and compressive loading, has more strength, melting point, and coefficient of friction.



Infill %

It is better to analyse and decide on infill percentages according to the cost, application and working conditions. Since more material is filled for higher infill percentages and it increases the cost while also increasing the strength. On the other hand, lower the infill percentage, lower the cost and strength.
Image Reference: https://pick3dprinter.com/3d-printing-infill/

Environmental Effect

Additive manufacturing is heavily impacting the Environment by producing more carbon footprints/kg if compared along with conventional manufacturing. The studies and research should look on other powerful benefits of additive manufacturing of gear mechanisms to overlook on the conventional methods.

Standard Components

Standard components such as screws, nut and bolts, bushes, washers, pin, shafts etc. can be used to improve the performance of mechanisms at certain areas like strength, wear, friction and so on. For e.g. Standard bushes can be used to reduce the friction.

“Gear Up”

— Rohan Nawale, Technische Hochschule Deggendorf
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https://rohannawaledotadditivemanufacturing.wordpress.com/