3 - 3D Printing and Gearing

March 5, 2021 1:34 PM

Fri. Mar. 5/21
Start: 1:45 pm.
End: 4:00 pm

* Solidworks toolbox has some gears but they are not true involute gears and shouldn't be used for manufacturing (they're only for modelling purposes)

Some spur gear generators (for solidworks):

https://www.thingiverse.com/thing:8077

https://grabcad.com/library/robust-involute-spur-gear-generator-solidworks-1 → "For modelling a TRUE Involute Spur Gear in Solidworks"

→ same guy also made helical gear generator — good to keep in mind

Note: use the updated file:

"Robust Involute Spur Gear Generator - Better 02.SLDPRT"

Note: this template is set for the User input of the following:

"Diametrical Pitch" , "Number of Teeth" & "Pressure Angle"

Note on material for 3D printing Gears:
https://www.instructables.com/A-Practical-Guide-to-FDM-3D-Printing-Gears/

Nylon > PLA > ABS > PETG

Nylon filament is an incredibly strong, durable, and versatile 3D printing material. It's low friction coefficient, high inter-layer adhesion, and high melting temperature make it an excellent choice for 3D printed gears. The drawbacks of nylon are its propensity to absorb water and the difficulty of printing with it.

That leaves most folks with the choice between ABS & PLA. PLA has high rigidity and superior wear properties over ABS which make it a better choice *when application temperatures allow*.

PLA's low heat distortion temperature makes ABS a better choice for applications involving temperatures above ~75C (ABS softens around 105C).

By the way, the biodegradability of PLA is an overhyped property. Yes, PLA is biodegradable. But not in a scale that is in any way noticeable for the end user. Do not equate biodegradability with water solubility. To biodegrade this plastic, you need a specialized composting facility with a controlled environment.

∴ but hey. it's still something

PETG is a ductile material but it is also softer, more flexible, and less scratch resistant than either ABS or PLA which makes it a worse choice for gears. (PETG material data sources here and here.)

On designing 3D-printed Gears: https://www.sculpteo.com/blog/2019/11/20/3d-printed-gears-pro-design-tips-and-software-advice/

- recommended ratio: 0.2 – 5
- for 20° pressure angle, recommended minimum 13 teeth
- generally, fewer teeth = stronger
  - and tiny teeth are hard to produce
- thickness: recommended min 3-5 X the circular pitch
- for additional accuracy:
  - consider adding extra gear (= more stability?)

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PLA PLASTIC — MORE MECH PROPERTIES:

Poisson

PLA : $\mu = 0.320$ https://iopscience.iop.org/article/10.1088/1742-6596/1359/1/012107/pdf

PLA HP : $\mu = 0.134$

PLA, injection mold grade : $\mu = 0.36$ https://core.ac.uk/download/pdf/143478508.pdf

59 MPa tensile Strength https://core.ac.uk/download/pdf/143478508.pdf

8990 psi ≅ 62 MPa Yield Tensile Strength https://plastics.ulprospector.com/generics/34/c/t/polylactic-acid-pla-properties-processing

Elastic Modulus = 3500 MPa https://core.ac.uk/download/pdf/143478508.pdf

DETERMINING STRENGTH OF GEARS

Plastic Gear Strength:

Bending Stress

The bending stress on a gear tooth of a standard tooth form loaded at the pitch line can be calculated using the Lewis Equation :

$$S_b = \frac{FP_d}{fY}$$

where:

S_b	=	bending stress
F	=	tangential tooth loading at the pitch line
P_d	=	diametral pitch
f	=	face width
Y	=	Lewis form factor for plastic gears, loaded at the pitch point

- from 'A Guide to Plastic Gearing' by GE

GE_plastic...

Contact Stress

The equations we have looked at so far have been examining the forces trying to bend the gear teeth and shear them from the bulk of the material. These forces lead to failures by tooth breakage due to static loading or fatigue action. The other forces we saw in our examination of gear action generated surface stresses by contact of the gear teeth and their relative motion to each other. These stresses lead to failure in the surface of the gear teeth, or wear. To assure a satisfactory life, the gears must be designed so that the dynamic surface stresses are within the surface endurance limit of the material.

The following equation was derived from the Hertz theory of contact stress between two cylinders, and modified to employ notation used in gearing:

$$S_H = \sqrt{\frac{W_t}{fD_p} \frac{1}{\pi\left(\frac{1-\mu_p^2}{E_p}+\frac{1-\mu_g^2}{E_g}\right)} \frac{1}{\frac{\cos\phi \sin\phi}{2}} \frac{m_g}{m_g+1}}$$

where:

S_H	=	surface contact stress (Hertzian stress)
W_t	=	transmitted load
D_p	=	pitch diameter, pinion
μ	=	Poisson's ratio
E	=	Modulus of Elasticity
ø	=	pressure angle
m	=	speed ratio, Ng/Np
N	=	number of teeth

START: 5:15

END: 7:00

- worked on Excel Sheet

Diametrical pitch $= P = \dfrac{25.4}{\underbrace{m}_{\text{module}}}$