Anti-twister

Design, Manufacturing and Modeling a magical mechanism

Project Background

A very common requirement in the process industry is to transmit energy or mass between fixed and rotating points. Any continuous communication channel setup between the two points(one end fixed and the other rotating) will usually experience a twist. Thus there is a need to design a mechanism which is free from these limitations of twists and can work equally well for all forms of energy (electrical, optical, mass etc.). The present study aimed at finding , prototyping and modeling possible solutions to this problem.

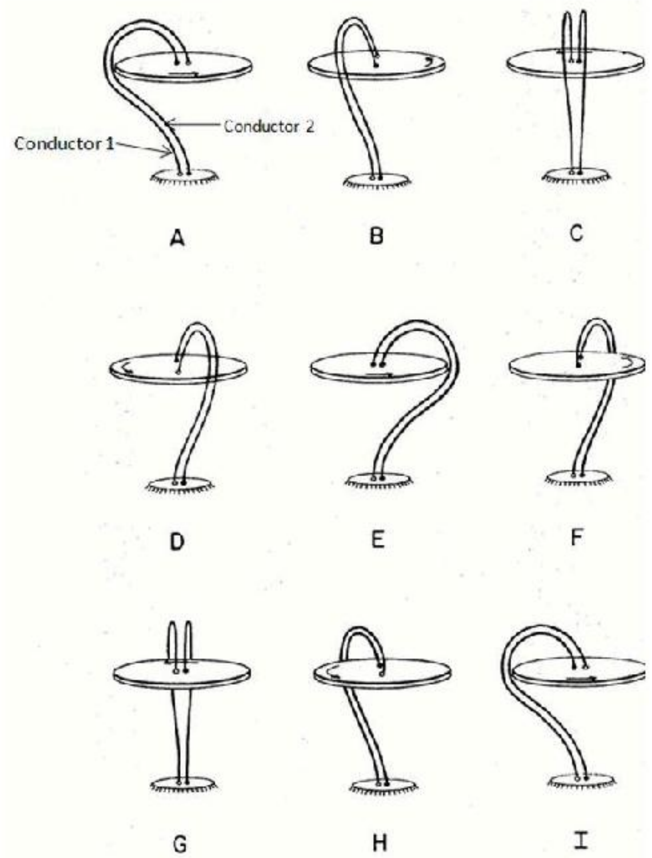


Fig. 1 The solution strategy (Adams, 71)

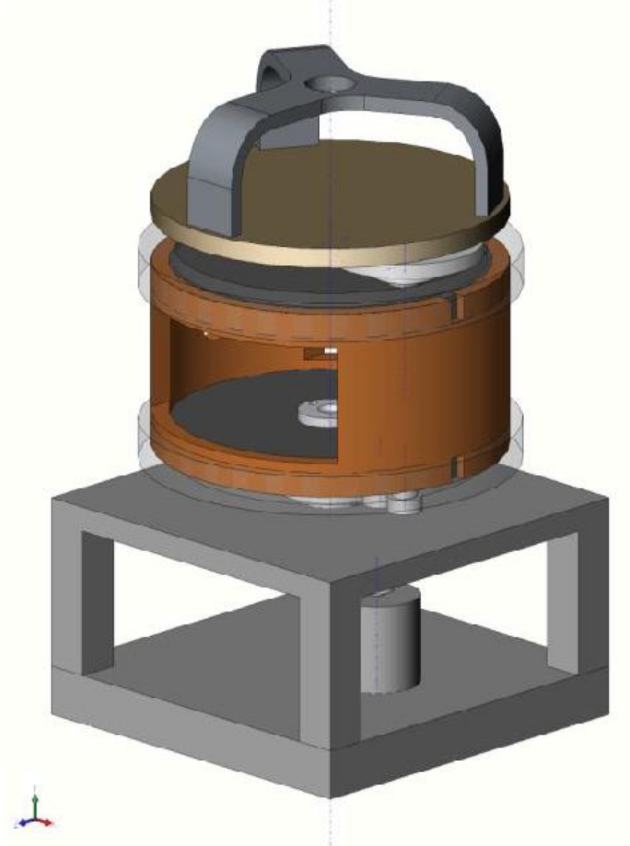


Fig. 2 First phase design (without compliance)

Methodology

An ingenious solution strategy for the same was identified from patent search. The strategy stated that if any point on the communication channel is constrained to rotate at half the angular velocity about the same axis then the twist cancels out after two complete rotations. However its working has not be explained. Thus, to date there has been no mathematical model of the cable/ribbon/tube (used in transmission of energy) which explains the working of the mechanism. Also, owing to the absence of mathematical theory it was difficult to rule out other possible variants of the same strategy. Hence an exercise in analysis and prototype design to implement this strategy was carried out.

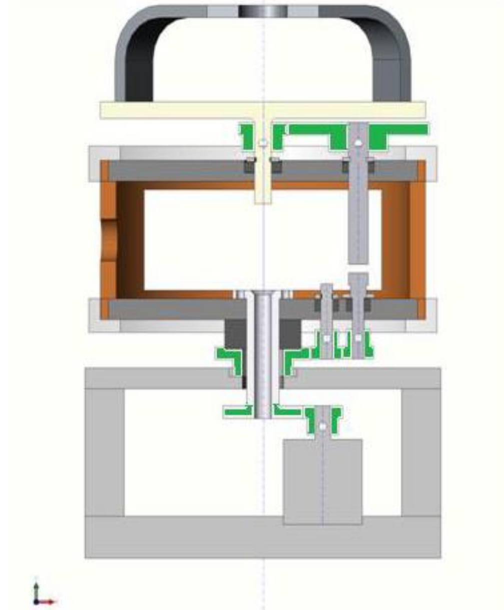
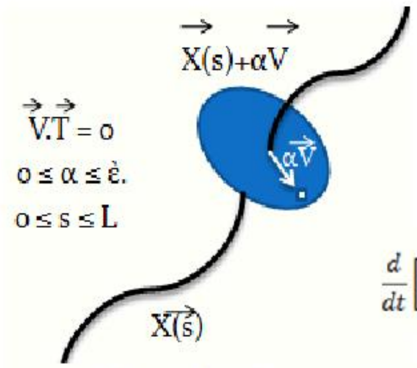


Fig. 3 The epicyclic gear train



$$\omega(\sigma,t) = (V \times \frac{d}{ds}V) \cdot T$$

$$\frac{d}{dt}\left[\frac{d}{dt}(A\omega) - A\kappa\left(\frac{d}{ds}\dot{X}\right).B\right] = \frac{C}{I}\frac{d}{d\sigma}\left(A\frac{d}{d\sigma}(A\omega)\right)$$

$$\rho\ddot{X} = \left(\frac{d}{ds}F_T - \frac{1}{2}EI\frac{d}{ds}\kappa^2 + g_T\right)T + \left(-EI\frac{d^2}{ds^2}\kappa + \kappa F_T - C\kappa\tau\omega + EI\tau^2\kappa + g_N\right)N$$
$$+ \left(\frac{d}{ds}(C\kappa\omega - EI\kappa\tau) - EI\tau\frac{d}{ds}\kappa + g_B\right)B$$

Fig. 4 Mathematical Modeling

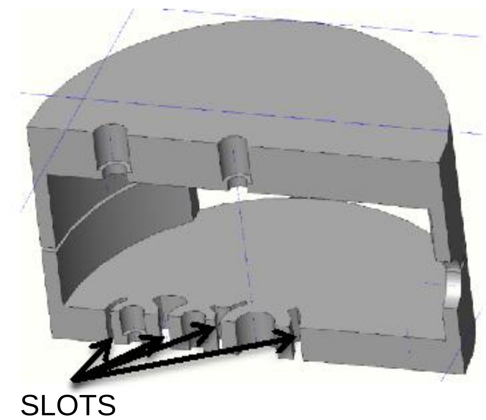


Fig. 5 Design modification to introduce compliance

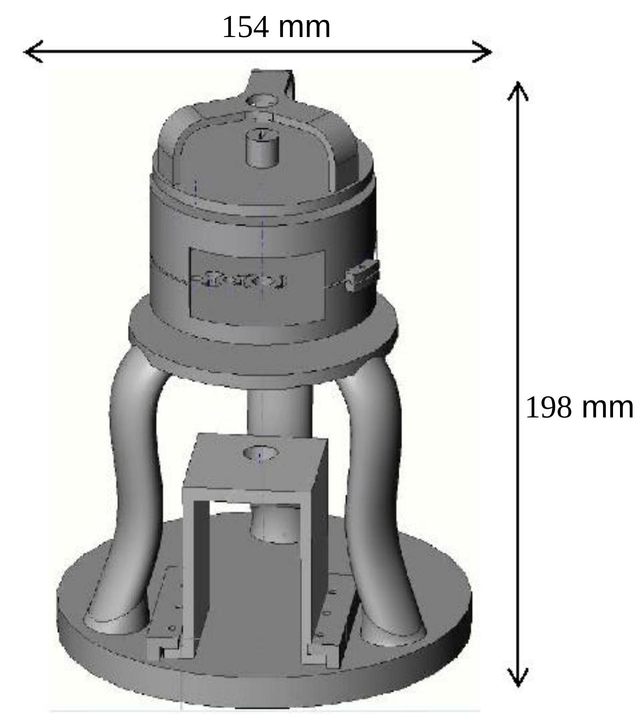


Fig. 6 Final design (with compliance)

Results

The Final design iteration is shown in fig. 6. Owing to the complexity and strict alignment requirements of the epicyclic gear train compliance was introduced into the design (fig. 5). Attempts at mathematical modeling using Non linear Finite element models were only marginally successful as the deformations were large and extremely non linear, leading to convergence issues.