Hooke's (Universal) Joint: Output Speed Variation

Output shaft speed of a Hooke's (Cardan) joint at a shaft angle and input position, its maximum and minimum, and the speed fluctuation.

Method: Rattan; Theory of Machines; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Input speed	1,000.0	rpm
Angle between shafts	20.002	°
Input shaft position, from the driving yoke perpendicular to the plane of the shafts	30.000	°

Calculated results

Parameter	Value	Unit
Output speed at θ	967.99	rpm
Maximum output speed	1,064.2	rpm
Minimum output speed	939.68	rpm
Total fluctuation	12.451	%

Notes for this case

- A double Hooke's joint with equal angles and in-phase yokes cancels the fluctuation; constant-velocity joints avoid it altogether.

Formula and method

$$\frac{\omega_2}{\omega_1} = \frac{\cos\alpha}{1 - \sin^2\theta \sin^2\alpha}, \quad N_{2,max} = \frac{N_1}{\cos\alpha}, \quad N_{2,min} = N_1 \cos\alpha$$

Variables

N_1	Input speed	1/s
α	Angle between shafts	rad
θ	Input shaft position, from the driving yoke perpendicular to the plane of the shafts	rad
N_2	Output speed at θ	1/s
$N_{2,max}$	Maximum output speed	1/s
$N_{2,min}$	Minimum output speed	1/s
$\Delta N/N_1$	Total fluctuation	-

Method and standards

Hooke's joint kinematics.

Assumptions and limits

- Rigid joint.
- θ is measured from the position where the driving yoke is perpendicular to the plane containing both shafts: the output is slowest there (θ = 0°, 180°) and fastest at θ = 90°, 270°.

References

- Rattan
- Theory of Machines
- 4th ed. (McGraw-Hill, 2014); Bhandari
- Design of Machine Elements
- 4th ed. (McGraw-Hill, 2017) (Hooke's joint: $\omega_2/\omega_1 = \cos\alpha/(1 - \sin^2\theta \sin^2\alpha)$)

Report details

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Release checks	2 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/machine-design/hookes-joint-velocity

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.