TWO NEW DESIGNS OF ELASTIC AVERAGING COUPLING

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INTRODUCTION

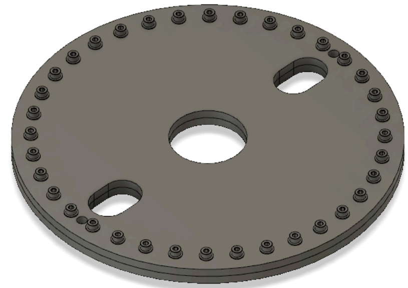
Elastic averaging can enable high precision alignment with rapid fabricated parts [1]. This work builds on a previous design of couplings that combine blind assembly with elastic averaging and self-locking tapers in [2] with iterations that are designed for manufacturing. This work builds on analysis of elastic averaging couplings with different numbers of splines/connections in [1] and provides additional experimental data to verify these analytic predictions.

The first new coupling is a spline coupling (Figure 1) with radially tapered fingers that allows for radial adjustment compliance. This is an evolution of a coupling with diagonally tapered fingers, which are replaced with vertical fingers with radial thickness variation to allow for more rapid and simple manufacturing while theoretically providing similar stiffness and damping capabilities. The second coupling is a disk with 36 pin and slot holes (Figure 2) that are predicted to show improved alignment over a single pin and slot, while also allowing for greater dimension tolerance for each pin and slot feature.

FIGURE 1. Spline coupling with radially tapered fingers.

PROCEDURE

Three versions of the disk coupling will be built: the first on a HAAS mill for maximum precision, the second cut via water-jet, and the third laser-cut acrylic. Elastic averaging is achieved with slotted spring steel elastic



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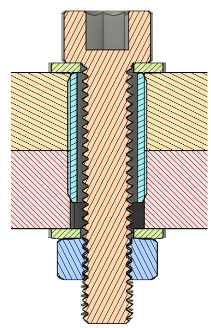

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FIGURE 2. a) Disk coupling model with 36 pin and slot holes, with elastically averaging inserts. b) Section view showing bolt, nut, washers, and elastic averaging insert (blue) that presses into the hole and slot.

average inserts (EA inserts), which are pressed into the holes and slots such that they 'fight' when the disks are connected. As described in Teo et. al., the standard deviation in displacement, ρ, varies with the number of elastic contacts n with the relation $\rho = 1/\sqrt{n}$ [1]. This work will verify experimentally the standard deviation with increasing number of elastic contacts for the couplings presented.

Deviation in alignment between the top and bottom plates in x, y, and Θ will be measured via CMM as shown in Figure 3, with the following testing procedure: a fixture is fastened to the CMM table. The two disks are bolted to the fixture via aligning holes (a). The CMM is programmed to get the center of the inner circle of the top and bottom plates (b), and the line of an aligning slot (c) for top and bottom plates. The distance between centerpoints in X and Y gives X and Y displacement, and the angle between the line (c) gives angular displacement. During testing, the plates are removed from the fixture, the appropriate number of EA inserts are pressed in with an arbor press or a hammer, and the plates are bolted into the fixture and the CMM program is run. Tests are repeated five times each for 4, 9, 16, 25, and 36 pin-slot connections for each version: Milled Steel, Water-Jet Steel, and Acrylic.

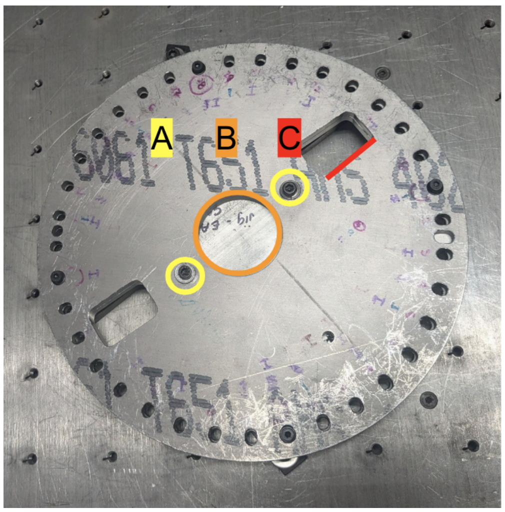

FIGURE 3. CMM measures displacement in X and Y between top and bottom plates by locating the centroid of inner circles. Slots in the plate show misalignment in Θ.

Further testing may include an additional water-jet coupling with purposeful misalignment errors. Additionally, the spline coupling will be iterated with varying numbers of elastic contacts, and testing will be performed to determine radial alignment.

RESULTS AND DISCUSSION

Preliminary results show agreement with the theoretical predictions $\rho = 1/\sqrt{n}$, and show that while greater precision can be achieved with the milled steel vs rapid fabricated versions, the rapid fabricated versions differ by less than 25 microns. Further testing and modelling will be conducted to verify these results.

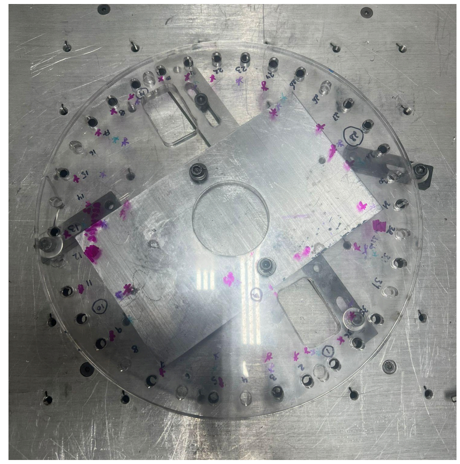

FIGURE 4. Clear acrylic plates mounted on the fixture in the CMM table show fixture position.

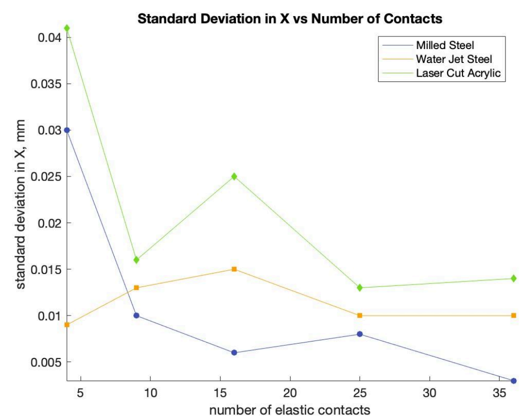

FIGURE 5. Std dev in X vs number of contacts.

This work will improve on existing data to verify the deviation of elastic averaging couplings as a function of number of elastic contacts, as well as introduce two simple couplings which can be fabricated rapidly and with loose tolerance and still achieve high precision comparable to parts made with conventional manufacturing processes.

REFERENCES

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