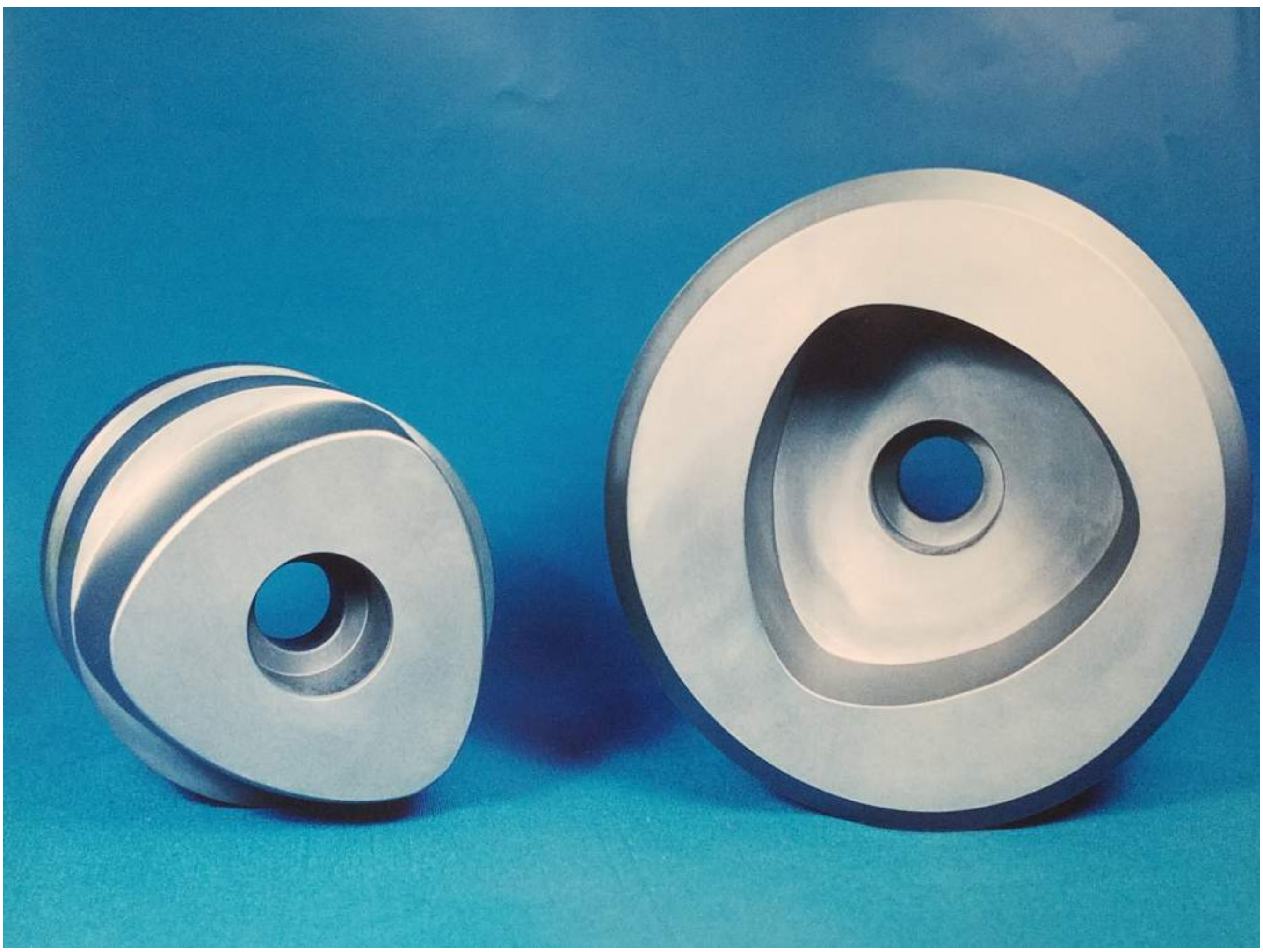
STOFFEL POLYGON SYSTEMS INC.

The Magic Polygon



Taper Polygon; Zero Backlash; Quick Disconnect Coupling

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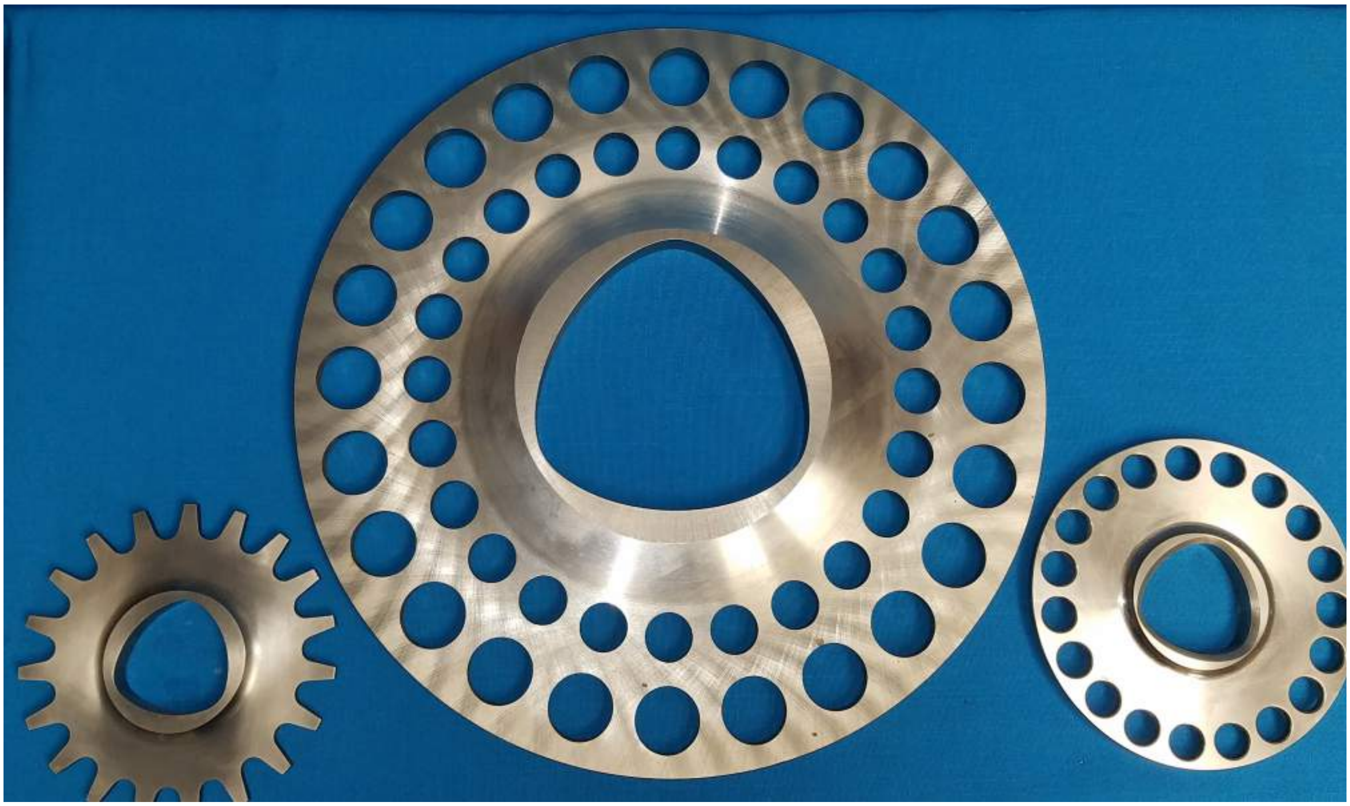
The Polygon profile is the greatest torque transmission shape ever devised...



Water Brakes

Our Polygon is not really a polygon, which is a straight sided shape, but the Germans called it that when the Polygon shape was first devised about 1950! Its smooth curves present lower stress risers than any other shape. The profile is actually a modified epicycloid, that is, the radius of curvature is constantly and continuously changing around the entire profile. The result is that the contact between the mail and female is not LINE contact (as in a square drive socket wrench), but conformal AREA contact. The contact patch is wider. This distributes the torque over a larger area, thus lowering the stress.

So Simple - It's Magic!

Pump Impeller

The result is that more torque can be transmitted in any given shaft diameter than with any other type of connection: splines, keys, interference fits, roller pins, square drives, hex shapes, and ANY other shape.

The familiar square drive used in socket wrenches provides a useful comparison. When the square drive transmits torque, the theoretical contact is line contact at the four (4) corners. This is theoretical because in actuality, the male and female deform slightly to form a contact patch that has a width instead of pure line contact, which has no width. However the width of the contact patch is small, but it depends on the characteristics of the materials involved.

Hardened steel components will have a much narrower contact width then soft steel or brass. It is easy to understand that the narrower the width of the contact area, the greater the stress (psi/sq in). This is true for pretty much all connection types: splines, keys, and even polygons. But the difference is that polygon contact is NOT line contact, but surface contact, because the male and female shapes are conformal.

Thus, when torque is applied, the male and female conform to each other and spread the load (force) over a greater area.

Feed Screw

Splines have a greater torque transmission capacity than keys (after all, a spline is really a bunch of keys) so let us examine this torque transmission mechanism more closely. For over 100 years, splines' torque transmission capacity has been calculated using only 25% of the teeth as transmitting elements. This type of calculation has proven itself ever since it was devised. The reason is that no matter how close the manufacturing tolerances, one could never count on all of the teeth transmitting equal amounts of torque. Some of the teeth transmit more torque than others. Those that transmit the most torque yield first, then the greatest torque moves to another tooth, and so on, until all the teeth have yielded and the spline fails. Even involute splines (much more expensive to machine) which in theory are self centering, exhibit the same behavior and are calculated using the same 25% of the number of teeth.

The Polygon, on the other hand, has three (3) contact patches (not lines). For any torque to be transmitted, all three patches have to be in contact with the mating female, but not just in contact, EQUAL contact, and the force transmitted is exactly equal on all three contact patches. So, the force is equally divided among three lobes! Numerous users of polygon shapes as torque transmitting elements have had to convince themselves of these properties, and have done Finite Element Analysis (FEA) on the connection, comparing the results to FEA's on splines. Universally, the result has been that the peak stress in the Polygon is about half as great as with a spline connection.

Thus in a given shaft diameter, nearly twice as much torque can be transmitted as with a spline machined into the same shaft diameter.

What does the above mean for torque transmission applications?

1. **If space or weight are issues, as they often are, a Polygon connection can be made smaller and lighter**: It may cost a bit more because it is a little more difficult to machine the polygon than keyways or splines, but if the extra cost of stronger housings to hold larger spline elements is considered, often the Polygon will be less expensive.

2. **Since the peak stress is half, it means that nearly twice as much torque can be transmitted in the same physical envelop!**

3. **Fatigue curves over the years have shown that when the peak stress is 50% lower, the fatigue life increases by an order of magnitude (10 times)**: Thus, when a spline connection is failing prematurely, (say in 5 years instead of 10 or 20), if it can be converted to a polygon, it will probably never fail. Practical examples of this can be provided.

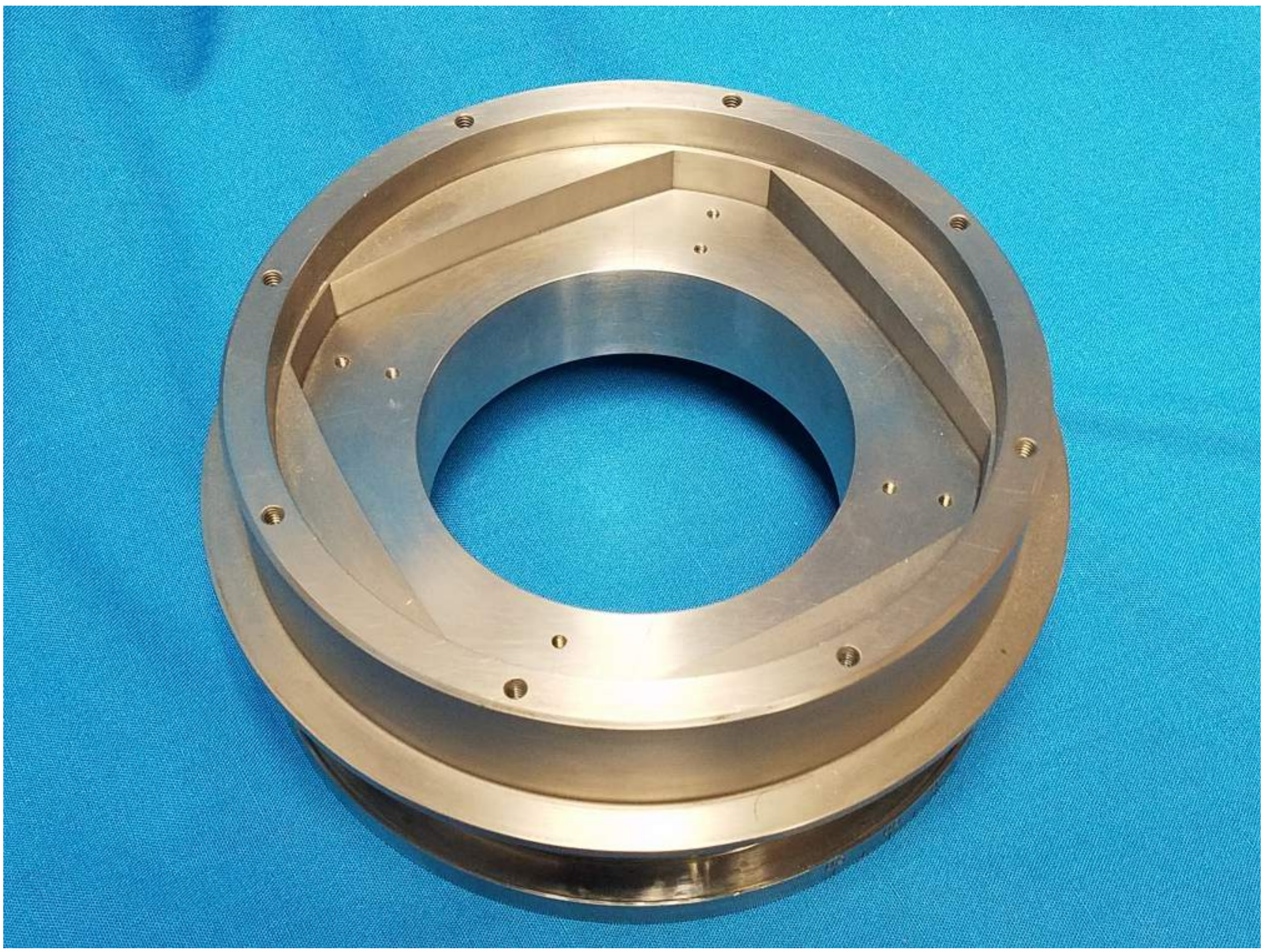
4. **The polygon male is self centering in the polygon female**: This is particularly valuable in rotating machinery: pumps, turbines, compressors, etc. If an impeller is mounted on a shaft in a cylindrical fit, and torque transmitted with keys or splines, at some point of the tolerance spectrum, or operating temperature gradient, the male-female fit might loosen slightly thus allowing the impeller and shaft axes no longer to coincide properly. This cannot happen with a polygon fit, even a loose fit will not misalign. This has practical applications. Many decades ago, Ingersoll Rand demonstrated this property to customers by disassembling the impellers from the shaft of a Centac compressor, then reassembling it (with lobes in the same positions as before disassembly), and showing customers that the assembly did not have to be rebalanced! This is simply impossible in any other kind of fit, even (or maybe especially) with an interference fit! What a huge benefit!

5. **Assembly of a polygon is easier than other connections**: There are no keys to lose or or drop into the units, or loosen over time. With proper design of the leads in the male and female, the Polygon can be assembled as easily as or more easily than a spline.

6. **Cleaning**: In some industries, especially food processing, elements have to be thoroughly cleaned to process different materials. The three (3) lobe Polygon has no tricky corners or recesses to trap materials so they are quick and easy to clean thoroughly.

7. **Zero Backlash**: A tapered three (3) lobe polygon provides absolutely ZERO backlash. The angle of the taper determines how easy the connection is to disassemble. For example, a taper of 2.4 in/ft is a borderline locking taper; any steeper and it is releasing and the connection has to be held together with axial forces; any less taper and it is a locking taper, the less the taper the better locking (and the more force to disconnect). Sankvik's Coromont Capto tool holding system is an excellent example of a solid locking taper at 1:20 or 0.6 in/ft.

8. **Sliding connection**: For minimal backlash in a sliding connection (a connection that can slide under load, like straight sided splines) a four (4) lobe polygon can be used. It has about the same torque transmission capability as a three (3) lobe, but will slide under load with backlash of as little as three arc seconds! It will take about double the force needed to slide a spline, but still slides reliably without binding.



Satellite Tracking System Acutator

With all the above advantages, it is amazing that Polygons are not more widely used in the United States. The reason is that there are no English language engineering or machine design textbooks (so far) that describe Polygons. German language texts have described Polygons since the 1960's, so, often North American use is the result of a German language educated engineer trying to solve a torque transmission problem. The only English language text describing polygons is the “Machinery's Handbook”, for the first time in the 23rd edition. Isn't it time for American engineers to adopt this ingenious technology?

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For Further Information or Quote Assistance Call either:
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