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Timing Pulley Drive Specialists
Manufacturing for 75 Years

SHAFT-SAVER™ White Paper

Summary
This whitepaper looks beyond just designing a drive system to include maintaining and repairing the system in the field. Simple design tweaks can drastically decrease customer repair costs over the life of a drive system and allow customers to maintain the 'like new' performance of drive systems even as they age. The most critical is the method of attachment of the pulley to it's shaft or point of rotation.

Drive Design Considerations
There are five main considerations that generally need to be reviewed when planning a fractional horsepower drive design system. These are:

- Operating environment
- Drive loading and speed
- Initial target cost to produce
- Repairability (or disposability) and life expectancy
- The real estate available in your product to fit the drive system into

Pulley Mounting Methods
A synchronous drive consists of a Driver or power source connected to a Driven device through shafting and/or belts. The goal is to transmit power while at the same time maintaining a desired timing or ratio between the Driver and the Driven devices. Doing this usually involves timing pulleys, toothed belts, shafts and/or other mounts to hold the pulleys, and possibly tensioners or idlers depending on loads and drive geometry. Belts are sized to match the distances between and the diameters of the pulleys, as well as meshing with their teeth. Pulley diameters are determined by the desired drive ratios and the space available for the drive system in the final product.

Timing pulleys are generally mounted using set screws or press fit onto shafts, with set screws being used heavily in smaller drives. They can also be drilled and pinned into place, welded, or mounted with anaerobic compounds (Loctite) to hold them in position. Of these, using setscrews is the most common since it is easiest to remove and replace compared to the other methods. Yet even setscrews cause problems for adjustments and repairs.

Setscrews work by pushing the pulley away from the shaft on the side where the setscrew is located. The threads of the setscrew in the pulley enable the setscrew to push against the shaft. It is actually the backside of the pulley that is pulled against the shaft. This and the setscrew tip itself pressing on the shaft provide the holding power for the pulley/shaft connection.

The problem is that the setscrew tip will deform the shaft surface to some degree. Even hardened and ground shafts will show indentations from setscrews. If the setscrew tip or cup point pushes up material from the shaft, which happens easily on cold rolled steel shafts, this material makes it harder to remove the pulley. And if alignment between the pulley and the shaft is critical, the ‘dent’ in the shaft from the setscrew makes it difficult to make small adjustments to pulley location or rotation since the setscrew can get ‘pulled’ back into the original dent that was made the first time the pulley was tightened. Both the original adjustment at the factory and any field repairs can be made more difficult by the presence of the dent from a standard setscrew.

There are ways to compensate for the ‘denting’ problem. You can use hardened and ground shafts, which won’t eliminate the problem, but their harder surface makes the resulting dent smaller. The hardness depth is usually stated as .040 minimum for shafts under 1 inch in diameter, although it can vary between different manufacturers. There is a cost penalty, but alignment and repair are made slightly easier. There are also special hubs that do not mark the shaft at all. These hubs have two machined slots and one screw that pulls the hub towards itself so that it ‘hugs’ the shaft. While the screw itself doesn’t touch the shaft, and therefor can’t mark it, the hub is larger and wider than standard timing pulley hubs and torqueing the screw is more critical since you are not only tightening the screw in its threads, but also bending the hub material to provide enough grip to hold the shaft and hub together. Tighter tolerances on the gap between the shaft and the timing pulley hub are required as a result. This approach is generally the more costly solution and torque values that differ from standard ones for setscrews must be communicated to users in the field.

Finally, there is a setscrew based solution that eliminates the ‘dent’ problem totally. A special copper alloy is used at the tip of the screw to contact the shaft. This copper deforms and expands around the setscrew point, acting as a barrier between the setscrew and the shaft. Yet the actual gripping force on the shaft by the pulley that is occurring on the opposite side is unaffected. So there is no ‘denting’ of the shaft at all. The only evidence left if you remove the timing pulley is a slight coppery circle about the size of the setscrew head. This is where some of the copper alloy will have ‘smeared’ into the pits in the shaft surface, leaving a copper reflection where this has occurred. Even a ground shaft will have some surface roughness, even if it’s been ground and polished. It is the depths in this surface roughness that the copper fills and is slightly visible on the shaft. The diameter of the shaft and smoothness are unaffected by the copper should the pulley be relocated or removed from the shaft.

The copper tipped setscrew has an added advantage in cases of high shock loads. The indentation of a set screw into the shaft provides a marginal addition amount of grip in case of a rotating force on the pulley that was strong enough to threaten the clamping action on the backside of the pulley/shaft connection. But if it spins, the tip of the standard setscrew will definitely mar the shaft. Tests have shown the total gripping strength is of the copper alloy tipped setscrew equal to that of a standard cup point setscrew and over 1.5X times higher than other specially modified hub solutions. The special alloy copper tip solution has a modestly higher cost than a standard pulley, but no drawbacks such as shaft damage or difficulty in repositioning.

Case Studies

Precision Gearing:
Precision equipment sometimes use gears to maintain alignment between multiple shafts. A manufacturer building equipment for the U.S. Navy had this situation. Small gears were used to set the ratios for different shafts. The challenge came in that some shafts had pointers for arrows used to provide information for the operator and the alignment specifications between multiple indicator arrows was very tight. The pointers could not be adjusted so instead, the gears would be realigned on the shafts to get within tolerance for the pointer. Drilled and pinned gears had been tried with no success since it was impossible to make very small alignment changes since the drilled holes prevented anything other than large adjustments since a new hole was required. Shafts had to be thrown out, new ones installed and redrilled and pinned to attempt to improve the alignment. Permission was received to try standard cup point set screws torqued to specific amounts to maintain firm grip between the gears and the

shafts. But the same problem with realigning the pointers was still present. The cup point set screws would displace metal on the shafts, forming kind of a crater with raised edges and a sunken pit. This was even though the shafts were hardened and ground. Realignment attempts required sanding the shafts to remove the raised edges from the setscrews but could not do anything about the crater. So realignment attempts were often thwarted by the new desired location being so close to the old one that the setscrew ended up going back into the original position unless the new spot was more than ½ a screw diameter away from the old spot, or the setscrew would just fall into the old hole when it was torqued. While an improvement over drilling and pinning, it did not solve all the realignment issues and rework was high as a result.

Finally, customer permission was given to use copper alloy tipped set screws after testing showed that their gripping power to the shaft was better than the gripping power of a cup point screw. Actual realignments done with the copper alloy tipped screws did not have problems with attempts being hampered by previous alignments, since the copper alloy tipped setscrews caused no shaft damage. A realignment was just as easy as the original alignment was. This approach obviously made field repairs or adjustments easier as well and provided a stronger connection between the shaft and the gear. The copper alloy tipped screws solved several problems and improved both producibility and repairability.

TIMING PULLEY FASTENER SELECTION GUIDE							
Fastening Method	A	B	C	D	E	F	G
York Shaft-Saver™	Y	Y	Y	Y	Y	Y	Y
Modified Hubs (Offset screws)	Y	Y	Y	n	Y	n	n
Clamps (Separate Components)	Y	n	n	Y	n	n	Y
Keys	n	n	n	n	n	Y	Y
Pins	n	n	n	n	Y	Y	Y
Cup Point Setscrews	n	Y	n	n	Y	Y	Y

- **Legend:**
- A - Shaft remains smooth and unmarked.
- B - Self-contained solution (no additional components needed).
- C - Part is fully supported on drive axis with no offset.
- D - Easy readjustment.
- E - Pinning is possible if needed.
- F - Resistant to dirt and debris.
- G - Holding power not overly sensitive to screw torque.

SHAFT-SAVER™ - GRIPPING TORQUE VALUES

Shaft Dia.	Material, steel	Screw size	Shaft/hub break-away torque (inch/lb)			
			Standard Allen Set Screw (1)		Shaft-Saver Set Screw (2)	
			1 scr.	2 scr.	1 scr.	2 scr.
.156	Hardened and ground	4-40	4		3	
.187	Hardened and ground	6-32	12		10	
.250	Hardened and ground	8-32	20	45	20	40
.312	Hardened and ground	8-32	32	42	30	52
.375	Hardened and ground	10-32	48	62	44	65
.250	Drill rod	8-32	25	45	32	40
.250	Cold rolled steel	8-32	20	35	12	22

1) Shafts sustained indentation damage from standard Allen set screws
2) Shaft-Saver shaft break-away torque exceeds the point where belt slippage occurs

	Screw size	Torque inch/lb
Test Condition: Maximum recommended screw torque in an aluminum hub per SAE recommendation, steel screw, Aluminum 2024 T4 hub, no lubrication	4-40	3
	6-32	6
	8-32	11
	10-32	20