Thoughts on Starter Drive Wear and Engagement

By John Jervelund

The relationship between the starter solenoid, shift lever, drive, and ring gear is both complex and simple. The simple part is that in response to the pull of the solenoid, the shift lever pivots on an axis, pushing the drive into engagement with the ring gear, the solenoid contacts close, and the starter starts to spin.

The complex part is that the timing of this sequence is absolutely critical. If the starter is spinning before the drive is fully engaged, or the retraction of the drive from the ring gear is delayed, both the drive and the ring gear will be damaged. The question is, what would cause either of these conditions to exist?

Solenoid-activated starters can be divided into two groups, fixed and adjustable timing. They share some things and are very different in others. Here are a few causes to think about.

Ring gear wear—While this cause gets a lot of play and blame, in actual fact, I don't think it is as big a factor as it's made out to be. If the ring gear were badly worn, it would be possible for the drive to skip on the edge of a tooth and increase its rpm substantially before contacting the next tooth. If this were the case, it would most likely be accompanied by quite a bit of noise—enough that the owner would be investigating.

The most probable result of this condition is a broken DE housing, similar to what Delco experienced with their Lester 6449 starter (although their problem was caused by a defective crank positioning sensor). Alternately, if there were a burr on the teeth, the drive might not be able to penetrate the ring gear, but more likely would be held by the spin of the ring gear, causing a delayed retraction.

Wear on or a twist in the spline that the drive rides on, could cause the drive to be delayed engaging the ring gear, or retarded on release, as could a sticky material on that spline. The wear or twist would have to be fairly slight or the drive would hang up completely, either engaged or disengaged. If the problem was a sticky material on the shaft, it would most likely occur more often in cold weather.

A bent shift lever will take the starter out of time the instant it happens. It is worth comparing the lever you want to salvage with a new one, to be sure it isn't bent. It is also worth marking each lever as to which side was in or out and marking all of them in the same fashion. This will enable you to spot a reversed lever and possibly a bent one.

Some shift levers are made from a bent piece of steel shaped like a "U." It is important to know which way the "U" faces—toward or away from the solenoid. On some of the Denso/Deere direct drive starters, if the lever is reversed, the starter will work as long as the engine starts! Should the engine fail to start, the solenoid will not disengage and will keep the engine cranking until the cables are taken off or the batteries go flat. In either case, the starter will be destroyed. On the Denso/Deere starters, the flat of the "U" must face toward the solenoid.

Shift lever wear—On fixed timing starters, the shift lever is the timing mechanism. If there is wear on the buttons, the drive will not be pushed forward properly and the solenoid contacts can close before the drive is properly positioned in the ring gear. Wear can occur on both sides of the buttons, but the most wear usually occurs on the side that is against the drive while it is being pulled out of engagement. This is because the drive collar is up against the buttons in a metal to metal contact for the time it takes the armature to stop spinning.

This makes a case for changing the brake washer every time, instead of trying to salvage it. If the drive is spinning for 1/10th second longer than it is supposed to, it will rotate an extra 60 times. I have been told that the pinion on a Delco starter is spinning at between 30,000 and 35,000 rpm just after the key is released.

Wear on the retracting side should cause prolonged engagement, not premature spinning. But when someone has removed the lever and re-installed it backwards the effect is opposite. Even if the lever is re-installed the same way it came out, with worn buttons the drive will remain engaged for longer than what was intended and the clutches will be worn prematurely (see previous paragraph). The wear on a shift lever button should never exceed 10 percent on the pull-out side. I don't think anyone has established a wear maximum for the push-in side; if they had, it would be much less than 10 percent.

Timing on the adjustable style of starter is, in some ways, even more problematic. Some starter manufacturers use shims, some an eccentric pivot pin, and others an adjustable rod on the plunger assembly. However it is done, it is exact, not something to be guessed at. On Delco heavy duty starters, the timing is not exact, only + or - 1/32 inch (.031 inch). In Lucas starters it is measured in thousandths of an inch.

Mitsubishi uses shims, although I don't think anyone knows what the specification is, and Mitsubishi won't tell us. Each new Mitsubishi solenoid comes with four shims, two of paper, that together equal the thinnest metal shim, and when that shim and the paper ones are put together they equal the thickest metal shim.

How to use them is a real mystery, but if someone has a definitive answer I would like to know what it is. I have heard: "use all," "use none," "use only one" (but not which one), and if the "use one" was correct, why give you four? The result is that I, like everyone else, have a whole toolbox full of useless shims.

Lucas Industries uses an eccentric pivot on their heavy starters. Again, I don't know what the exact spec is, but it is a pain to adjust it to what you think is correct, then have it move when you tighten the locking nut.

I set mine so that when free spinning with the drive fully extended, the outermost part of the drive comes within .020 inch of the stop collar. Right or wrong I don't know, but would love to learn.

Delco, Leece-Neville, and Prestolite heavy duty starters use an adjustable plunger to time the drive. Ultimately, Leece-Neville had so many problems with the timing of their drive, and people not doing it, that they went to a fixed link solenoid where there was no adjust-

ment. All you had to worry about was that the lever wasn't worn or bent.

On Delco 37, 40, 42, and 50 MT starters, there is an adjuster plug on the DE side of the center housing. By removing the plug, it is possible to adjust the "throw of the drive," but how much and how to do it? Suffice to say, that you don't use an air impact gun!

If you put power to the switch terminal, but not the main battery terminal, the solenoid will engage and hold the plunger so that it can be adjusted by hand. On a 12 volt starter, DO NOT use a 12 volt source. You are energizing both coils and since a 12 volt HD solenoid can draw 90 amps, this will cause overheating very rapidly. For 12 volt solenoids, use 6 volts and then only for about 15 seconds at a time with a break in between. For 24 volts use 12 volts and so on.

With the solenoid engaged, measure the distance between the inside of the DE housing and the lead edge of the pinion teeth. Delco 40, 42, and 50 MT starters all use the same timing; 23/64 inch (19.3mm), + or - 1/32 inch (.79mm). The 37 MT uses a different specification of; 1.78mm, + or - .25mm, for both the 200 and 300 series.

In my opinion, improper "drive timing," is the root cause of most drive/solenoid problems and failures, particularly in heavy duty starters.

A sticking ignition switch, that either doesn't supply enough current to fully pull in the plunger, or alternately fails to disconnect sharply to stop the flow of current, will produce these results. The problem of delayed release can also be caused by low voltage, which causes an increase in amperage, resulting in an increased temperature and a slight melting of the contacts, permitting them to stick together.

There has been a problem with the Ford PMGR starters (mostly in retro-fit applications) when people install a jumper strap between the switch terminal and the B+, and then control the B+ through a start relay.

Since the PMGR is a permanent magnet starter, it produces power during the time the armature spins, after the start sequence is complete. Once the key is released, with a jumper installed, this current can back feed through the "hold-in" winding, delaying the release of the drive.

Ford used this setup with the older 460cid engines, but that starter used wire wound fields, so the problem didn't exist.

The pinion, on a drive, must move backwards on its own shaft to allow for what is called "indexing" (the mesh between the teeth of the pinion and the ring gear). If the pinion can't move, there is a high probability of "tooth abutment" and the drive will either not be able to enter the ring gear, or the solenoid contacts will close and the drive will be doing high rpm when it does mesh. Generally, if the pinion doesn't move, the drive is defective. You would be best to check for this during installation rather than when it becomes a problem.

Another check that needs to be done during installation, is that the *plunger assembly moves smoothly through the whole length* of the solenoid bore, and doesn't have excess sideways movement. (If the plunger sticks or is too sloppy, see previous paragraph.)

Many people keep every key they own or can find on the same ring. Problems with the ignition switch can sometimes be traced to the weight of all these keys bouncing in the switch as the vehicle travels down the road, causing premature wear in the switch. I know of one instance where the wear was sufficient to cause the starter to engage while the truck was traveling down the road at 60 mph! That was an $8,000 adventure.

There is a style of drives called the *"Barrel" or "Flo-thru" drive.* On this older style of drive, the pinion actually sits still and is screwed into mesh by the rotation of the armature. The armature spins about 11/2 revolutions to get the drive into mesh. The problem occurs when people use a 6 volt starter in a 12 volt application. At 6 volts the armature moves at a specific speed, but at 12 volts, it moves twice as fast, which will damage the "rebound" spring and/or the ring gear.

This is not a complete list of what can cause these problems (don't have time or space), but rather the ones that came to mind when I was asked to do this article. I do consulting work for a drive/solenoid manufacturer, and their quality control department tells me that they can find nothing wrong with more than 95 percent of pieces returned as "defective."

The fact that changing the drive or solenoid solved the problem, doesn't mean that the piece was defective. It could also mean that in changing it, you improved the ground, cleaned a connection, or removed an interference in the mechanical operation. It is my belief that making the timing right will avoid more than 50 percent of the come back problems. It's about timing, timing and timing.

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