Torsional Dampers
Not Harmonic Balancers

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Fallacies

The term harmonic balancer is used often to describe a torsional damper. The truth is, it has nothing to do with primary or secondary balance of the rotating assembly. Some engines like the 400 Chevy are externally balanced and do have a counterweighted damper (and flywheel), but this weight has nothing to do with the primary function of the damper, it is nothing more than a convenient place to add needed weight to balance the assembly.

A second myth is that running an aluminum hub in place of a damper will make the engine rev quicker from a reduction in rotating weight. This may be true to a point, but the reduction of torsional vibration far overshadows the extra weight. It has been dyno proven time and time again that engines make more power with a good damper. In the case with stock type dampers, the biggest and heaviest dampers usually make more power than the lighter ones. Why? They can dampen more. The aftermarket has developed many different types that can do just as well or better as well as reduce weight, which is even better.

Some say that a damper is not needed if the engine is balanced well, which is total nonsense. As I said above, it has nothing to do with the balance of the rotating assembly. Others say that as long as the valvetrain is well matched, a damper isn't needed. That is also false, but they are thinking a bit more on it and there is a point to be made there. The valvetrain harmonics have a lot to do with it, but I'll get into that later.

Torsional Vibrations

No matter how well a rotating assembly is balanced there will be torsional vibrations. It is not possible to counter act a torsional vibration through primary or secondary balance. Torsional vibrations must be dampened with an opposing force to resist them. Since torsional vibrations are rotational, more or less counterweight cannot help.

So what exactly are the cause torsional vibrations? During each power stroke the cylinder pressure applies a large load on the rod journal. This load flexes the crank in the direction of rotation (that journal speeds up in relation to the rest of the crank). Once it flexes, it is followed by a rebound in the opposite direction (the journal slows down in relation to the rest of the crank). This rebound resists crankshaft rotation. This happens with every cylinder fire. The crankshaft actually vibrates by the rod throws speeding up and slowing down rapidly. Crankshaft rotation at a steady rpm is anything but steady; the crankshaft is rapidly changing speed. Very minute changes, but changes nonetheless.

The frequency of these vibrations is determined by the power strokes of the engine. At some point, higher in the rpm range, the frequency of the power strokes will match the crankshafts natural resonate frequency. This is when the vibrations skyrocket and can kill a crank in short order. Just like when you tune a guitar, if the frequency is right, it will vibrate the tuning fork. The impulses on the crank will do the same thing to the crank when the frequencies match. This is a very bad situation to get in.

The natural resonate frequency of a crank depends on many factors. They are all broken down to stiffness and mass. The larger the mass, the lower its resonate frequency will be and the stiffer the material the higher it will be. Anything you do to the crank or anything that you bolt to it will change these 2 things.

A flywheel and the damper itself add mass to the crank. If you've done any lightening, you've reduced mass and changed the resonate frequency. The material the crank is made from has an effect as well. A cast crank is not able to sustain as much torsional vibration as a steel crank, but that does not make a damper any less important, it also takes less vibrations to fatigue a cast crank. Crank treatments also change the resonate frequency.

With all the things that can effect the resonate frequency of a crankshaft, you should be able to see that a crankshaft that works over a relatively wide rpm range is important. Most stock dampers work well over a wide rpm range, however, they do have a limit. If you build an engine that will rev out of this range, you risk excessive torsional vibrations that could rob power and cause premature crank failure.

Fatigue

When a crankshaft flexes, it fatigues. You can only bend metal so many times before it work hardens and cracks or breaks. This applies to crankshafts as well. Torsional vibrations will fatigue a crank, which will reduce its life. Years ago, it was popular among the circle track crowd to run a lightweight aluminum hub in place of a damper. This came about by several failures of stock dampers, which were not built for high rpm use. Rules then outlawed stock dampers in several race classes. Racers figured that a lightweight hub is a cheap alternative to an aftermarket SFI approved damper; they also assumed that a lighter hub would allow the engine to rev faster. After a huge increase in crankshaft failures, they realized the importance of dampening torsional vibrations.

The bending loads on the crank are more than most would think. Without a damper, an average small-block in the 500-5500 rpm range can actually see over 1 degree of deflection (more than 1/2 degree in each direction). If the crank has a 3.5" stroke, the rod centerline rotates in a circle with a 3.5" diameter, or moves a total of 9.62" per revolution. Divide that by 360 degrees and the crank is deflecting a little under 0.030", which is a lot for something as ridged as a crankshaft. It does not take long for that kind of vibration to destroy a crankshaft, especially if the vibrations match the crank resonate frequency.

Valvetrain Harmonics

The crankshaft drives the camshaft though a chain, belt or gear(s). Any torsional vibrations at the crank will naturally be transmitted to the cam. These vibrations can and do cost power. If they are not controlled, they can cause spring surge and early valve float.

Valve spring selection is very important, but even carefully selected springs can loose control of the valvetrain do to torsional vibrations. You can run a flat wound damper in the springs or use various type of springs that have variable resonate frequencies to limit the effects of vibrations, like barrel wound springs. There are many ways to dampen valvetrain harmonics at the spring, and most do a good job, but limiting them at the crank is much better.

Gear drives are by far the worse as far as transferring vibrations. I should actually say that they are the best, since just about every bit of vibration is transferred through them and some cheap (or just poorly designed) ones can even create more vibrations. When using gear drives the importance of a good torsional damper is even greater. A stock timing chain or aftermarket roller chain is a better choice in most cases than a gear drive.

A belt drive does a pretty good job of limiting the vibration that is transferred to the cam at higher rpm, but offers little advantage in the lower rpm range.

How Dampers Work

Most dampers work on a simple principal, friction. Just about all stock type dampers that I have seen are the elastomer type, the exception to this is some diesel applications that use viscous type dampers. With the elastomer type, an outer inertia ring is bonded to the inner hub on with rubber like material. The inertia of the outer ring resists changes is speed (torsional vibrations). So you have the center hub wanting to vibrate with the crank and the outer hub resisting. The high internal friction of the rubber is what dampens these motions by turning them into heat.

Elastomer balancers can and do work well, however, they are limited to certain frequency range. This range depends on the weight of the inertia ring and the stiffness of the rubber. Most stock balancers are not good for a higher revving performance engine.

When it comes to a stock damper, every test I have seen shows that bigger is better. The big ones used on the stock 302 Chevy engines show power improvements over the lighter ones used on other engines even though they are heavier and may take more power to spin. This power gain is from a reduction of vibration to the valvetrain. A stable valvetrain will make more power. The bigger is better thinking isn't true with aftermarket dampers, but I am a firm believer of it when it comes to stock parts.

Viscous dampers are another type, which also rely on friction to do the dampening. With these dampers, the outer hub is a sealed case. There is an inertia ring inside this case with very close tolerances to the outer case. This inertia ring is not attached to the outer case. The only thing that resists the inertia ring from spinning freely is a high viscosity fluid that completely fills all space around it.

Viscous dampers work over a larger rpm range that elastomer types, making them more desirable for custom engines that use different rotating assemblies or rev out of the rpm range of a stock engine.

There have been a few other styles of dampers that use friction, but the Viscous and elastomer cover most of the market today. I've seen ones that have a small clutch in them that slips to absorb vibrations. With these, I'd worry about wear, when a clutch slips, it wears, so as the damper gets miles on it, would the rpm range or effectiveness change as well? I don't know, they are not very popular, so information is scarce.

I have no experience with pendulum type vibration absorbers, the TCI "Rattler" being one of these. I've seen tests that show good and bad, but no solid evidence toward either. These were originally designed for use on aircrafts. Aircrafts that were generally used at low and over a narrow rpm range, so that might tell us something. These don't rely on friction but an actual counter force. In theory, the design looks very sound, but I do have any results from an automotive application as of yet. For a low rpm street engine, they look to be an advantage, but I question their ability at high rpm. I'd like to see some back-to-back testing against other types. I cannot say anything bad about them, but I cannot say anything good either.

Damper Installation

Do not beat press on dampers on with a big hammer and in no instance try to pull them on with the mounting bolt. Tools for this are cheap, can be made or rented. A good tool is about $20-25 and is very simple. A basic tool screws completely into the crank threads, and then a nut with a thrust bearing is used to press the damper on. This keeps you from stripping out the threads in the crank.

You can also boil a damper is water for about 30 minutes and they usually slide right on, it's just a little harder handling a hot damper. Whatever way you decide to use, please leave the hammer in the toolbox for this job. I have seen many auto parts stores offer free tool rental or just $5-6 per day, so there is no reason not to do the job right.

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