TORQUE PLATES

Are they worth the cost and STRESS?

BY **CHUCK LYNCH**

As I have cruised the web, listened to podcasts, watched videos, and have been entertained or horrified by discussion on social media, I have come to realize that the subject of torque plate application is greatly misunderstood. Sometimes, we "old salts" think that old subjects are just old subjects; but as new machinists enter the industry, we often forget how much content there is to learn… and apply. NOT ONE of US starts out with the relevant knowledge, nor have practical hands-on proficiency. Yet today, after being in the industry for over 30 years, I still learn something new every day. Often times, the new thing I learn pertains to old products and methods. In this article, I will identify several points to consider when using torque plates for any application, no matter the design or age.

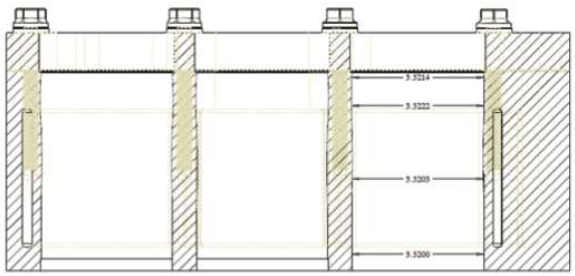
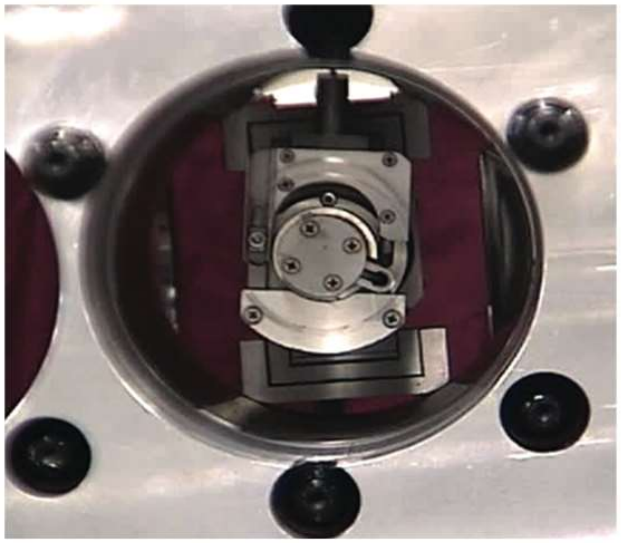


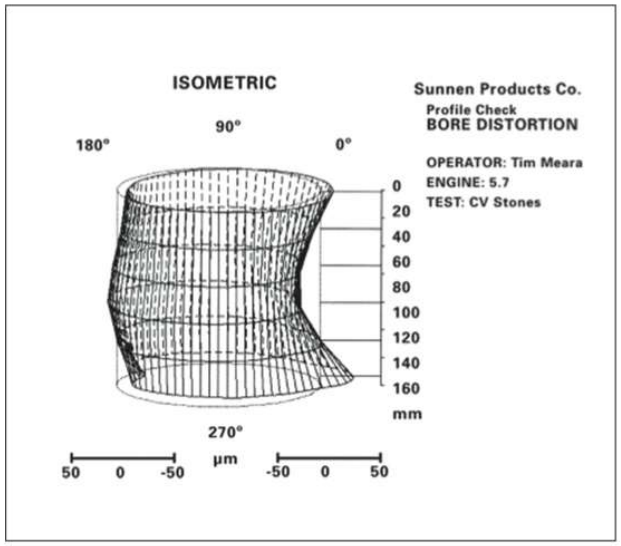
Figure 1. Fastener load crushing the can effect; courtesy Russ Hayes and Jasper Engines.

When do I use a torque plate?

I will preface this by stating that every block has opportunity for improvement, but there are applications that are less of a concern. That said, if the bolt holes are structurally engaged into the deck/gasket surface of the block, the upper cylinder distortion is going to be far more distinguishable and impactful on performance. I state "distinguishable" because even a dial bore gauge does a good job of giving you the visual of "out of round" or "poor circularity" condition that is created when the clamp force of the fastener reacts against the gasket and stresses the casting. This is greatly impacted by the fulcrum point, which is the combustion opening of the head gasket. Depending on the gasket design, this fulcrum impact can vary greatly. More on that later.

Most modern blocks have very long cylinder head fasteners that engage in the lower cylinder area or into the crank housing bore area, but there is still going to be bore distortion. Although it is much reduced, there is still bore distortion that may or may not be distinguishable with a dial bore gauge. What a dial bore gauge will not show you is cylindricity – for example, when a bore is banana-shaped, lobed, accordion-shaped or a combination of the aforementioned.





Figures 2 and 3. Incometer; courtesy Sunnen Products.

Why is that? With many thousands of pounds of clamp force (10-15,000 psi is common with current design head bolts) it is reasonable to ascertain that distortion of the cylinder bore is going to exist. The cylinder bore has design features that make it a terrible example of column strength. Cylinder bores typically have reduced wall thickness between cylinders to allow coolant flow. They have a thinner wall on the minor thrust axis for weight reduction and thicker/heavier walls on the major thrust axis to support the load applied during the combustion cycle. These bore construction challenges have driven the evolution of honing which is driven by proper measurement and knowing the shortcomings of process. The Incometer or PAT Gauge is one method that utilizes a fixed shaft that the measuring head travel around. The scanning head CMM does helical bore traces around a projected centerline. Both are providing data points that help us better determine the overall geometries of a cylinder.

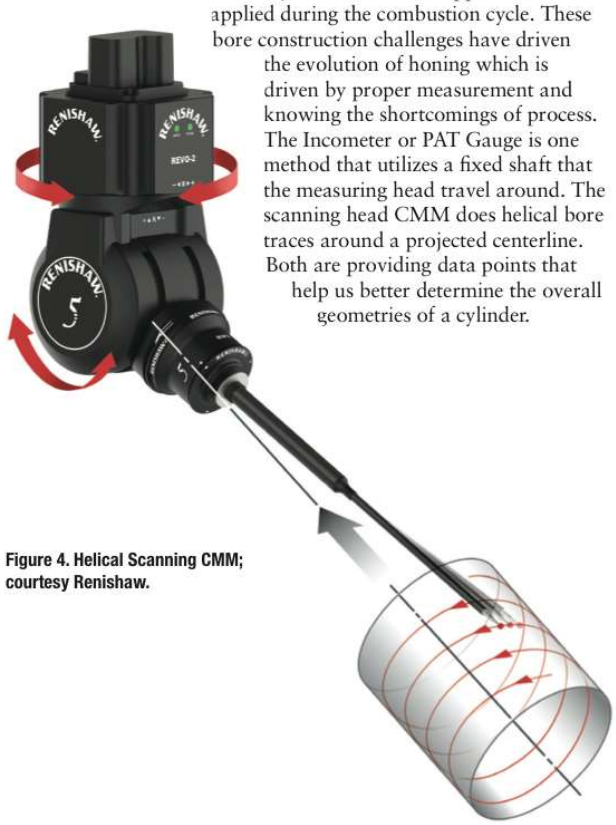


Figure 4. Helical Scanning CMM; courtesy Renishaw.

Gasket Design

Is the head gasket required when torque plate honing? If you are not going to use a gasket — the correct gasket — do not waste your time with a torque plate. The combustion opening seal of a head gasket is the area that generates the highest level of stress and impact on the bore, and that is by design to maintain combustion seal. The design of head gaskets can vary immensely from a single vendor — for example, performance applications, marine or stock replacements. Now, couple that with the variation of design from vendor to vendor and their take on the needs of a particular application. Some of the variables are very noticeable and some are not. You are definitely going to see a difference between an MLS and non-MLS but are you going to see the difference in design intent between graphite gaskets, paper clay composition, plate gaskets or MLS?

Here is a list of head gasket design criteria that will impact the reaction of the torque plate and the head and block castings when assembled.

- Combustion opening of the gasket material (may be referred to as armor, C.O. flange, fire ring)
- Flange over body height when compressed
- Flange material/chemistry (for example: 304 stainless)
- Is the flange floating? Some are retained with grommets
- Is there a wire ring inside the flange? Common in performance applications and diesel.
- Graphite density
- Perforated core or solid core
- Paper/clay composition – some are fiber reinforced and the fiber varies greatly in volume and material. Kevlar was/is a common fiber choice.
- MLS gasket material/steel alloy
- MLS layer count
- MLS embossment height and design
- With or without stopper
- Stopper design

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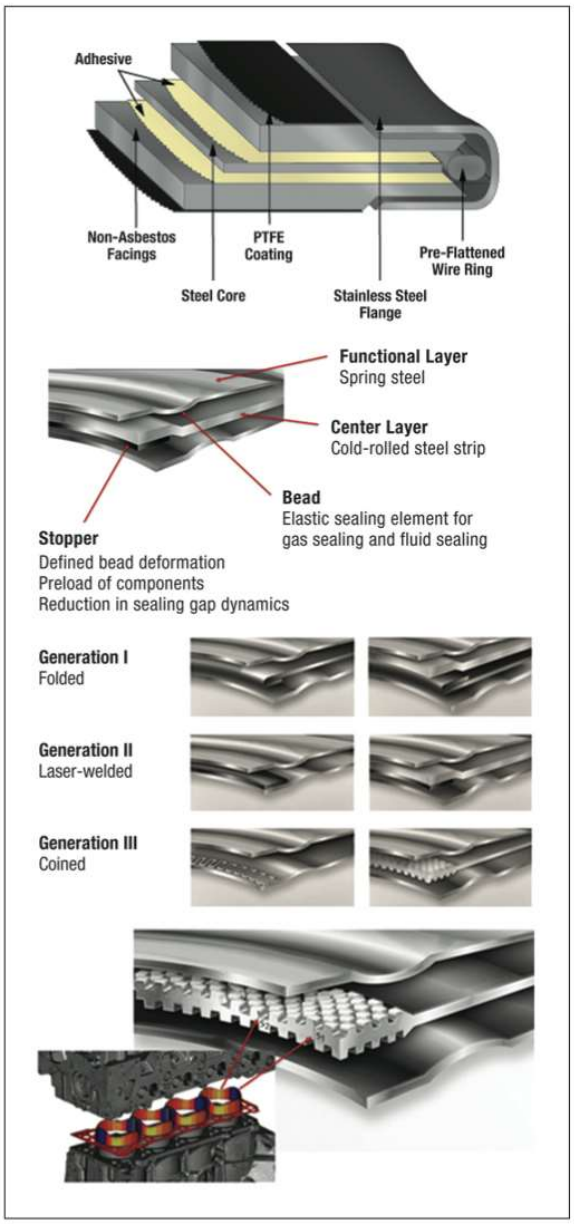

Figure 5. ElringKlinger patented design and developed stoppers; courtesy ElringKlinger.

Fasteners

One major challenge when trying to develop a process for torque plate honing an engine family is finding fasteners. The fastener should match the tensile strength, thread engagement and the under-head friction that is produced during the actual engine assembly to yield the most repeatable results.

Another related challenge is threaded holes in the casting are constantly being conditioned; good or bad, or good too bad by the process of running fasteners in and out. The threads of the fastener and the threads of the casting will exhibit changes in surface finish, hardening and fitment between the fastener

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Figure 6. Courtesy Dimas Lourenco, Atomic Engine and Machine.

and receiving threads. This is exacerbated by high stresses of clamp force applied to both the head bolt threads and the block threads.

Lubrication

When you are assembling the engine, you consider lubrication choices. Likewise, you must consider lubrication material/chemistry and application of lubrication for machining. This is sometimes unpopular for reasons of cost and clean up. If the material that you are using during machining has a different coefficient of friction than assembling, you are going to have undesired variation in results of bore geometry. This can also affect other machining processes as well such as connecting rods and main housing bores.

The Plate

In a perfect world we would install the head, the head gasket, and fasteners that we are building with during the honing process to achieve the true stresses and distortion, but we cannot do that. The fact that we need to have a big hole to allow installation of the hone head provides challenges in creating stresses that are exhibited when the engine is assembled. What does that mean? It means that we have to take a lot of measurements, document your results, and be prepared for frustration. The amount of variability in the process can test your resolve; therefore, you must document, document and document.

The torque plate does have to meet certain parameters to be effective in replicating the stresses of the assembled engine.

- Most importantly, the combustion opening of the gasket must not hang into the bore opening of the plate. If the flange or combustion opening embossments of the gasket are not loaded by the plate, the stresses will be incorrect or non-existent.
- The plate or block must have positive location for the gasket, such as the dowels. The gasket cannot be allowed to float around or there will be no repeatability or reproducibility in the process.

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• The plate must be large enough to cover areas of high stress like pressurized oil passage grommets of embossments, fuel passages, etc.

The Block

Although more current block architectures have seemingly been designed with upper bore distortion in mind, there are other areas that are impactful of the bore that must be recognized. Many blocks are split through the crank housing bore as a sub-section of the block. These main bearing assemblies should be installed and properly tightened to create the relevant lower cylinder area distortion. Many automotive main bolts apply 4000-6000 psi of clamp force and much higher for the diesel segment. As stated earlier regarding the head gasket, if you plan to hone without the main bolts, do not waste your time with the torque plate. It is these areas that have the highest amount of clamp force that are going to yield the highest level of distortion. Many modern V-style blocks should really have plates installed on both banks while honing because of the concentration of stresses impacts the whole block.

Getting Started

This part can be costly but necessary if you have decided that the risk versus reward of buying the plate is justifiable. You will possibly ruin a block learning what you need to know to create a process. This is a process that can and likely will vary from one engine family to the next.

Hopefully, if you have decided to purchase the torque plate, you have acquired fasteners that meet the desired tensile strength and thread engagement. Many people make spacers to use OE fasteners. Keep in mind, the more spacers and shims you use increases the variability and that diminishes repeatability.

1. Bore and hone a block without torque plate as a baseline. Hone the bore as round as possible and record results. This is mapping your bore.

2. Install the head with gasket and take the same measurements and record. Remove the head.

3. Install the torque plate and torque to the specified torque. Follow the same measurement protocol as the prior steps and record the actual finding.

4. This is where you will adjust. (I recommend a dial torque wrench with a tattle tale indicator so that you can capture the highest observed torque. An electronic wrench could record as well.) Loosen the fasteners and then re-tighten to 75% of the specified torque. Gauge the bore to determine

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if you are seeing distortion differences compared to no plate on the first round of measurements. (IMPORTANT: You cannot rush the process, or you may overshoot the point at where the distortion was comparable to the head being installed.)

5. You may find that you do not tighten all fasteners to the same value. That is fine and quite probable. The reality is that you are trying to emulate the installation of the head.

Results

You ARE going to have some variation with cylinder bore honing. As alluded to many times, the goal is to reduce the magnitude of the variables. A repeatable and reproducible process is the goal, so documentation is key as each block family will likely have its own process.

Like most things in life, there are variables or challenges that make us deviate from walking the straight line. Torque plate honing is definitely not going to be a straight line but, in the end, there will be an improvement in the quality of the bore. Aim big, miss big…aim small, miss small.■

Chuck Lynch, AERA Director of Technical Services
815-305-6367
chuck@aera.org