THE PIN-NACLE OF PERFORMANCE

Piston Pin Theory, Design And Proper Application

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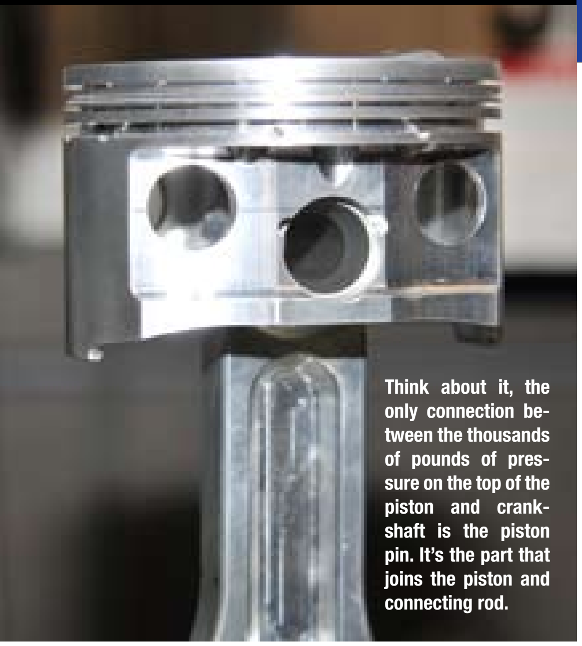
Think about it, the only connection between the thousands of pounds of pressure on the top of the piston and crankshaft is the piston pin. It's the part that joins the piston and connecting rod.

If an engine has a crankshaft it uses a piston pin (or wrist pin) to attach the piston to the connecting rod. Yet this critical component has enjoyed little discussion in print or as the focus of bench racing sessions. Even the most cutting-edge teams and engine builders look at the piston pin with not much more scrutiny than they would a pair of laces when purchasing new shoes. I have never had anyone tell me that they chose a pair of shoes because of the laces.

To further compound this effect, most piston companies supply piston pins with their product, so other than a few decisions or recommendations from the technical line not much thought is dedicated to the pins.

The piston pin is the vital mechanical link that hinges the piston to the connecting rod. Though it is deceptively simple in appearance and has no moving parts, it must be recognized as a precision-engineered component. This is because it has to satisfy several conflicting requirements; it must combine strength with lightness, be close fitting but with freedom to move and resist wear without scuffing.

If you apply a logical thought process to the building of a race engine then reason would demand that you would have to scrutinize and carefully select the piston pins. That is why this primer will introduce a process that is not commonly exercised: choosing the piston pins independent of the piston manufac-

Different styles of piston pins are manufactured from various materials to suit a variety of applications. Using the correct one is a must for engine longevity.

A full-floating piston pin can be held in the piston by a number of methods. From left to right is a single spiral lock, a thicker spiral lock, a wire clip and, finally, buttons made from aluminum that simply ride against the cylinder wall and don't allow the pin to walk out of the piston.

turer. If you optimize the piston design why not do the same with the pin? This ideology may be to the chagrin of the piston companies, but most race engines already have an array of components from different manufacturers, applying the best technology for the application.

Our quest to fully understand the piston pin brought us to the state-of-the-art manufacturing plant of Trend Performance Products. The company produces a wide collection of piston pin styles, designs and materials along with application-specific coatings. Trend is not in the piston business but is a company that designs, engineers and produces piston pins, pushrods, and tool-steel solid flat tappets. Piston pins are a good part of their existence. Thus, if you really want to learn about the simple looking piston pin there is no better place to go.

Let's start with this: The piston pin is hollow and typically produced from fine grain carbon steel with a controlled hardness. It is then lapped to a mirror finish. The diameter of the pin may be as much as 40 percent of the piston diameter (on some engines) so that maximum bearing pressure in the piston bosses can be controlled. On a mild performance engine the thermal pressure reaches 600psi or higher. On a four-inch diameter piston that figure may be higher than 8,500 lbs – or over four tons of load on the pin! Under load its shape and longitudinal bending are not expected to exceed 0.001 inch and 0.003 inch, respectively.

The pin must be fastened to the piston so that it stays centered. If this were not done it would move and gouge the cylinder wall. There are four methods that are used to fit the pin to the piston through the small end of the connecting rod, although in the case of most automotive engines, there really are only two methods used.

The first is a pressed pin, whereby the pin is pressed into the rod and oscillating only in the piston bosses. This method is used in the majority of stock engines. In this design the pin is press-fit through the small-end bore of the connecting rod with a 0.0008-inch to 0.0012-inch interference. This means the hole in the rod is smaller in diameter than the outside diameter of the piston pin. The pin usually has a 0.0003- to 0.0005-inch clearance fit in the piston bosses.

The second and most popularly used in race engines is fully floating. This design allows free pin rotation in the eye of the connecting rod and in both bosses of the piston. A lock ring is installed at the end of each piston boss to retain the pin and hold it centered.

The other two methods are a clamp and set screw, but both are usually not utilized in any style of automotive engines.

Today, piston pins are manufactured using sophisticated CNC equipment, which can hold tolerances to extremely small numbers. After manufacture, the pin surface is lapped to a mirror finish to alleviate stress risers. In some cases, a coating is also applied to the surface.

Inserting a piston pin into a piston might seem like an easy task, but the tolerances must be held tight in order to eliminate the piston wobbling on the pin, yet not so tight as to cause galling and seizure.

Honing the piston pin bore allows for the proper clearance.

A tapered piston pin is one where the inside diameter is tapered to place the majority of the metal where it will do the most good, in the middle of the pin. This allows for a relatively lightweight pin, which can withstand the pressure.

In most cases, an uncoated pin is utilized inside a piston that has had its skirt coated for reduced friction and oil-clinging.

Coated piston pins are now becoming vital to enhance the metallurgical properties of the material used.

As it can be understood, the tolerance for the piston pin is extremely tight and very critical to the life of the engine. The quality of manufacture and materials is imperative to maintaining the tolerance under severe cylinder pressure load and thermal stress.

What most do not acknowledge are the expansion and contraction rates of a wrist pin, which is a function of its metallurgy and manufacturing process. A general rule in the industry is: A one-inch diameter steel piston pin will expand 0.0003 inch for every 50 degrees F increase in temperature, while the pin hole in most aluminum pistons will expand 0.0006 inch for every 50 degrees F increase in temperature.

Under certain engine conditions the pin temperature can be much higher than the bosses in the piston, and when this occurs the oil clearance is reduced. If the pin fit becomes too tight a seizure will occur.

A press fit pin will sometimes seize after a prolonged heavy load. During the extreme conditions the engine is generating extra heat. The crankshaft soaks up this heat. When the load is released, for example, by letting off the throttle, the piston pin bores cool rapidly and shrink. However, the heat that has been stored in the crankshaft continues to travel up the connecting rod directly into the pin. This prevents the pin from cooling and shrinking in size. As a result, pin clearance becomes tight and a seizure occurs.

Fully floating pins are not as susceptible to this condition and therefore required on high-performance engines, even ones that are not used for racing but will endure a sustained thermal load such as tow vehicles or other hard-working engines.

THE DIFFERENCE IS IN THE DESIGN

High-performance engine technology has advanced through material science, processing and machining. Trend has recognized this and has not stood still—they have a full-time engineering staff that explores relevant new materials and processes and how they can be used to make better piston pins. This is critical because cylinder head and valve train advancements have had a marked effect on engine power and operating rpm. Many companies still try to hold the piston to the rod with 50-year-old technology. Trend has become the leading supplier to all types of racing but has become the pin provider of choice in the winner's circle of NASCAR and professional drag racing such as Pro Stock and nitro-burning Top Fuel and Funny Car.

Since there is always a balancing act of cost-versus-performance, Trend offers not only different styles of piston pins but also a varied selection of materials. For normally aspirated engines, 4130 chromoly is used rather than the more commonly used 1018 mild steel. Pins manufactured from 4130 are recommended for street/strip engines up to 750 horsepower.

The next step up the performance ladder is H13 tool steel, which is the material of choice for premium piston pins. It is considered the best all-around material for most applications, especially power-adder users. The H13 pin has a Rockwell hardness value of Rc 54. The more common 9310 steel tempers at around 300 degrees F, but the H13 tool steel does not temper until 1,000 degrees F. This allows a special diamond-like carbon coating (DLC) to be applied as an option, which reduces both friction and wear.

M2 piston pins are manufactured with extreme wall thickness to withstand quite a bit of power such as that which a nitro-powered machine might dish out.

Trend Performance's wrist pin room stocks a wide variety of piston pins, which can be shipped almost immediately as needed by the customer.

C-350 is a maraging steel, an iron-based all-steel alloy, that was originally used for piston pins in NASCAR Cup engines and now recommended for high rpm and high horsepower uses. Harder and more expensive than H13, the C-350 maraging steel has Rockwell hardness value of just under Rc 60 but requires a diamond-like carbon coating due to its high nickel content.

The last is M2, which is considered a premium tool steel. M2 pins are used in some fuel car applications. An exceedingly tough material, it is superior in all ways to H13 and it has an advantage over C-350 maraging steel. It has a lower coefficient of friction when uncoated and is usually prepared to a Rockwell hardness of Rc 60.

Chemical enhancement of the metallurgy can be obtained with a DLC coating. This treatment will extend the life of the piston pins by a factor of four or more – virtually eliminating pin bore troubles in even the most demanding applications. Trend's coated pins in Pro Stock engine now last well over 100 runs instead of the normal eight runs. NASCAR engines with uncoated pins usually have had trouble completing a race due to galling, but with the Trend DLC coating they can complete four events with no concern for reliability or power loss.

The piston wrist pin is required to handle the extreme thermal load and cylinder pressure of the engine while staying rigid and minimizing any expansion or flex. And since the production of horsepower creates both cylinder pressure and heat, the piston pin is an essential element in an engine program and needs to be designed for the application. Trend has recognized this and has engineered a comprehensive line of pins to fill almost every need. DRA

SOURCE

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