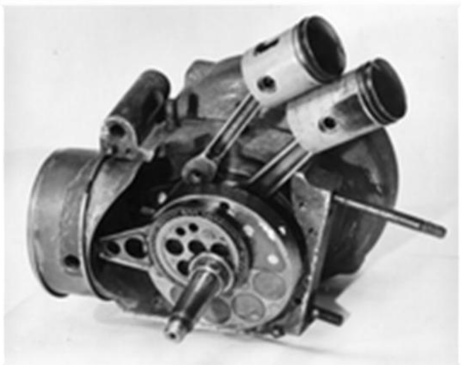
Chapter 13 – Crankcase

13.1 Volume

Crankcase volume is a hotly debated topic among tuners to this day. But before delving into the merits of the discussion, let's understand where this idea of compressing the crankcase might have come from. On the side, we see an old two-stroke engine with two pistons connected to the same crankshaft. Note that it has a third connecting rod at a 90-degree angle to the pistons.

In this connecting rod there was a third piston that worked inversely to the pistons, generating more pressure when they were down and generating more vacuum when they were up. This third piston did not have the function of generating power, only helping to increase and reduce the volume inside the crankcase.



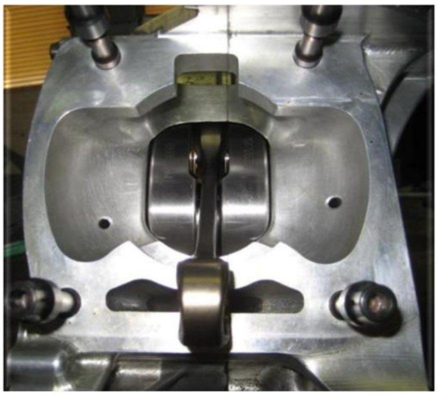
At one point in the history of two-stroke engines, there were no oversized exhausts, and the only way to increase performance was to improve the upward flow of the mixture through crankcase compression, created by the pistons' descent. In this case, it makes sense to think that a compressed crankcase will increase internal pressure more intensely and, yes, benefit cylinder filling.

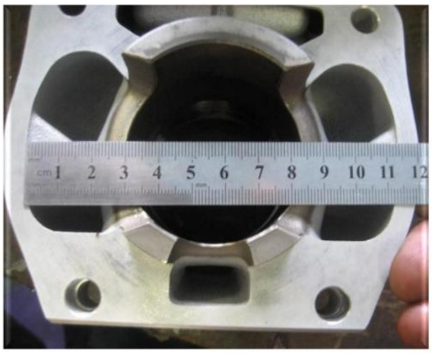
For years, tuners focused on maximum volume reduction, and the more compressed the crankcase, the greater the benefit. Another important fact about engines of this era is that they operated at low RPM.

Over the years, two-stroke engines evolved, and it was discovered that using a larger exhaust could extract significant power. However, exhaust systems were still poorly understood. Therefore, tuners continued to compress their engine crankcases, which still yielded power.

We need to remember that older engines were rudimentary and the quality of components was not as good, which prevented the creation of higher RPM engines. This partly explains why the crankcase helps with cylinder filling efficiency.

But as everything evolves, two-stroke engines now have crankcase designs that favor mixture flow more than volume. The crankcase below is from an Aprilia RSA, and we can see the width of the crankcase opening, which matches the rise of the cylinder's transfer ports. To give you an idea, the transfer ports are 114 mm wide, while the piston is 54 mm. This means the transfer ports are proportionally wider than the piston itself. Does this seem to favor flow or crankcase compression?





All modern engines from major manufacturers like KTM, Iame, TM and others seem to be heading in the same direction.

Below is the Aprilia RSA's spec sheet, and you can see that the crankcase-to-cylinder compression ratio was 1.23:1. To find the crankcase's primary compression, divide its volume by the cylinder's volume while the piston is at transfer height. If the RSA used a crankcase compression of 1.23:1, that's a good starting point. However, measuring this is somewhat complex, and I've never done it myself. Especially because if we measure and find a different value than we intended, especially if it's higher, we'll see in practice that changing this ratio is quite complicated.

Primary Compression	1,23

Michael Forrest wrote:

Primary compression

Modern short-stroke water-cooled engines with large transfer port areas do not require a high primary compression ratio; in fact, a high primary compression ratio substantially increases pumping losses and reduces available power. However, this does not apply to the long-stroke Villiers unit, which uses small transfer ports. Although pumping losses increase, there is a net increase in power. For road racing, a minimum geometric primary compression ratio of 1.4:1 is required; 1.5:1 would be better, but it is difficult to achieve without extreme measures. The higher ratio is used to squirt the charge through the narrow port. The velocity of the charge entering the cylinder is further improved by narrowing the port; its inlet area must be at least 150% larger than its outlet.

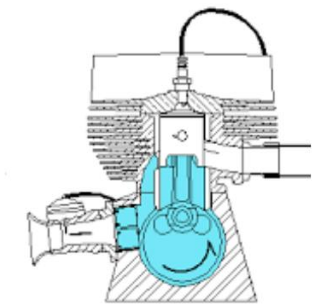
Modern engines should be considered as having transfer systems that perform a "store and feed" function for fuel, with the exhaust providing the real control. The modern exhaust design requires easy access to the fuel mixture supply, which is precisely what the large transfer system provides. What a modern system cannot do is sustain a long, deep draw of fuel from the crankcase through inadequate transfer passages.

13.2

13.3 How to measure

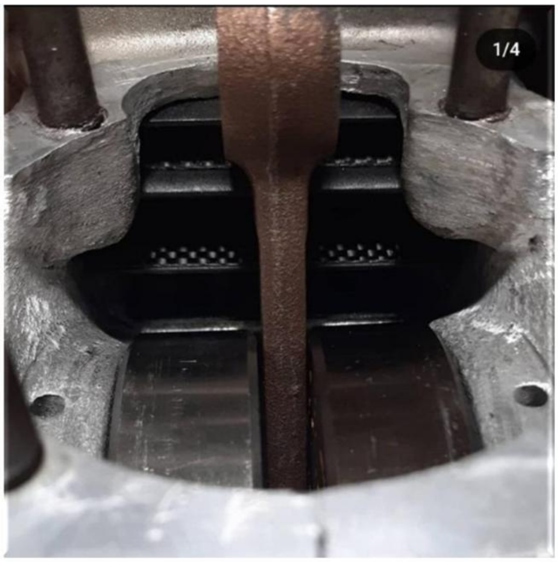
I'll explain it briefly here, but I'll be making available a PDF with all 12 steps suggested by Forrest to perform this measurement.

We must position the piston with the top at the transfer ports to seal them. Then, add oil through the reed inlet and tighten the reeds so that it occupies its space in the crankcase. All the space occupied below the piston, including the transfer port, is considered crankcase volume. Afterward, we must drain all the oil and measure the volume it occupies. Then, simply divide this value by the engine's cubic capacity. The value found is the crankcase primary compression, which typically ranges from 1.1 to 1.5:1.



13.4 Preparation

Preparing the crankcase is very simple, and there's not much to do other than matching it to the cylinder, removing any burrs that might impede proper flow, and, if possible, opening the intake port for greater torque. Care must be taken when removing material to avoid weakening the crankcase, especially near the studs, as the base can warp, losing the proper seal with the cylinder. On the side, we see a crankcase from which I removed a lot of material below the stud threads, and when tightening the cylinder, the stud area warped, compromising the seal. Below is a photo of the same crankcase that I had to reweld to add material.



We have two types of crankcases, which are those with intake through the crankcase or through the cylinder.

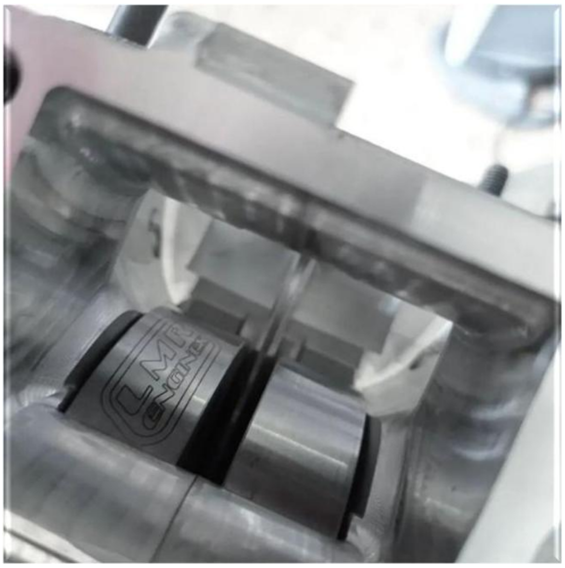
Cylinder intake: Examples include RD, DT, Agrale, and motorized bicycle engines where the intake is via the cylinder itself. In this case, the only work required is to ensure the cylinder and the cylinder are perfectly aligned, as shown in the photo. It's worth mentioning that adding a higher reed torque will allow the engine to breathe more freely. However, larger isn't enough; it also needs to be of good quality.

Crankcase intake: Examples include engines from mopeds, scooters, karts, CR, YZ, Gas Gas among other more modern engines. In this case, we'll have to analyze each case individually, engine by engine, to adjust the mixture flow without compromising the structural integrity, as in the case I mentioned above. When in doubt, it's best not to touch the crankcase.

You can see in the photo below that the stud reinforcement hinders flow, but without it, we lose the structure necessary for proper crankcase rigidity. So in this case, we'll keep the reinforcement where it is.

Some crankcases have the studs further apart and allow this flow improvement work as shown alongside.

We can see that all the flow coming from the vane torque has an open path without any obstacles. However, note that the studs in this case are more open, allowing this passage without restriction. Therefore, great care must be taken when analyzing each case. The more modern the design, the easier it is to notice this difference in stud position, as they are designed precisely for the best feed flow path.



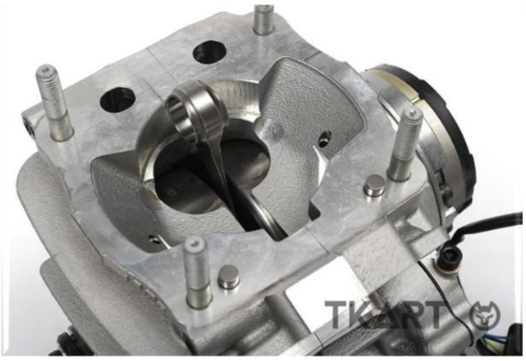
13.4 Case studies

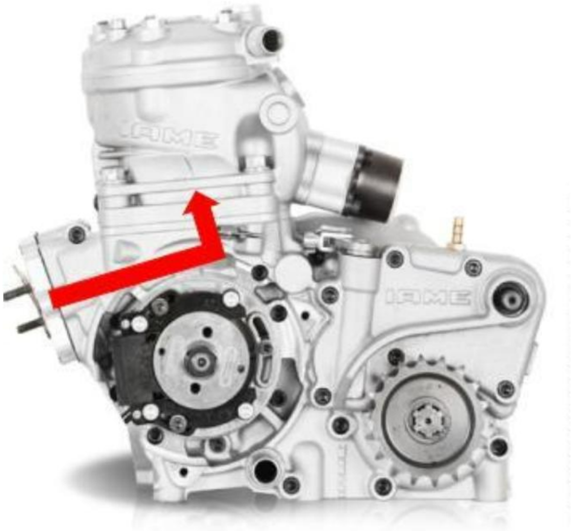
Below we see modern engine crankcases. Note the size of the vane torque and the direction in which it is positioned, directing the flow upward, providing better direction for transfers.

The best direction for the intake port is to face upward. Note the narrow angle between the cylinder base and the base of the vane torque. We can see that the manufacturer opted for a fairly large vane torque with a flow director. The flow director occupies an empty space within the torque that can cause turbulence and redirects the flow where it should go.

intake flow rise angle using the reed torque. You can also see that the crankshaft is covered by a shroud, which isn't for crankcase compression, but rather to reduce turbulence in the transfer upstream zone, maintaining continuous flow on its upstream path. This crankshaft shroud is increasingly used in modern engines.

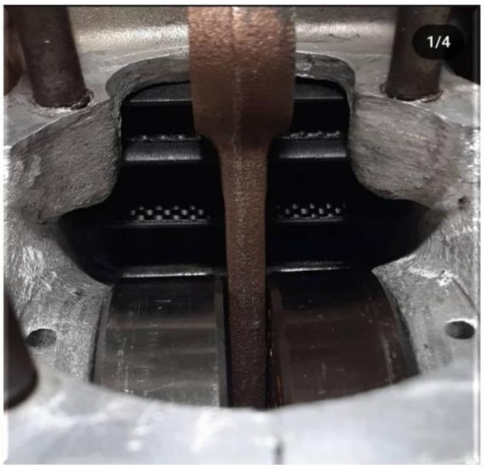
Below, we can see the Iame X30 with an upward intake inlet angle and the same turbulence shield from the crankshaft, protecting the transfer rate from rising. Therefore, what we can conclude is that manufacturers are concerned with the best flow path and feeding of the cylinder transfers, rather than compressing the crankcase.





The key to crankcase preparation is assembling the crankshaft and cylinder and observing where it's worthwhile to remove material and where it isn't. Common sense is essential here, as each engine is built differently. The most worthwhile step is, if possible, installing a larger torque pyramid, preferably with a flow regulator. Also, remove any burrs and imperfections that could restrict the flow path.

An important tip is to test the new torque wrench for length. If it's longer than the original, check to see if the petals will collide with the crankshaft or connecting rod when opening. In this case, use a spacer to further space the torque wrench and prevent the petals from colliding, preventing breakage.



13.5 Internal finishing

Below, another myth is widely discussed, and what we see in practice is a rustic finish, either sandblasted or polished with sandpaper or soft stone. There's no polished or shiny finish where fuel droplets can accumulate. We should always look at the best-built designs and draw our own conclusions. If a polished finish had any benefit, it would be used in these engines. Here, we also need to be cautious about outlandish discoveries like golf ball holes that have never been tested in practice. To debunk this is naive, to say the least, considering that racing engine manufacturers have probably already tested everything and none of this nonsense is present in these engines.

Aprilia RSA crankcase

Other examples:

13.6 To compress or not to compress?

This question can only be answered with a little reflection, as it depends on the construction of the engine and the use that will be made of it.

Old engines, no longer in use and running at 5,000 or 6,000 RPM due to long strokes and poor transfer quality, should indeed be compressed. However, they no longer exist, and even if some are still in operation, it would be sacrilege to tamper with a living fossil.

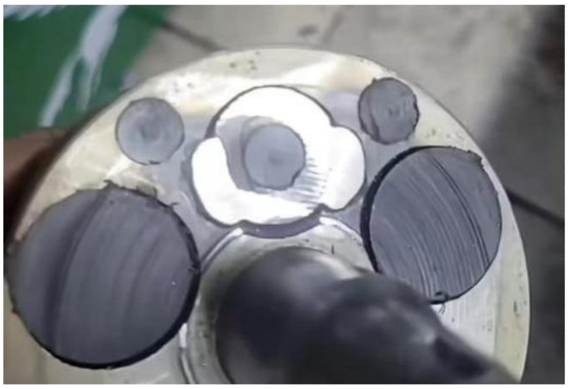
Engines from the '70s and '80s are still running around, and let's consider whether they use stock exhausts that limit their revs. In that case, yes, it would be worth compressing the crankcase. But wouldn't it be easier to replace the exhaust with a larger one that helps fill the cylinders instead of opening up the entire engine and filling the crankcase with solder, epoxy resin, or corks and glue?

More modern engines, without exception, already come from the factory with a custom-sized exhaust. Considering that they already have modern transfer systems, and knowing that with this type of transfer system, taxing the crankcase results in a loss of pumping, as Michael Forrest suggested, is it worth increasing primary compression? Therefore, in this case, there's no point in wasting time and effort, especially since if this technique were valid for this application, the manufacturer of this modern engine would have already done so.

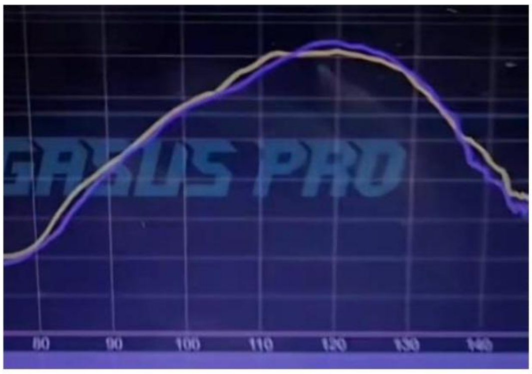
The truth is, I've never done it and I don't have a solid conviction on the subject. I've never used this technique, based on what the literature says, racing engine examples , and what history has shown me so far. If you're convinced and have already tested primary compression increase with good results, I suggest you continue doing it.

13.7 Test in practice

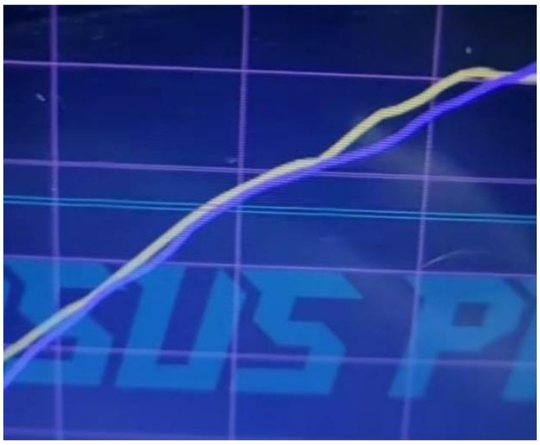
I ran a practical test by filling the bores of a Yamaha crankshaft and performing a before-and-after test. The only modification to the engine was the addition of acetal material to the crankshaft bores.



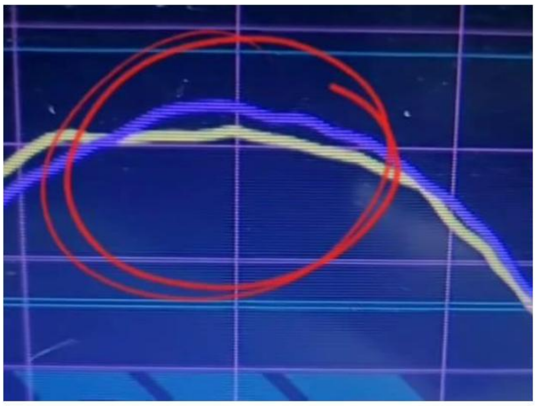
This was the result on the dyno. Yellow line with open holes and blue line with closed holes.



At low speeds, the gain was 0.4 hp.



At high speed, the gain was 1 hp.



Honestly, after I did this test, I never worried about whether to plug it in or not. Of course, if we're looking for power where we don't know where else to find it, we can choose to close it in cases where we're looking for more torque and open it where we're looking for more peak power and higher RPM.

Furthermore, for me, this test is practically inconclusive, since it required opening the engine and there was a very long time interval, perhaps a day, which is known to result in changes in power output. Several times, power output varied by up to 5% from one morning pass to another in the afternoon. Another point to be noted is that the crankshaft balance was altered. It had already been balanced without the acetal bushings that closed the bores, so weight was added at that point. Therefore, I can't guarantee that this test was truly conclusive, but it's clear that this intervention won't change much.

Chapter 14 – Exhaust

14.1 Introduction

Two-stroke engine exhausts come in a variety of shapes, with the earliest ones designed for low-rpm torque and fuel economy. They featured a system that compressed the mixture out of the exhaust port to prevent fuel from being wasted.

Over time, the custom exhaust system was developed, and the entire dynamics of this engine were forever changed. Initially, it was poorly understood, but over the years, it evolved, creating unimaginable