

## Chapter 6 – Cylinder: Graduation

### 6.1 Introduction

, helps concentrate or spread the powerband, as well as raise or lower the maximum power RPM.

When we define what use will be made of the project, we need to define the heights of the windows, but to know the correct height, we will always base ourselves on the graduation.

The caliper is universal in 2-stroke engines. Regardless of displacement, piston size, or crankshaft stroke, it gives us an idea of how the engine will behave. If we were to base our calculations on port heights, a slight change in crankshaft stroke would significantly alter the engine's behavior, and we would no longer have a logical line of reasoning. Believe me, when you familiarize yourself with the caliper of two-stroke engines, regardless of their size, you'll know how they will behave. That's why I call the caliper universal, because anyone who mentions port angles will be easily understood in a conversation among tuners.

Therefore, avoid talking about port heights; they say very little about any engine. Keep in mind that a 24mm height in an exhaust port on a small-displacement engine creates a relatively low exhaust caliper, but on a large-displacement engine, it can represent a very high exhaust caliper. This is due to the

crankshaft stroke, which is low in small engines and high in large-displacement engines. The crankshaft stroke changes the exhaust caliper, even with the same port heights. What I mean is that we can have two engines with the same exhaust caliper heights. If they have different crankshaft strokes, the exhaust caliper will be different, and so will the behavior.

As you can see in the image below, I've separated the exhaust and transfer window grades by setup type. I've divided them into light, street, and track to make them easier to understand. I'm just giving you a starting point. Always start with lower grades than I've suggested, and progress as you learn and learn.

Here again, we can't ignore the type of transmission we'll be using. There's no way to work with street tuning using the highest gear ratio recommended when we don't want to give up low-end torque. There's also no way to work with high gear ratios in a CVT engine that has few adjustment features.

<b>GRADUATION</b>						
205						
202						
200						
195						
190						
185						
180						
175						
170						
165						
-						
-						
-						
-						
135						
132						
130						
125						
122						
120						
115						
	EXHAUST	TRANSF	EXHAUST	TRANSF	EXHAUST	TRANSF
	LIGHT	LIGHT	ROAD	ROAD	TRACK	TRACK

Above this table, use the blowdown to differentiate the different applications you may have.

## 6.2 Case studies

Let's analyze some cylinders and their versions in order to understand what graduation manufacturers and tuners usually use and how it actually behaves.

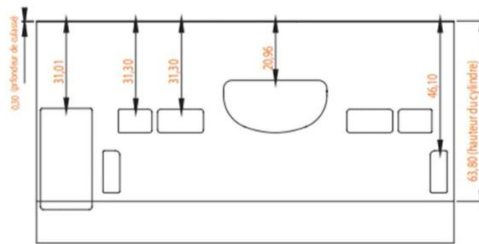
Below, we see the portmap (port height map) of a 70cc MXS cylinder in the Sport trim. Note that it delivers 16 HP at 11,500 RPM and that the stroke ratio is 190/126/124. The blowdown of this cylinder is 32 degrees, which we will learn how to calculate and

analyze later. The important thing here is to understand the stroke behavior and what it does to the engine.

(Test trial without any preparation of the cylinder kit / the engine)  
With adequate components, the maximum horse power is 16HP at 11500 rpm and 11Nm at 10500 rpm (at rear wheel).

#### 8. ANGLE AREA TIMINGS OF THE SPORT CYLINDER

Exhaust duct	190°
Intake lateral ducts: A,B windows	124°
C window	126°

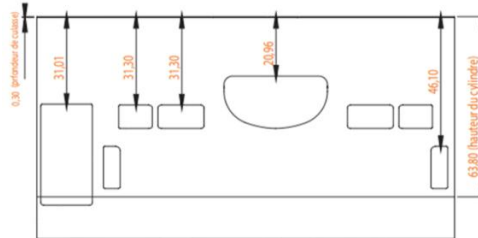


Now let's compare the same MXS cylinder supplied in the Racing version. In the photo below, we see that horsepower has increased to 18.5 HP and the power zone has increased to 12,500 RPM with a 196/132/134 ratio. This cylinder's blowdown is 31 degrees versus the Sport's 32 degrees. Let's assume they're the same. So, what we see here is that increasing the ratio by 6 degrees across all ports increased horsepower by 15% and raised the power band by 1,000 RPM. The manufacturer doesn't say whether there's a difference in port width, but everything indicates there isn't. Therefore, the power increase was due solely to the port height.

(Test trial without any preparation of the cylinder kit / the engine)  
With adequate components, the maximum horse power is 18.5HP at 12500 rpm and 12Nm at 11500 rpm (at the rear wheel).

### 8. ANGLE AREA TIMINGS OF THE RACING CYLINDER

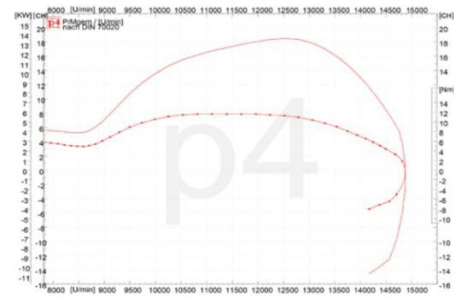
Exhaust duct 196°  
Intake lateral ducts: A,B windows 132°  
C window 134°



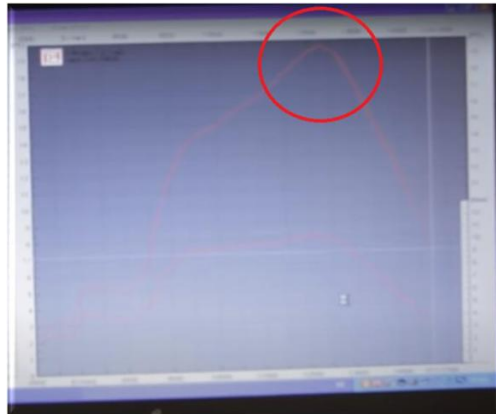
In the same PDF, the manufacturer reports this power curve for the MXS 70cc Racing.

However, I had access to the engine test and this curve is much steeper than shown here.

### 7. POWER CURVE OF THE RACING CYLINDER KIT



Below, we see the actual torque curve of the MXS 70cc on the dyno. Higher RPMs with blowdown above 30 degrees generate peak engines. But whenever we concentrate power in a narrow RPM range, we achieve a higher peak. In this case, as we saw in the gearbox section, this type of curve is acceptable in CVT engines. As long as we have a quality CVT system that we can adjust to work at this peak, we will have a very strong and efficient system. In the exhaust ports, blowdown, and exhaust section, we will learn how to concentrate or spread the torque zone.



As a matter of curiosity, the cylinder is this one:



The cylinder was installed on a scooter:





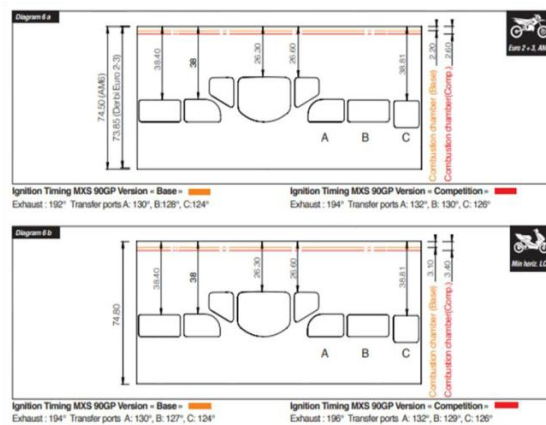
**CONFIGURATION MOTEUR**

Kit cylindre: MXS Racing 70cc non préparé (squish: 0,55mm)  
Kit admission: «Big Valve» MXS Racing prototype  
Carburateur: Stage6 R/T 28mm Dell'Orto VHST + tulipe Stage6  
Pot: MXS Racing prototype  
Allumage: Stage6 R/T (fil vert: non connecté, avance: 3,2mm avant le PMH)  
Vilbrequin: Polini «Evo»  
Variation: complète Stage6 R/T  
Bas moteur: Minarelli vertical non préparé

And now let's analyze the Racing 90cc version, the MXS GP2 90:

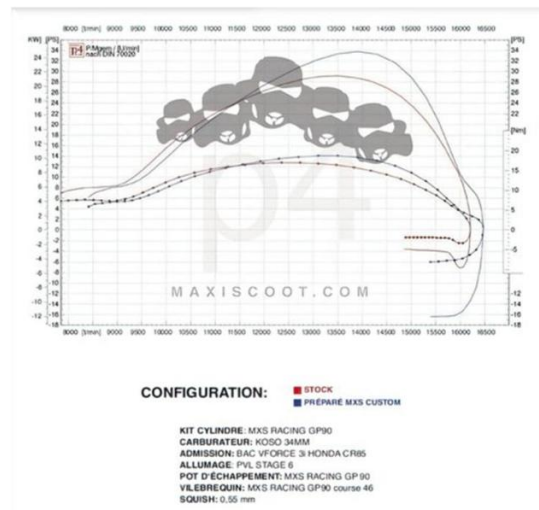


Here we have a very versatile cylinder. The manufacturer recommends graduation settings for street and racing applications for engines with shifters and CVTs. Racing settings are higher and even higher when the engine has a CVT. The graduation is adjusted using gaskets included in the kit. We see that the indication for a street shifter is 192/130 and for track applications, 194/132. Both have a 31-degree BD (blowdown). For scooters with a CVT and street applications, we have 194/130 and track applications, 196/132, with a 32-degree BD. Note that the transfer window graduations are staggered, but we'll cover this in the module that covers this topic.



Below we see the power graph for this cylinder in two configurations: stock and tuned by Maxiscoot . They

don't specify the tune used on the cylinder, but it originally delivers almost 30 hp. This is likely the highest-rated 196/132 configuration. And in the tuned configuration, it achieved 34 hp. Maxiscoot suggests replacing the combustion chamber along with a higher-octane fuel and a 38 mm carburetor for increased power.



I'll show you some examples of undergraduate programs that I've collected over time, and it shows that there's nothing mysterious or complicated about

choosing a degree when you know what you're looking for.

Below we see a Top Performance Scooter cylinder with street-grade rating. The stock configuration is 192/130, and according to the manufacturer, it generates 24 to 25 HP.

80cc Top Performance AM6  
94% largura 😊  
194/130



Below are some more examples of graduation:

88cc BRK Porting  
196/132



80cc 2win Ripper Porting  
Hier einmal den Auslass auf 194° angehoben.  
Die Stömer hatten ab werk schon 132°,  
mussten also nicht geportet werden.

Ver tradução



Por causa disto, agora temos  
transbordações que estão exatamente a  
130o sem precisar de portá-los!  
Agora a tomada foi portada para 195o.  
A tomada esquerda e a do meio estão quase  
terminadas, a direita ainda é original.  
Ai o cilindro pode voltar pro cliente

Classifique essa tradução



First with 196/132, second with 194/132, third  
with 195/130.

Below are some more examples of graduation:

Olá Tunerzz  
Atualmente em progresso: 90cc Italkit 🤖🔧  
Na primeira imagem pode ver o quão grandes podem ser as saídas laterais e na segunda foto. Imagine o quão pequenos eles são originais. Que vergonha. Perde-se muito potencial, mas com alguns trabalhos de fresagem é um cilindro muito forte 😊. O cilindro recebeu um pacote completo meu e é portado para 198/132o.  
Claro, o motor também está moído. Mas atualmente tenho tanto pra fazer que raramente consigo postar aqui. Vou mostrar mais do meu trabalho agora. Tenho muitos projetos interessantes no momento.  
😊  
O que você acha sobre seus projetos? 🤖🔧



80cc Zinn Runden Zylinder.  
195/130° geportet.  
Horizontale Richtungswinkel korrigiert  
Booster exhaust verbreitert

Ver tradução



The first with 198/132 and the second with 195/130.

### 6.3 Graduation

In this module, we will only focus on learning how to measure graduation and understanding how it relates to the usability applications we want for the engine.

In the exhaust window, transfer and blowdown modules, we will talk about how to concentrate or spread the power band to better match the type of gearbox we will use and also considering the application.

Here, we simply need to understand that the higher the gear ratio, the greater the engine's power, but at the expense of power loss at low RPM. Let's remember the horsepower formula, which takes engine RPM into account. If we increase the torque range at higher RPMs, we gain power. Therefore, increasing the gear ratio helps with power gains. Of course, other factors contribute to this as well.

Two things happen when we increase the caliber: the first is that by increasing the port height, we send the shock wave to the exhaust sooner, considering we open the exhaust port earlier as well. The second is that we have more cylinder filling time, considering we open the transfer port earlier than before. If we increase the transfer time, we increase the amount of mixture entering the cylinder.

cylinder, which justifies more power. When I say earlier, I mean that we have higher ports, and when the

piston descends, it uncovers the ports earlier than it would have if they were lower.

This effect generates an increase in the powerband at higher rpm, as the shock wave also arrives earlier. This is why we lose power at low rpm, as the wave returns at rpm where the exhaust port is at an angle unfavorable to supercharging. In other words, the shock wave won't return when the piston is about to close the exhaust port, helping to compress the engine and not favoring the return of the mixture sucked in by the exhaust. This is what causes the loss of power at low rpm. We'll understand this effect much better when we delve into the exhaust module.

That's why I always say that events in two-stroke engines are closely interconnected. And that's why we need to always think about the whole process. Both the effects that each modification has on its operation and behavior, and how this behavior helps or hinders the intended use of the engine.

Engines with shifters intended for street use typically require low-RPM torque for low-revving performance. These engines will require lower gear ratios.

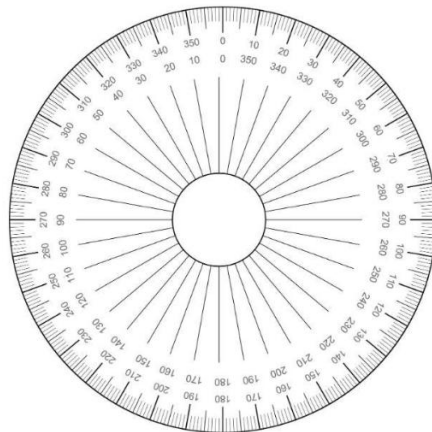
Engines with shifter gearboxes used on the track can have a very high gearing, since, excluding starting at traffic lights, they will work in gear changes at very high revs.

CVT engines that will be used on the street will require lower revs, as we don't want an engine rewing to 10,000 RPM every time we go out. Or, we may want a high-revving engine on the street.

Just like we want a CVT engine to start at 10,000 RPM and maintain that high RPM on a 201m drag strip. Understanding this concept of applying graduation according to use and the parts installed in the set is the basis for starting any preparation.

#### 6.4 How to measure graduation

First, you'll need a graduated dial and attach it to the crankshaft shaft. I'll leave an example below that you can print and cut out.



To measure, you'll need a feeler gauge measuring approximately 0.2 mm. I usually use automotive valve adjustment gauges, which are quite inexpensive and last for many years. They also serve other purposes, such as measuring the ring gap, as we'll see later.

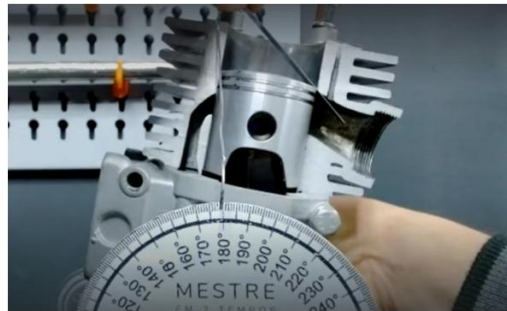
You'll need to attach the graduated disc as mentioned and, using a wire or tin can, create your reference as shown here, indicating zero. You can see that the blade is being pressed by the piston against the top of the exhaust port of this cylinder, which I cut in half to demonstrate this process. The measurement here isn't precise, as the piston wobbles due to the missing half of the cylinder, but for educational purposes, it will serve.

The graduation measurement always occurs with the crankshaft rotating, fully opening the window, passing through bottom dead center and returning to close the window, again lightly pressing the vane between the piston and the top of the window.



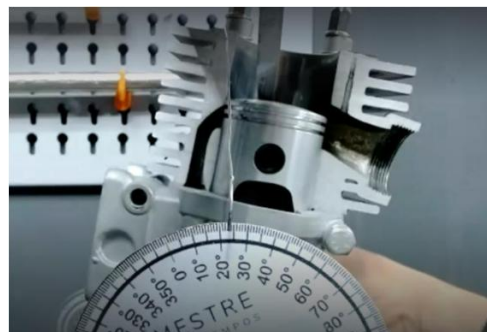
The mistake you can make is turning in the direction the graduation decreases, that is, backwards. Example: 350, 340, 330 as you rotate the crankshaft. The graduation needs to increase, passing through 10, 20, 30, and so on. If the graduation decreases, simply rotate the crankshaft 180 degrees and return the wire to pointing at zero. This is why I don't recommend tightening the dial too tightly; leave it slightly loose so you can rotate it to make these adjustments. But not so loose that it rotates incorrectly and gives you an inaccurate measurement.

With the reed clamped between the piston and the top of the window, check that the wire actually points to zero and turn the crankshaft until the piston slightly crushes the reed again as shown in the image below.



As you can see, we found 179 degrees, which is the exhaust port graduation. Always write it down on a piece of paper so you don't forget and need to retake the measurement.

To measure blowdown, simply return the dial to zero and press the reed against the highest transfer as shown in the photo below. We can see that this cylinder has 24 degrees of blowdown. Don't worry, we'll cover this topic later.



Now we move on to the lateral transfer, where we repeat the process of crushing the reed at the top of the transfer and rotating the disc so that the wire points to zero. Rotate the disc again, opening the transfer and passing through bottom dead center, and crush the wire again. We can see that the lateral transfer is 131 degrees.



Another way to calculate the blowdown is by subtracting the exhaust port graduation from the transfer, that is,  $179 - 131 = 48$ . Since the piston passes through the blowdown twice, just divide this number by 2 and we will have the same 24 degrees that we measured previously.

So, we have a cylinder with 179/131/24, and you'll find this nomenclature in all the literature you read. That's why it's crucial, and I emphasize, to always talk about degrees, never about port height to top dead center. Imagine you're used to 50cc engines and are

familiar with thinking about port heights. A 30mm-high port, for example, in a 50cc engine has a low caliper, but those same 30mm in a 300cc engine will have an extremely high caliper. But whenever we talk and think about caliper, regardless of engine size or displacement, 160 degrees will always be a low caliper, and 190 degrees will always be a high caliper. It's important to know that changing the crankshaft stroke, increasing or decreasing the number of gaskets, or altering any cylinder or piston height will affect the caliper.

## **Chapter 7 – Cylinder: Exhaust Port**

### **7.1 Introduction**

The exhaust port's importance and function are poorly understood. It controls the exhaust gas output, directly impacting power and how it's delivered. As we'll see in this module, the choice of opening shape, type, graduation, and size will largely dictate the behavior of two-stroke engines.

Here we'll cover a wealth of theory drawn from many textbooks on the subject, as well as the conclusions and expertise of this writer. This means you won't find anywhere else the learning you'll get here. I'm convinced that a major shift will occur in your mind, and many things will begin to make sense from this module onward.