https://doi.org/10.26552/ pas.Z.2022.1.15

CONSTRUCTION DESIGN OF A THREE-CYLINDER TWO-STROKE RADIAL ENGINE

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Abstract

The goal of modern society is to improve efficiency in all areas. Our goal is to convert the old engine parts into a functional power unit that is more efficient than the donor parts. Modern electric motors with high efficiency are our main competitors, but our motor has an advantage in a simple design that is easily serviced. We achieve low weight by using lightweight aluminum air-cooled cylinders. In my work, I deal with the fundamentals of two- and four-stroke internal combustion engines. The importance of primary and secondary forces caused by the movement of the crankshaft and pistons is also discussed. Of course, we'll go over how to fill the engine while it's running (carburetor/injection). Following that, I'd like to go over the overall functionality of the drive unit as well as the significance of specific components. In practice, we concentrate on simulating our experimental engine. The purpose of this entire article is to provide the foundational documentation for the subsequent construction of this power unit.

Keywords

Trabant radial engine, Trabant three-cylinder engine, Trabant aircraft engine.

1. INTRODUCTION

Air force propulsion units have been in development for a very long time. The primary goal has always been to make the drive unit powerful, light, dependable, and efficient in a variety of other ways. The four-stroke engine, which has been used by the air force since its inception, excels in the majority of the features mentioned. Although the two-stroke engine is described as being unfriendly to the environment, it is more efficient than the four-stroke engine in many ways. These areas include, for example, the final product's weight to power ratio and ease of construction. These are the benefits we want to emphasize when designing our three-cylinder engine, which will primarily use components from Trabant 601 engines P60, P63, P65, and 5B. Since its inception, this type of engine has been used in air transport, as many designers of paragliders and other ultralight aircraft-capable devices have recognized the engine's potential. The engine's power ranges from 23 to 26 horsepower, but by fine-tuning it with a few simple adjustments, you can increase its power while also lowering its consumption. Unfortunately, a design suitable for a car is not perfectly suitable for aviation.

The benefits were also noticed by the STRX 1200 engine designer, who used the so-called engine top to combine two P63 engines to create a four-cylinder boxer engine. Unfortunately, the STRX 1200 engine and the original Trabant engine are not as efficient as they could be. This is primarily due to the designers' available options at the time. As a result, we decided to use all of our knowledge and modern technologies, as well as suitable engine components P60, P63, P65, and 5B, to create a design that will outperform the original design in every way.

2. TRABANT ENGINE

The Trabant 601's two-stroke powertrains have evolved significantly over the course of its production. The designers relied on knowledge gained from the development of previous types of engines used in the first P50 vehicles. This machine also had a power unit with the same name. It was a two-cylinder, air-cooled, two-stroke engine with a straightforward design.The P50 engine had a volume of 500 cm3 and produced 13 kW at 3750 rpm in the first versions. While maintaining the volume, the power was gradually increased to 15 kW at 3960 rpm. The drive unit was able to provide us with significant torque in the form of torque, up to 45 Nm at 2750 rpm, due to the relatively large stroke. The development was quite limited in order to keep the same structural elements.

The P50 engine was replaced by the P60 engine, named after the new Trabant model. A significant change was the increase in volume from 500 cm3 to 594 cm3 (rounded to 600 cm3), which increased our torque to up to 51 Nm at 2700 rpm. Our power increased to 16.9 kW as a result of the higher torque value, particularly at higher speeds. This engine was used in the Trabant P60 / 600 as well as the early Trabant 601.

With further evolution, to the P63 type, a significant developmental leap occurred. The modified geometry of the discharge channels increased the torque to 54 NM around 2800 rpm and the power to 19.12 kW at 4200 rpm. This engine also stopped using M18 threaded spark plugs, which were less common, so it was an important spare part. Sparkplugs with a much (more frequent) M14 thread took their place.

The engine's subsequent evolution occurred in 1974 on the P65 model, with the most significant changes being the use of needle bearings in the upper eyes of the connecting rod. In the upper connecting rod eyes of all previous types, bronze bushings were used. Because this type of bearing necessitates a larger oil supply, an oil dilution ratio of 1:33 was used. Because needle roller bearings do not require such a constant supply of oil, the lubrication ratio has been reduced to 1:50. The engine has become much more efficient and environmentally friendly as a result of these modifications. Unfortunately, production quality has gradually declined since the early 1970s, and despite the use of components that should theoretically increase engine performance, reality has revealed that the power ratings set in 1969-89 have not changed.

The 5B engine was the most recent evolution, with designers attempting to solve the problem of gradual leakage of rubber seals on the crankshaft. They were able to solve this problem by using so-called sealing rings (Labyrinth). It is a construction in which steel rings in grooves that touch the inner steel structure ensure tightness. These seals allow the crank to freely move relative to the block, while their tight tolerances and the oil contained within them ensure the block's tightness. Pistons with a design that provided adequate strength while being light in weight began to be used. Heads with a compression ratio of 7.8 were eventually used, which were supposed to improve performance parameters, but the quality of production was so poor that it could not be proven [1][2][3][4][5].

Figure 1: Trabant engine. [authors]

3. EXPERIMENTAL ENGINE

The following are the conditions for our experimental engine: Engine capacity is limited to 1,000 cm3, design of a construction that ensures the engine's smoothest operation and longest possible service life, and use of modern technology to increase its parameters. Our primary criterion is the correct balance of the experimental unit. As a result, we decided to space our three cylinders at 120-degree intervals. All three pistons will move at the same time, ensuring these outcomes.

The correct operation of the engine is dependent on the creation of a sudden and uniform vacuum, which ensures the correct suction of the mixture as well as the uniform compression of the mixture for the engine's correct and most efficient operation. This also ensures the proper balance of primary and secondary forces, resulting in minimal engine vibrations and, as a result, the longest possible service life for the entire experimental unit. Even cooling will be ensured, resulting in uniform wear of the individual components.

To keep the volume constant, we decided to use three cylinders from the engine, P63, P65, and 5B, which have better geometry in the discharge channels. A "cut" is made when the rollers' dimensions change due to wear after extended use. This procedure expands the piston's bore. As a result, we'd like to go with a 74 mm bore, which will increase the engine capacity from 892 cm3 to 942 cm3. However, we still have enough material for any major drilling that would be required in the event of a seizure that would cause significant damage to the cylinder wall. In addition, I intend to use a more modern carburetor than what was used in the original engines. The PWK, Keihen, and Mikuny carburetors of the 1980s were already advanced enough to compete with modern electronic injection if properly set up.

However, due to the ever-improving electronic injection molding technology, their development has largely stalled. These carburetors, on the other hand, are significantly more efficient than any carburetors used in the Trabant car. This is also due to the fact that the original carburetors used a constant diffuser size and thus have the highest efficiency only at a limited range of speeds or with a specific volume of air flowing at a specific time. Carburetors with a more modern design allow us to change the size of the diffuser as needed. Furthermore, the overall construction is designed so that the channels are as short as possible in order for the fuel to travel as quickly as possible.

4. HOW IT WORKS

Many aviation enthusiasts may mistakenly compare our experimental engine to star engines, which operate on a four-stroke principle. It would not work if we converted our experimental engine to a four-stroke engine. This is because such engines are designed to keep the crankcase pressure constant, as increased pressure from poor piston movement design would cause increased stress on the rubber seals, causing them to fail and the engine to leak oil. In our case, however, the pressure in the crankcase must change as sharply as possible in order for the required flushing to be as efficient as possible.

The design itself, which would behave like a four-stroke engine, could be created, but the individual cylinders would need to be sealed. We'd also have to split the crankshaft into three parts, each of which would be sealed. As a result, it is unnecessarily expensive and difficult to produce. Simultaneously, the current operation of the pistons ensures that we experience minimal vibrations as a result of mutual interference of primary and secondary forces. These forces occur as a result of the piston changing the direction and force of acceleration.

The primary forces act on us once per crankshaft turn. We can get rid of them by using a counterweight that is positioned exactly opposite the axis of rotation of the lower connecting rod. The asymmetrical acceleration of the piston generates secondary forces. It is caused by the crankshaft, connecting rod, and piston design. As a result, when the crank rotates 90 degrees, the piston naturally travels a greater distance in the upper half of the stroke than in the lower half of the stroke. For every crank rotation, these forces are generated twice. Primary forces are more powerful than secondary forces. Both primary and secondary forces are significantly unpleasant in the original two-cylinder engines and are manifested by vibrations. The significant advantage of our design is the elimination of these forces as well as the reduction of vibration to a bare minimum.

Figures ABC depict an engine section. This cut is designed to go through all of the cylinders, which are offset from one another, as shown in Figure 1.

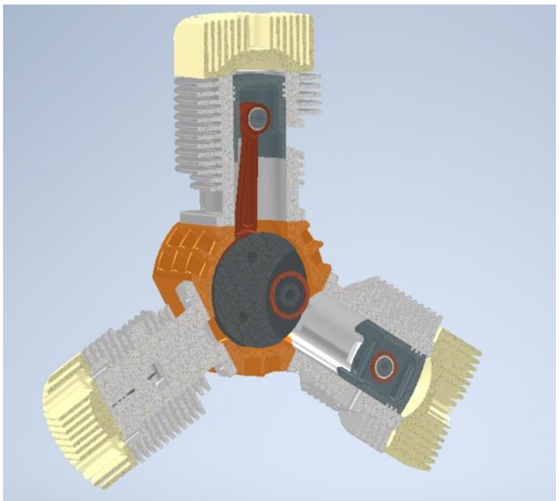

Figure 2: Model of experimental engine. [authors]

Because I want to explain the engine's operation to a new audience, I decided to use illustrations to describe the individual phenomena. The suction process is depicted in Figure 3 by the green arrows. The suction is created by the pistons moving towards the top dead center. They generate a negative pressure as a result of this movement, which causes the suction reed valve to react and open as a result of the negative pressure. The pistons simultaneously compress the fresh mixture enclosed in the combustion chambers during this process. The flywheel supplies us with energy for this story.

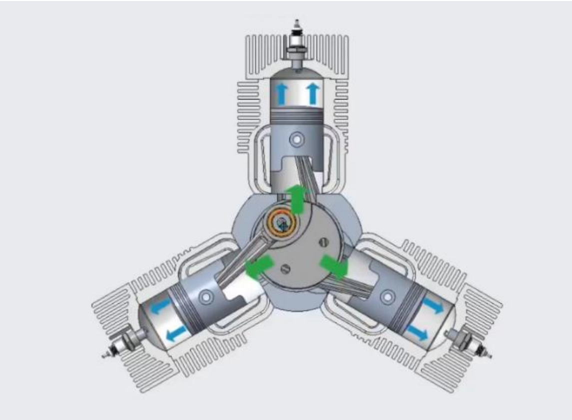

Figure 3: Suction process. [authors]

Figure 4 depicts the following expansion process in the combustion chambers: the pressure on the individual pistons, which creates work. The space under the pistons begins to contract, and the suction reed valve closes, causing an overpressure to form, which will be explained in the following paragraph.

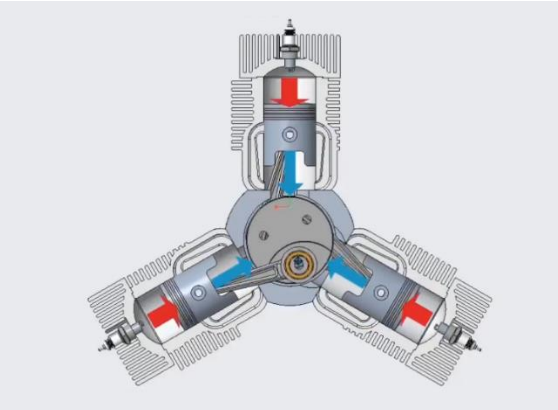

Figure 4. Expansion process. [authors]

We can see in Figure 5 that the individual pistons got under the holes in the individual cylinders. First, the exhaust ducts open, allowing the combusted mixture to leak in. After a while, the overflow channels open, allowing the necessary mixture from the crankcase to flow. The discharge channels are shaped in such a way that the burnt mixture is flushed into the exhaust. Following that, the pistons begin to move toward the top dead center, and the cycle is repeated.

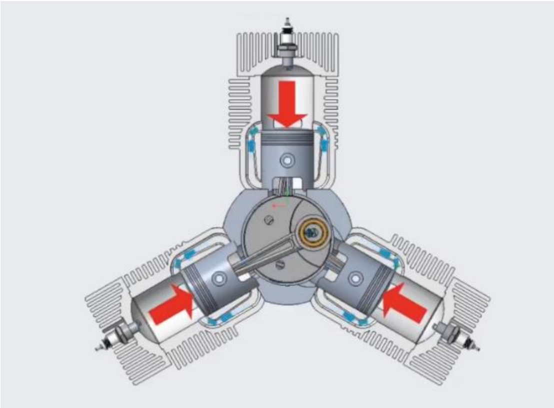

Figure 5: Exhaust process. [authors]

5. USAGE

During the development of this paper, many people inquired about the purpose of our engine. Let's begin where similar engines have been used for a long time. Hang gliders are aircraft in which we attempt to use simple propeller engines. Trabant engines have served in this capacity for over 60 years. As a result, we believe that our engine will be well received, as the increased volume will result in higher performance, which is always desirable in aviation. Its design also ensures simpler assembly and eventual service, as well as improved and more even cooling of all cylinders. Another application for these engines is in ultralight aircraft. It would be considered a lower-power engine, but its light weight would appeal to many aircraft builders. As the final category of flying machines, I'll mention the UAV.

Figure 6: Engine for ultralight aircraft. [authors]

6. CONCLUSION

We declare that we have met all of our objectives. One of the goals was to make the construction as efficient as possible in order to ensure the best possible reliability, consumption, and functionality of the entire drive unit. We can make a functional unit at a low cost thanks to the design, which makes use of many components that we already own. The most difficult challenge will be producing the engine block, which will require a five-axis milling machine, also known as a CNC, but we are confident that the background of our University of Zilina will assist us in producing this part and the entire unit, which can become a functional addition to the Department of Air Transport. It would also be possible to apply motorsports knowledge to the production of a given unit, thereby increasing the performance of our unit to the highest possible level. We would like to express our enthusiasm for the issue in this manner, and in the future, we would like to be a part of a group of people who build this type of engine. We believe we have persuaded you of the importance of this paper.

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