Reference

October 15th, 2018

Z Mechanism Technology Institute Co., Ltd

Japanese Origin New Engine for Contra Rotating Propeller patented in US –No Longer a Dream: "Flying Car" by Z mechanism engine –

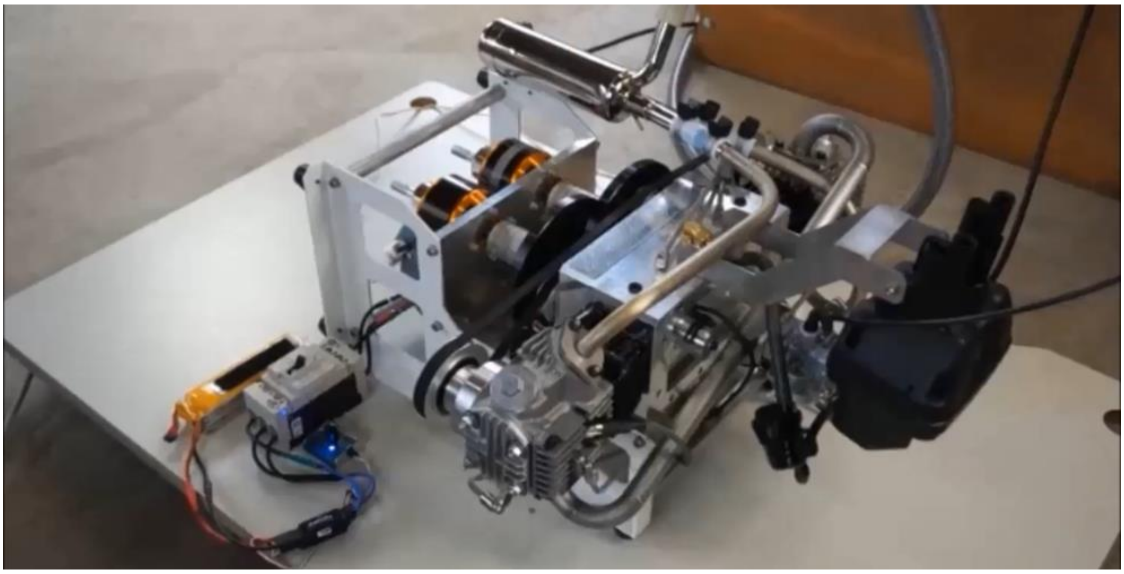


Fig.1 Dual Output Mirror-type XY separate crank mechanism Gasoline Engine

Z Mechanism Technology Institute Co., Ltd. (Head office: Yonezawa, Yamagata, Japan; President: Takumi Yoshizawa) is pleased to announce a US Patent has been granted to our original proprietary technology: Dual Output Mirror XY separate crank mechanism (US Patent No.US2018/0030889 / Japan Patent No.6052748). This patented technology is applicable for a contra rotating propeller (CRP) which realizes the "Flying Car" in the foreseeable future.

1.Technology Summary- Z mechanism engine enables "direct connection" of hi-performance contra rotating propeller. It has two shafts and they rotate as synchronizing automatically, which makes it possible to produce the stable jet blast flowing straightly. Moreover, if a second engine is added to the car, it can fly more stably and return to the ground safely even in the emergency case such as the main engine stops.

2.Background; Solving problems of conventional mechanism" – With the conventional piston crank mechanism, it always occurs a wasted vector which generates the side thrust loss (loss of force), friction heat, and vibration. Meanwhile, the Z mechanism is a new mechanism to convert the rotational force of crank into the liner motion as separating the force into orthogonal two directions of X-axis and Y-axis without occurring a wasted vector. It successfully canceled the side thrust loss from the mechanism.

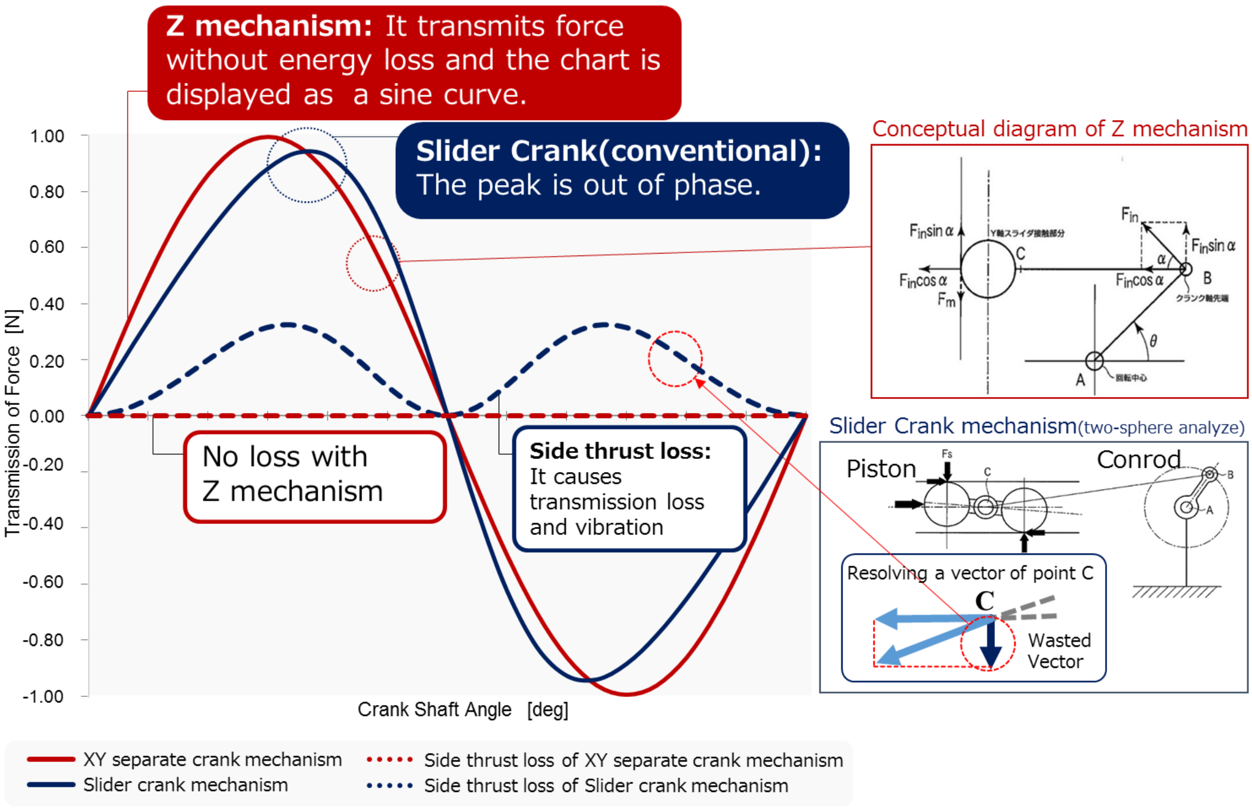


Fig.2 Slider crank mechanism and side thrust loss

By arranging two Z mechanisms facing each other (we call it "mirror arrangement") and rotating two crank shafts reversely, it realized the synchronous power output and extremely low vibration. Also, we confirmed that the first order vibration and the second order vibration were canceled by more than 90% compared to the conventional mechanism (Fig.3).

By improvement of vibration, piston diameter can be larger and there is no need to add multiple cylinders for leveling-off of vibration. It will realize that all current engine converges into two-cylinder engines in the future, which allows to downsize its whole body (Fig.4).

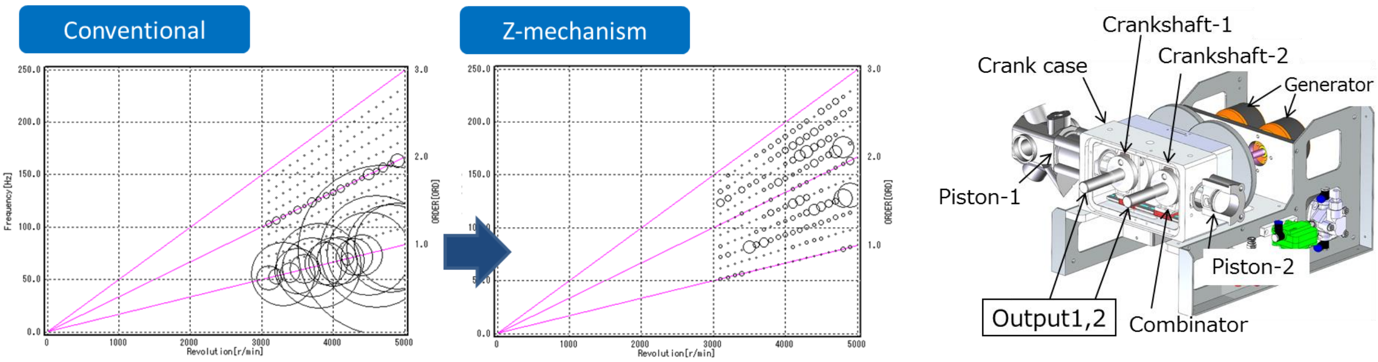


Fig.3 LEFT: Vibration improvement result RIGHT: Internal mechanism of Z mechanism

Source:The annual conference of Society of Automotive Engineers of Japan, in Spring 2018

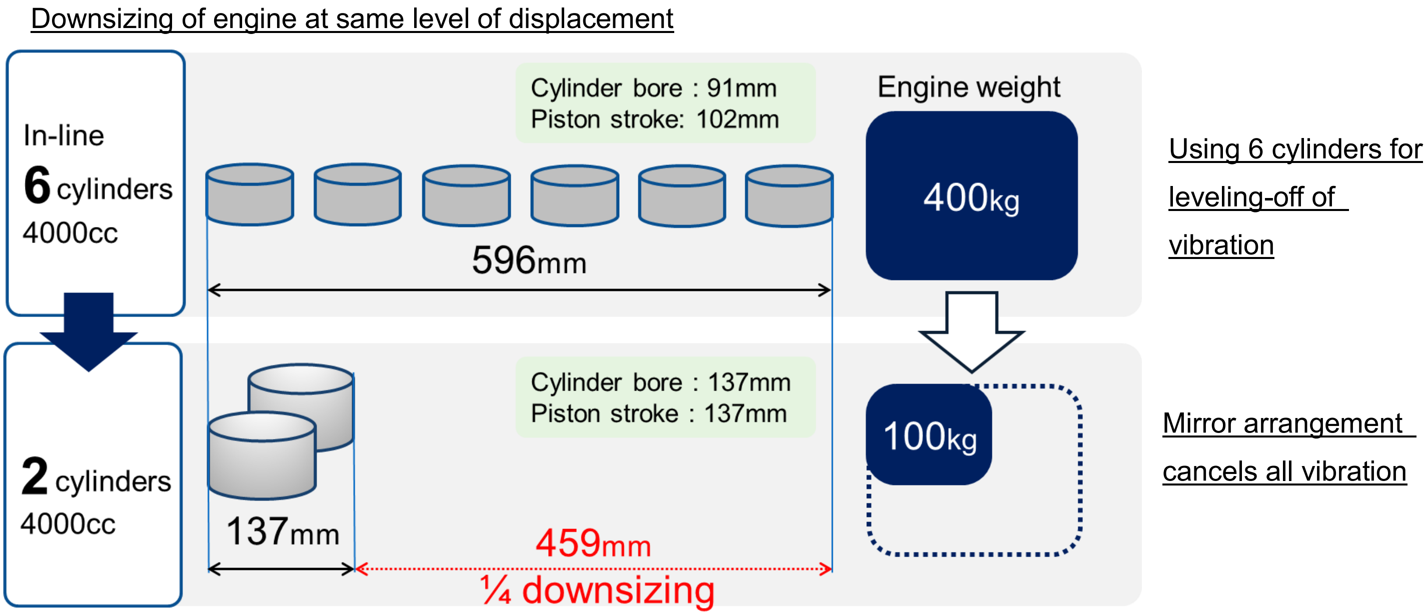
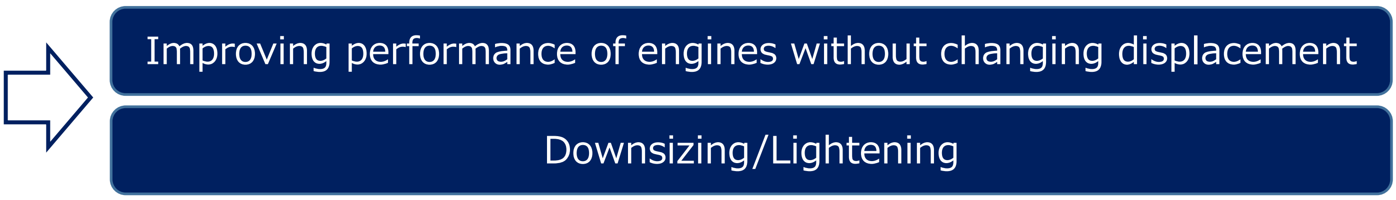


Fig.4 Example of downsizing and lightening by decreasing number of cylinders

3.Downsizing of engine at same level of displacement- To increase the engine displacement, enlarging piston diameter of conventional engine is very difficult due to vibration issue. Therefore, it conventionally applies multiple cylinders for leveling-off of vibration. While on the other hand, the Z mechanism doesn't occur the wasted vector on a piston, so it can enlarge the piston diameter easier. It also allows to improve combustion efficiency, decrease the number of cylinders, downsize, and lighten the whole body without changing its engine displacement as shown in Fig.4.

- Improved quietness by canceling vibration effect of mirror arrangement
- Significant downsizing/lightening by two-cylinder convergence
- Improvement of combustion efficiency by enlarging the bore diameter



4. Barriers for a flying car: Flying cars being developed currently have more than 3 rotors to achieve the stable flight. However, there are still various technical barriers for practical use such as lightening its load weight or improving the flight range. Some flying cars are designed with conventional reciprocating engines but, it also has a vibration problem caused by its side thrust loss. If you use motors instead of engines such as drones, it is mainly designed with two sets of motors (four motors) which are controlled as rotating reversely. In this case, it is easy to predict that the drone would fall down if any of motors breaks down.

Regarding to propellers for a flying car, it is said that a contra rotating propeller (CRP) is the best choice because it is hi-efficiency and capable of adjusting angles (cyclic pitch control). However, it needs a gearbox for reversing rotation of two shafts and the conventional one would be too large and complicated, and so the issue of weight by multiple driving part is a drag on its development.

To solve these problems, a “non-vibration” and “light weight” driving part and a “high-efficiency CRP” are the absolute prerequisites. However, these are the most difficult things and any fundamental solution hasn’t been found.

5. Why CRP fits flying cars? -When a propeller on a car rotates, the rotative torque is produced in the direction of propeller’s rotation, which tries to rotate the car body. To prevent the rotation, a helicopter is always designed with a tail rotor to cancel the rotative torque. Also, for example, the drone propellers in opposing corner are rotate reversely to cancel the rotative torque.

The CRP enables to cancel the rotative torque by reversing rotation of two propellers, and it produces a simple straight jet blast. This CRP mechanism is known as an aeromechanic common wisdom, and it is actually applied to ships and airplanes.
To build a contra rotating propeller (CRP), it conventionally always needs a gearbox with a planet gear to reverse the two divided rotative forces. The driving part including the gearbox must be too complicated, large, and heavy, therefore, it hasn’t been installed to a car yet. However, it is obvious that the CRP is the best for a flying car if there is a new technology to make the gearbox light and simple.

6.Problem solving by Z mechanism- To solve the problems of developing a flying car, we focused on a mechanism which can be a base for machine structure and we succeeded to prove that our Z mechanism engine can be an innovative solution for realization of the “non-vibration” and “light weight” driving part including a “high-efficiency CRP”.

Z mechanism engines, both a gasoline engine and a diesel engine, are designed as replacing the mechanism part and using the same cylinders, pistons and combustion mechanism as they are sold commercially. We confirmed that they canceled all the side thrust loss which is the problem of conventional engine. Moreover, the prototype kept running even the engine speed was over 12000 r/min as using the combustion part of a cylinder of 5000 r/min type). Since it has no side thrust loss, it becomes “non-vibration”, and we demonstrated that the glass bin on the mechanism didn’t fall off while the engine was running.

Regarding to the machinery efficiency, we succeeded to improve high pressure pump efficiency from 75% to 99% with our Z mechanism pump. At the same time, our reciprocating sliding friction-testing machine with Z mechanism has been running for 5 years without any troubles, which certifies its durability.

The Z mechanism is also capable of synchronous reverse rotating output by two crank shafts, and we believe that it can contribute to simplify and lighten a gearbox of CRP. This would realize the "light weight" driving part and a "hi-performance CRP" because simplification of gearbox can reduce the energy loss for CRP.

7. Primary features and future extensibility:

7-1 Features of Z mechanism engine

- By canceling the side thrust loss, it significantly expanded a high rotation speed range of conventional engine.
- Durability testing result shows that it is 20 times more durable than the conventional slider-crank mechanism with crosshead.
- It produces extremely low vibration by canceling vibration effect on the biaxial dual inverted output system.
- Two crank shafts rotate reversely, and it allows the CRP to connect directly with the gearbox.
- It is possible to operate with two shaft simultaneous contra output system without any gearbox.

  → It realizes to produce the stable jet blast flowing straightly. If it is applied to a flying car, it can soar with only one engine (it would be safer if one more engine is added just in case the main engine has trouble).

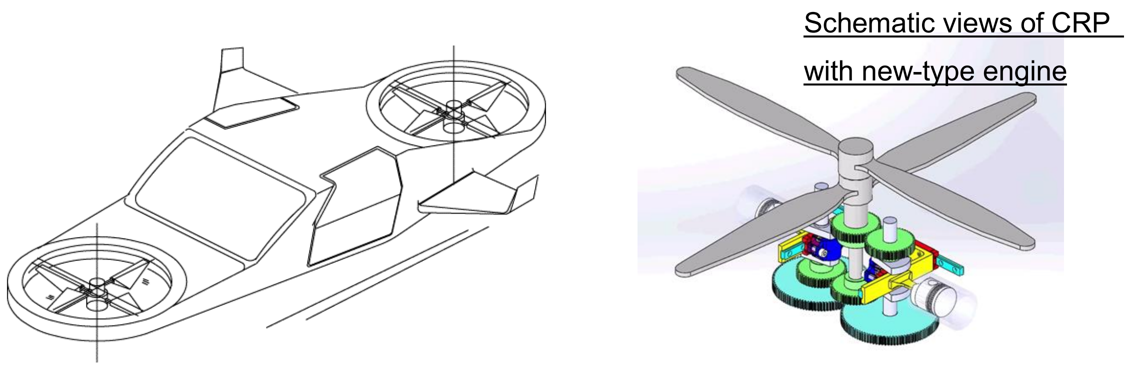


Fig.5 Image of Flying Car with New-type Engine

7-2 Future extensibility

① If the Z mechanism is installed into the four-cylinder mirror structure, it becomes possible to supercharge 4 times as much as the conventional one.

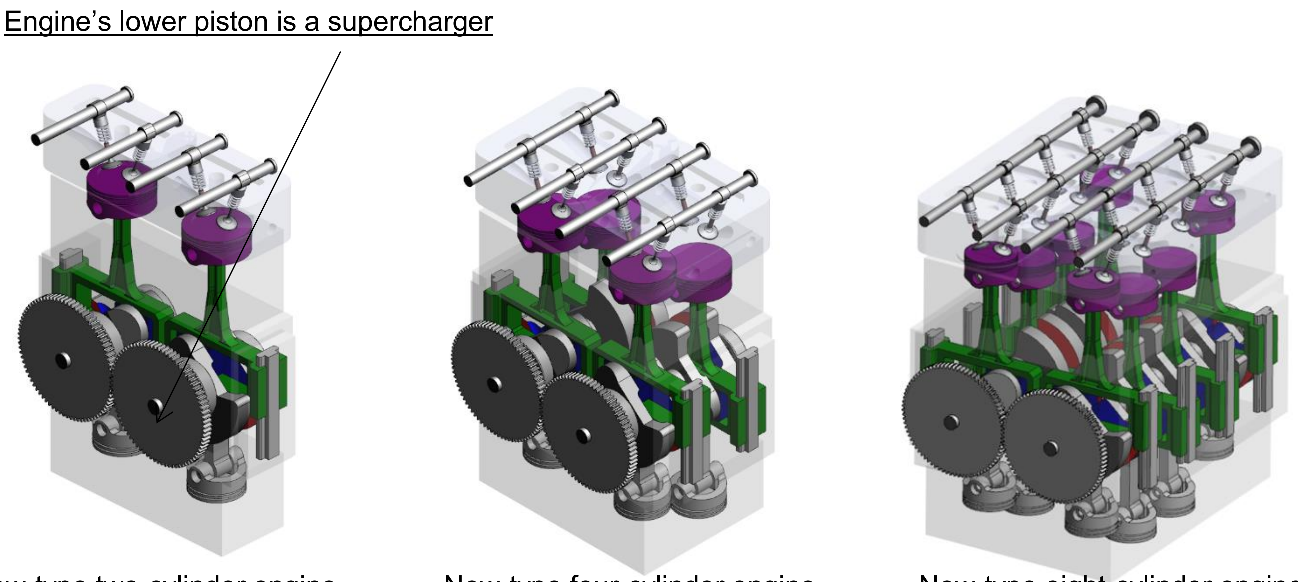
② Two-cylinder Z mechanism doesn't need a crosshead for piston, thus it is possible to downsize and lighten the whole body without changing the engine displacement. Therefore, the weight ratio becomes better than the motors as well.

- → It has high output power and light body, so it would realize various vehicles such as a flying car, flying cargo, and so on.
- → It is possible to design the Z mechanism engine with 10,000 horsepower/ton which is comparable to a jet engine (The conventional reciprocating engine produces Max. 2000 horsepower).
- → If it is installed into a drone, it can soar longer than the conventional motor drone.

③ If it is installed into a 1 crank-4throw mirror structure, it becomes a hi-performance and non-vibration engine which is applicable to a large marine engine and seaplanes.

④ Since the Z mechanism engine is an internal-combustion engine, the energy saves 1/30 compared to the jet engine which is an external-combustion engine. Z mechanism's air inflow is 1/1000 of the jet engine, so it less pollutes the atmosphere.

⑤ Since it can provide a low-speed torque, it is applicable to a large seaplane engine.



New-type two-cylinder engine with a supercharger (200%)

New-type four-cylinder engine with a supercharger (400%)

New-type eight-cylinder engine with a supercharger (800%)

Fig.6 Images of Z mechanism engine applications

8.Our patent property and publicity

Our technology regarding the Z mechanism is protected by patent domestically and internationally.

◆Primary patents of "XY separate crank mechanism":

JAPAN: No.5632962, No.6052748, etc.
ABROAD: No.US9316249(US), No.US2018/0030889(US), etc.

The Z mechanism engine was introduced in articles on a monthly magazine, "Nikkei Automotive" in February 2018(P.86-91) and in March 2018(P78-82). We also presented our research at the annual conference of Society of Automotive Engineers of Japan, in October 2016 and May 2017.