This is an unexpected return of the rotary engine.

As of 2023, the survival of the engine itself is in doubt, and Mazda has reintroduced the RE,

which was once withdrawn from the market due to its inability to meet fuel efficiency and emission regulations.

Moreover, it is a completely new model with a completely new design, and of course the title is SKYACTIV.

How to use: A prime mover for driving a generator for series hybrids.

AVL once made RE in a similar direction, but it was just a prototype.

Mazda introduced this as a system and has installed it on commercially available cars.

A new RE riding the big wave of electrification. Why was this newly adopted?

What are the advantages over reciprocating machines?

Since this is a new model that requires a huge investment, can we expect a return? My interest is endless.

The 8C type rotary engine attracts attention all over the world. Let's dig into this.

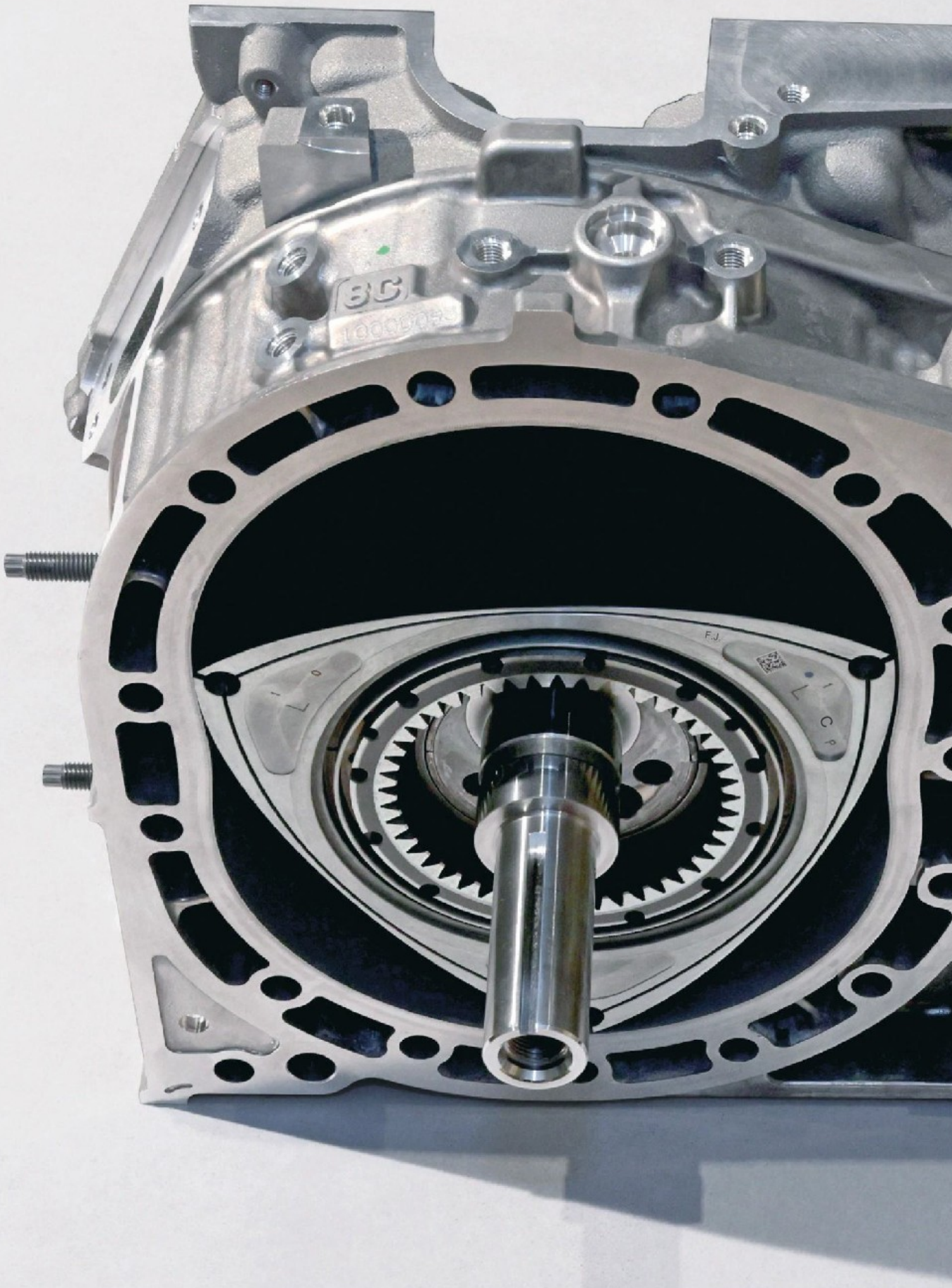
PHOTO: Hiroya YAMAGAMI

Wankel rotary engine **comes back!**

new generation rotary

Mazda 8C

Complete explanation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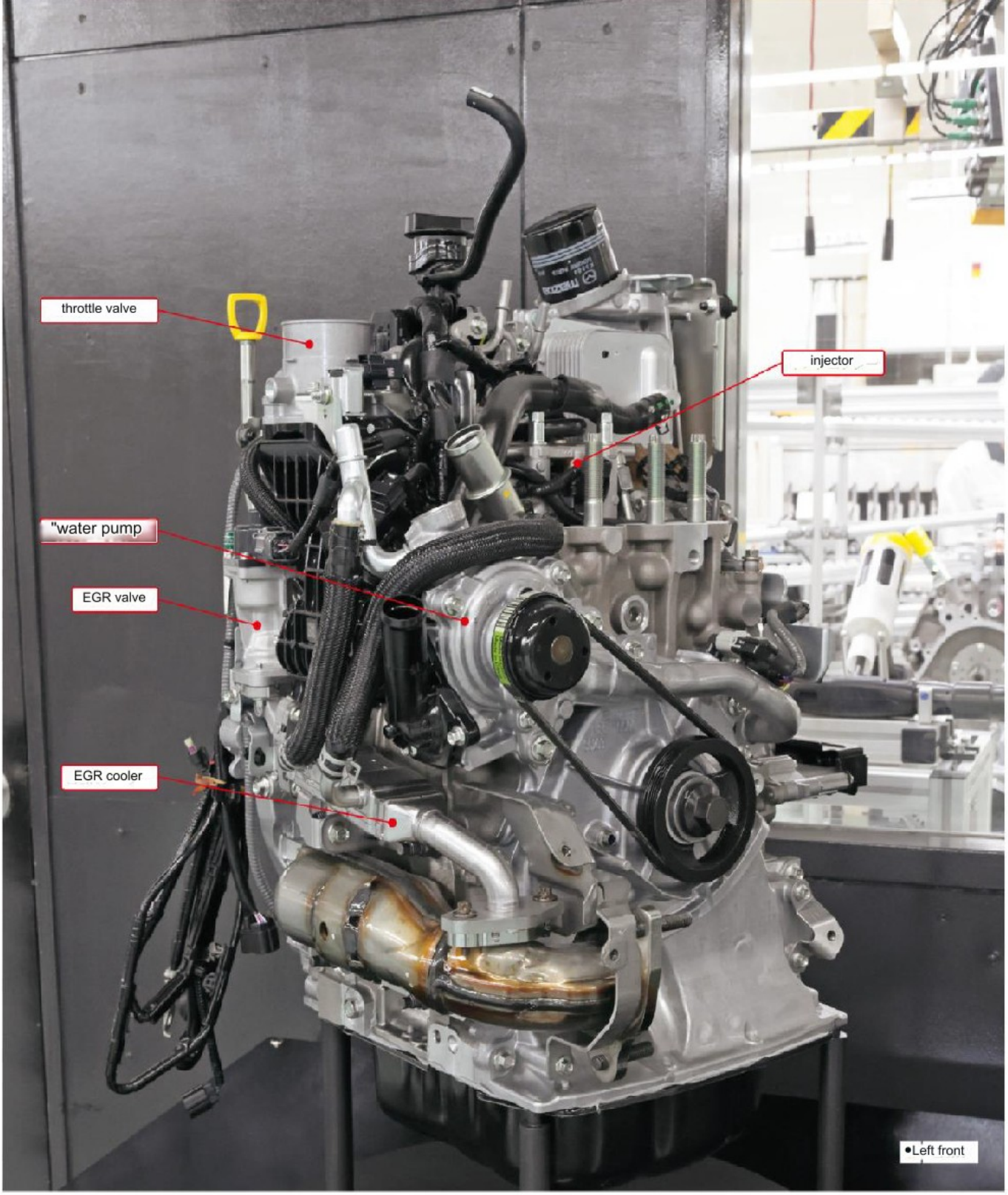


New
generation rotary!

Part 01

Overview_01

World, this is 8 degrees Celsius.

The e-SKYACTIV R-EV had already exhibited its hybrid unit, but since it was a cutaway model, we could not see any details of the engine. This time, for the first time, I was able to see the whole thing. Let's introduce it from each direction.

TEXT:MFI PHOTO: Hiroya YAMAGAMI/MFI

When I saw the actual machine for the first time, it was bigger than I expected. However, if you look closely, you can see that this is because the auxiliary equipment is on top, and that apart from that, it has a compact, cubic-like body.

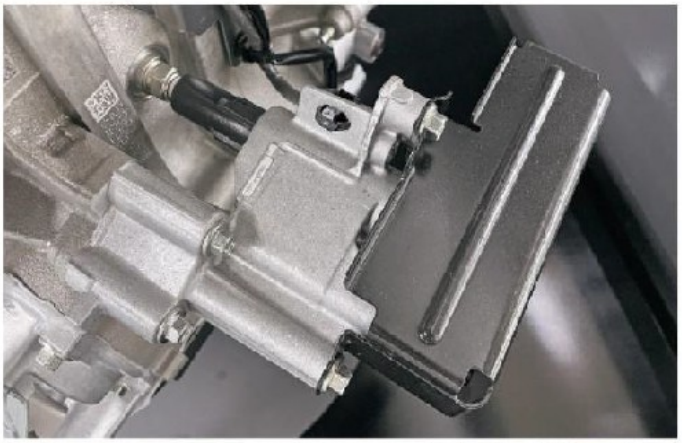
This is a new rotary engine for Mazda, and I wonder if it will be ``2" in terms of generation. The new machine, named 8℃, is an ambitious work that pursues thermal efficiency, incorporating many of the SKYACTIV concepts that have taken the world by surprise with its reciprocating engine. Rotary engines are huge and flat, and the moving combustion chamber makes cooling loss difficult.

The previous view was that the 8C tends to be inferior in thermal efficiency, but the 8C is a dedicated power generator for series hybrids (actually, DHE: the world's leading hybrid engine for commercial vehicles, along with Nissan's HR14DDe. It seems that the operating range has been brought closer to the high efficiency point. As for combustion technology, Mazda's specialty MBD: Making full use of model-based development, the complex behavior of RE combustion is highly analyzed, and in combination with direct injection technology, high-speed combustion is achieved.

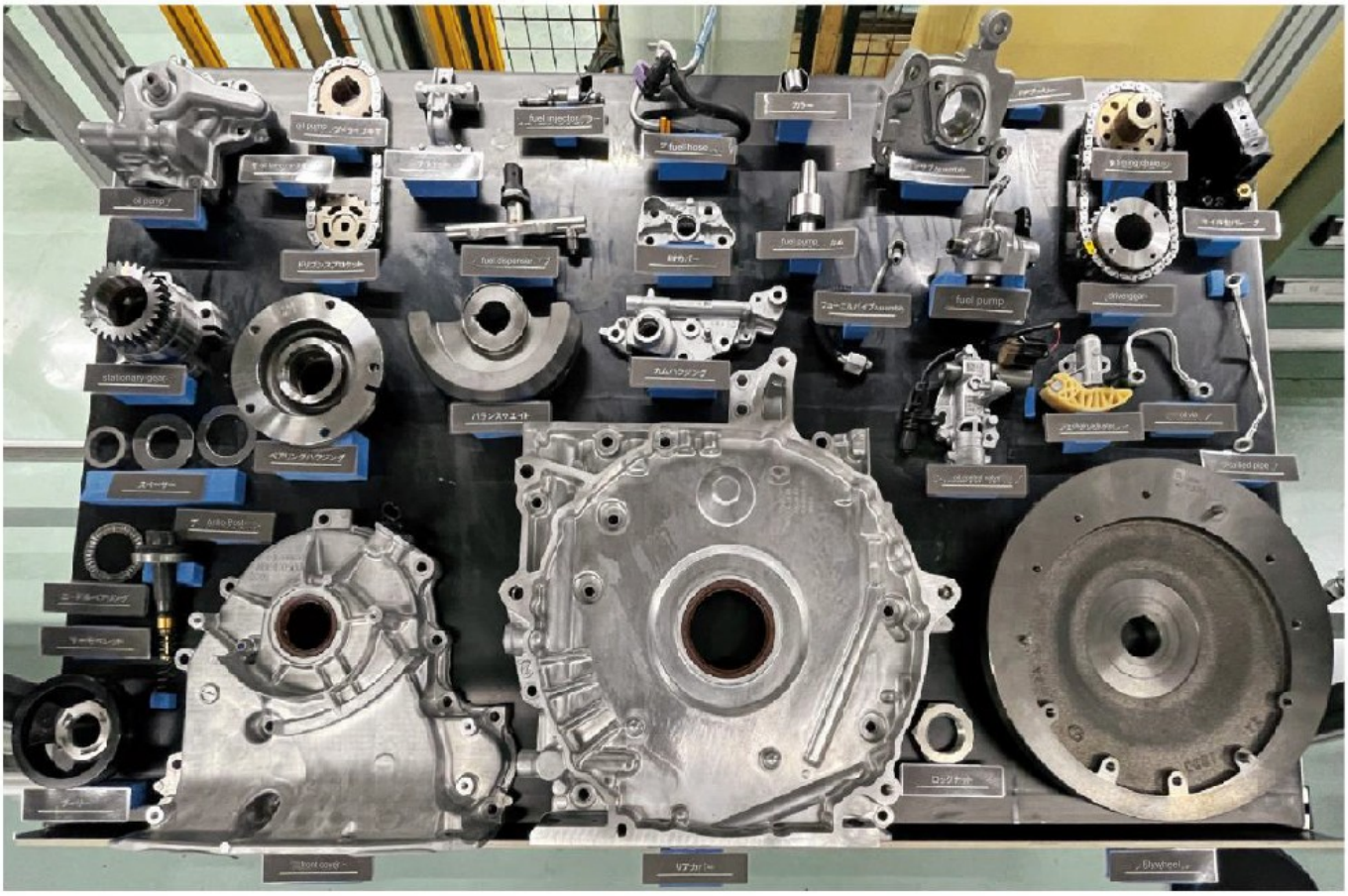
The first model installed is MX-30. First among Mazda cars It is a car model that plays a sharp role, and is perfectly suited to be the first in a series of HEVs that use RE. Since it will be mounted on the same vehicle, the powertrain is horizontally mounted, and unlike the previous 13B, the 8℃ is the first horizontally mounted RE. Compared to 13B, which had two chambers, the temperature of one chamber (single rotor) was 8℃, meaning that one rotor, which is relatively large and heavy, rotates at high speed, so it seems difficult to counteract vibrations. The layout is also unique in that the engine is mounted on the transmission side (on the left side of the vehicle), unlike a normal horizontally mounted powertrain.

Output shaft side

↑ Compactness can be seen when viewed from the rear, where there are few auxiliary machines installed. On top of the housing are the oil pump related parts at the rear of the main body, and the fuel intake related parts including the throttle valve at the front. Due to the adoption of direct injection, it appears that lubrication was difficult for the RE, which pumps oil directly into the working chamber. Exhaust air is discharged from the front lower part, and the piping is bent 90 degrees and sent to the rear. The actual exhaust pipe containing the catalyst could not be confirmed. It can be seen that a damper is provided at the connection to the generator to suppress vibration.

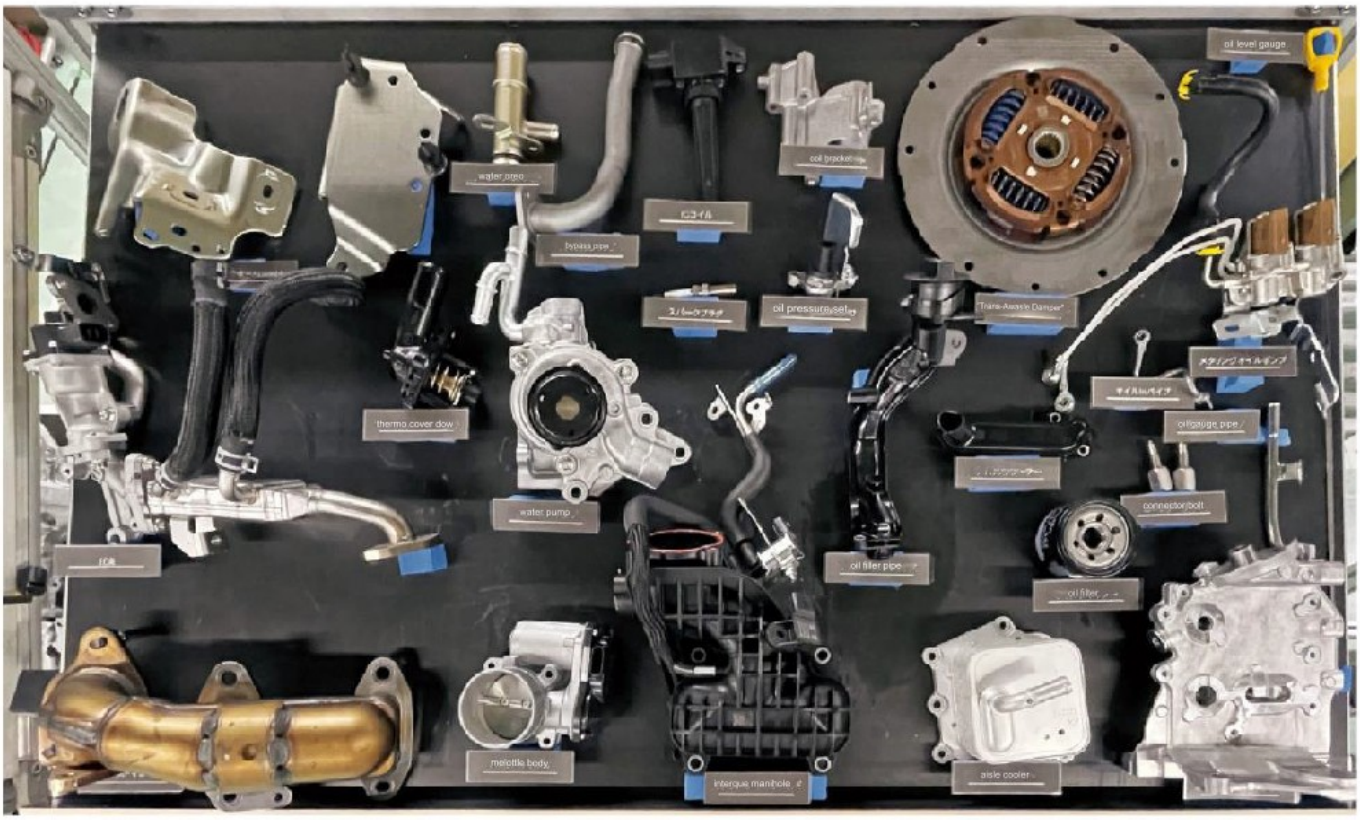


↓(Bottom) Exhaust manifold. An EGR diverter pipe was installed just before the flange that connects to the catalyst. EGR is returned to the intake pipe via a water-cooled cooler. (Right) Ignition coil and spark plug. REs up to 13B had two spark plugs, leading and trailing, but BC had one. Will they use specially shaped spark plugs for RE? (Bottom right) Direct injection area. The fuel rail is held in place by two bolts, and the injector is located beneath it.



↑ A group of parts installed on the engine body. The small number of parts in RE can also be understood from this. As you can see from the bolt flange, the flywheel has an eccentric structure. I guess the unit vibration is suppressed by combining it with the balance weight. Fuel pumps for direct injection require high pressure, so they rely on gear and chain drives, just like reciprocating machines. The oil pump is also driven by a gear and chain on a separate shaft.

↓This is auxiliary equipment. Reciprocating engines use EGR recirculation to reduce pumping losses and achieve high efficiency operation, but does the 8C use EGR to lower the mixture temperature? There was no specific explanation. The lubrication system is an integrated water-cooled oil cooler. You can see two supply pipes extending from the oil pump body. Connect this to the top of the housing, in front of the fuel injector.



A word that always appears in explanations of rotary engines is the trochoid curve. The original meaning is ``the trajectory drawn by a single point fixed on the circle when a circle rolls along an arbitrary curved path without slipping", and although the movement may seem complicated, this curve... can be calculated geometrically. By combining the outer and inner rotors to precisely follow this curve, it is possible to create a variable volume while sealing, and this has been used in many applications such as oil pumps for a long time.

In other words, the trochoid curve is not only used in rotary engines, but is simply one of the trajectories generated by rotational motion. It shows how a point far from the center of a circle moves as it rotates.

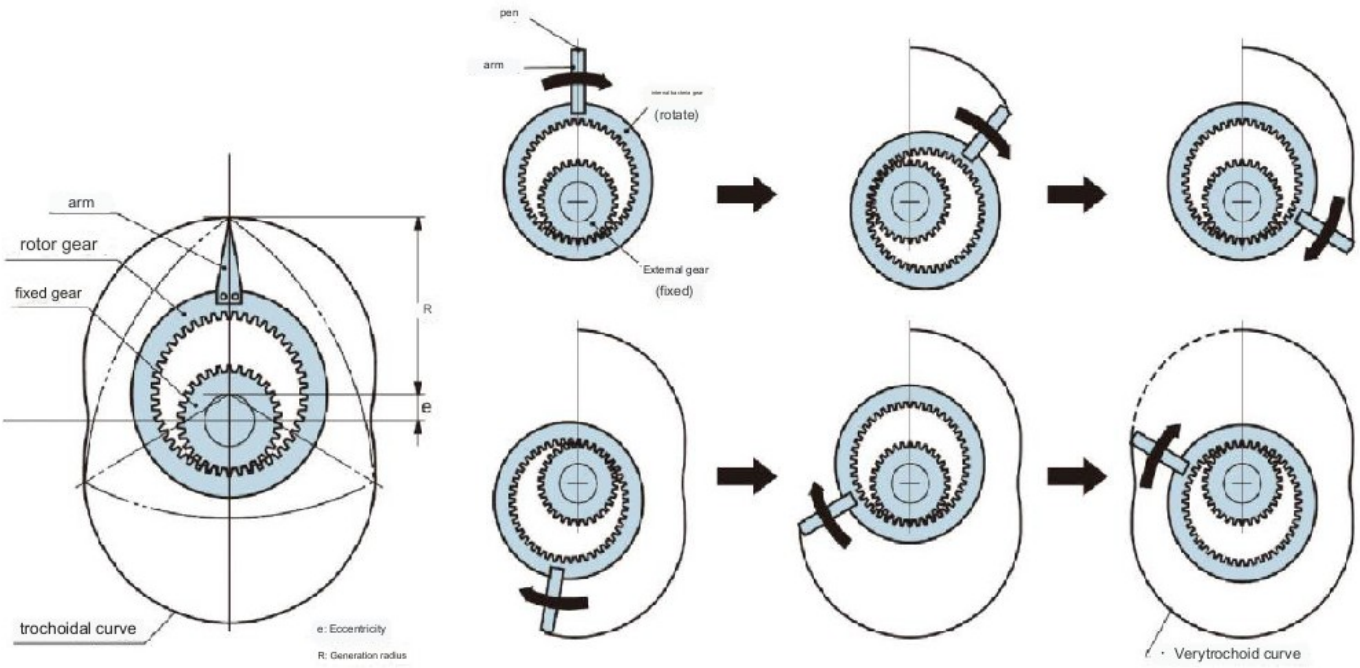
The rotary engine is an internal combustion engine that uses this trochoid curve. Unlike the general reciprocating internal combustion engine that uses pistons, the rotary engine was already developed in the late 16th century as a prime mover that could extract circular motion directly as driving force.

There was a time when what could be called the progenitor of research appeared in literature, and many researchers competed with various ideas. However, until 1957, when German Dr. Felix Pankel completed the Pankel-type engine using a triangular rotor, there was no example of this being put into practical use.

Dr. Pankel researched and analyzed various rotary engine proposals and created the optimal trochoid shape. Originally, it was used to polish the airtight seals of rotary valves and superchargers in aircraft engines.

Beritrochoid curve with two nodes of Pankel type rotary

The diagram below shows how to create a trochoid curve, which Dr. Pankel's team devised at a time when simulation was not yet mature. External gear in the center It is fixed and a rotor gear with internal teeth is engaged with it. If you combine the pen with an arm that matches the shape of the rotor and rotate it, this The pen draws a cocoon-shaped trochoid curve. The trochoid chamber inside the housing is always divided into three working chambers by a rotor. As the working chamber rotates, it "moves" within the housing, increasing and decreasing its volume.



Overview_02

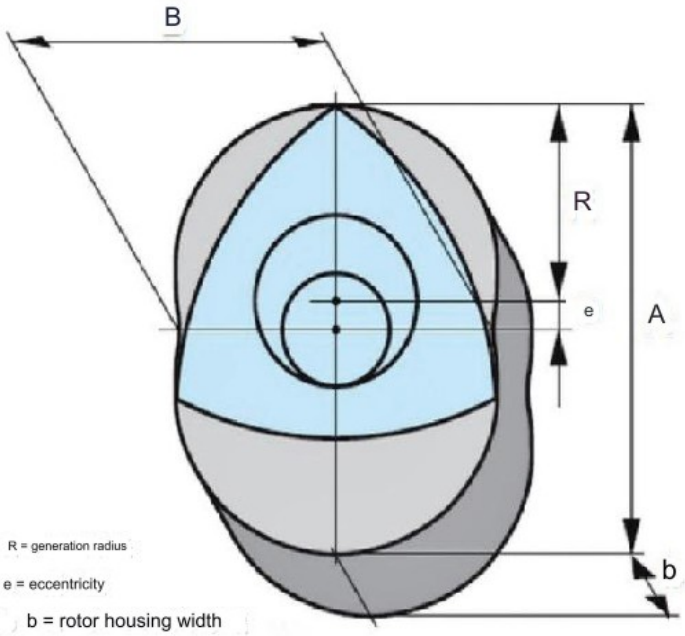
What is a trochoidal curve?

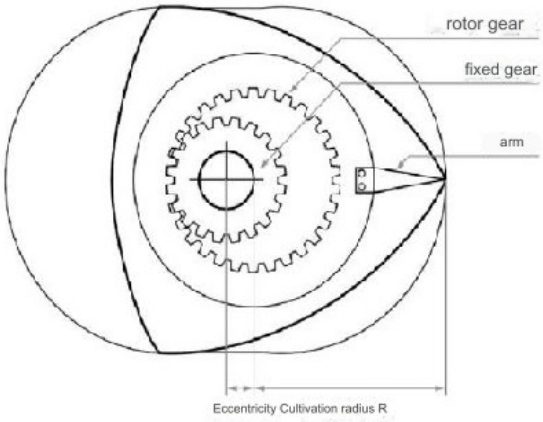
A rotary engine generates power by eccentric rotation of a rotor inside a housing.

The cocoon-shaped line connecting the trajectory of the rotor's apex during this process is the trochoid curve. It looks like a complicated movement

All of these operations are based on necessity derived from geometric calculations.

TEXT MFI FIGURE:MAZDA/Toshinao KUMAGAI





R = generation radius

e = eccentricity

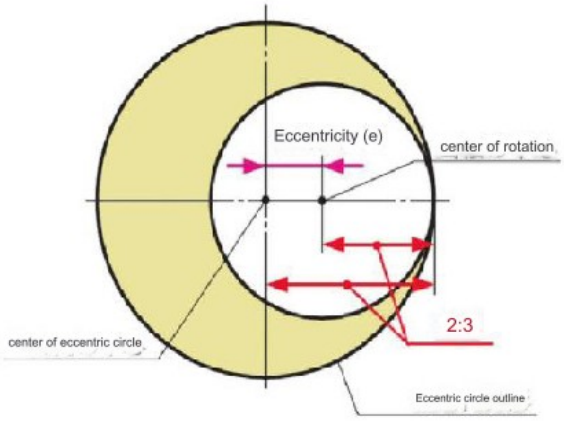
b = rotor housing width

A = Trochoid major axis length [2 (R'+e)]

B = Trochoid minor axis length [2 (R'-e)]

VH = stroke volume

VH = 33R'eb



Calculating the displacement of a rotary engine with a complex shaped working chamber

As mentioned above, the trochoidal curve follows a geometrically derived constant, and although the formula is complicated as shown in the figure above, the volume of the process can be calculated by calculation. The displacement of the rotary engine is obtained by subtracting the minimum volume from the maximum volume derived from this calculation. The creation radius is the value connecting the rotor center and the apex, and the eccentricity is the value from the center of the eccentric circle to the center of rotation. The 8C rotary engine is an all-new design that has been completely redesigned from Mazda's long-running past units in terms of both the radius of production and the amount of reserve. The eccentricity has been increased to create a long stroke similar to that of a normal reciprocating engine.

This can be said to be the result of making full use of his extensive experience in conducting research. The air-fuel mixture is combusted in the working chamber formed between the housing and the triangular rotor, which resembles a rice ball.This expansion pressure turns the rotor and generates rotational force. The inner periphery is required to have a trochoidal shape. Suppose we put a triangular rotor in a perfectly circular housing.

Good morning. In this case, the volume of the working chamber changes even if it rotates.

Even if the air-fuel mixture is ignited, the pressure remains in the rotor.

It only works in the direction of the heart and does not lead to rotational movement.

However, the trochoidal shaped housing and eccentricity

It is attached to the eccentric shaft that is the axis.

By combining the rotor with

The volume changes twice per rotation, resulting in inhalation,

Enables the internal combustion engine strokes of compression, expansion, and exhaust.

becomes. The triangular rotor is offset inside the housing.

Performs rotational movement, resulting in smooth operation with a small number of parts.

Pankel type rotary engine realizes smooth driving.

Jin, the trochoid curve supports its operation.

8C type rotary

beritrochoid curve

The illustration on the right shows the housing of the 8C unit

ng and rotor shape. MX-30's

Body frame common to BEV models

be able to be mounted on

The RX-8 was designed in consideration of its output characteristics.

RENESIS 13BI installed

The creation radius is increased by 15mm from the engine

set to 120mm. The amount of eccentricity is

At 17.5mm, these are zero based

The value was determined after consideration, but it is 13A

It was very close to the numbers, so I was disappointed.

For the cold shape, select the same specifications as 13A

This led to rapid development. What is

No, other technical factors are significantly

Since it is evolving, I call it "C"

There is. Displacement starts from 654cc for 13B

830cc (RX-8 is 2-row

).

New generation rotary!

Part 03

Comparison

13B and 8C, old and new comparison

The previous model 13B was a veteran unit that followed the basic design from Mazda's first RE/10A model. Since then, the 8C type has been introduced with all new features. I was blessed with the opportunity to see both of them together. Let's take a look at the differences between the two REs, which have a small number of parts and appear to be similar in shape. TEXT: Kota SERA PHOTO: Hiroya YAMAGAMI

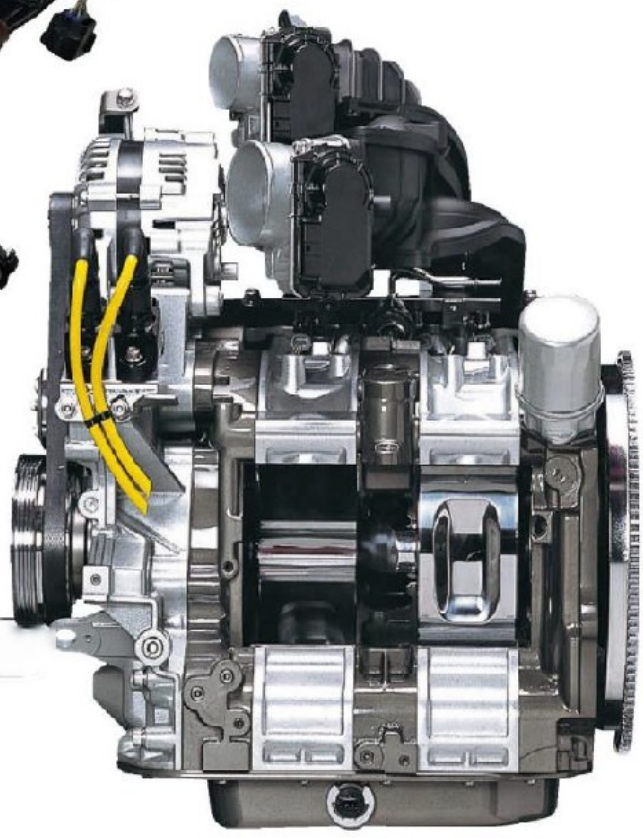
8C

SPEC I 8C-PH

Type: Wankel type rotor
Displacement: 830cc×1
C (eccentricity): 17.5mm
R (creation radius): 120.0mm
b value (housing width): 76mm
Compression ratio: 11.9
Maximum output: 53kW/4500rpm
Maximum torque: 112Nm/4500rpm
Fuel supply system: Direct injection
Intake port type/total number: side boat/2
Exhaust port type/total number: Side port/2

SPEC 13B-MSP high power version

Format: Wankel type 2 rotor
Displacement: 654cc×2
E (eccentricity): 15.0mm
R (creation radius): 105.0mm
b value (housing width): 80mm
Compression ratio: 10.0
Maximum output:: 184kW/8500rpm
Maximum torque: 216Nm/5500rpm
Fuel supply device: port injection
Intake port type/total number: Side port/4
Exhaust port type/total number: Side boat/2



13B

Horizontal single and vertical 2 rotors

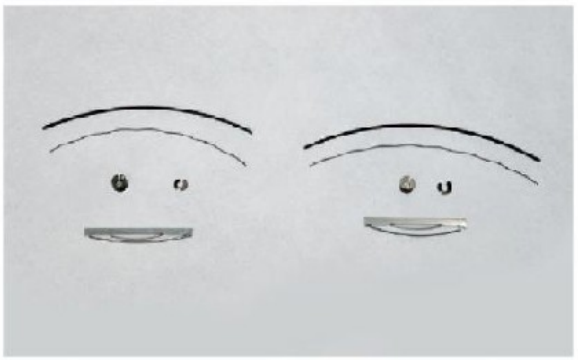
The 8C is a horizontally mounted single rotor, and the photo shows it mounted in a car, viewed from the rear. There is space for a 12V battery on the top left side. Designed to be slim despite mounting restrictions in the width direction. The generator is located on the right side. The main difference from the 13B is that it uses an EGR cooler (mounted on the front). What you can see in the middle row on the left side is the water pipe. The intake and exhaust system is located at the front, with the exhaust pipe exit peeking out to the left. The 13B, the predecessor of the 8C, had a two-rotor vertical layout. The right side is the rear of the vehicle.

rotor

The rotor flanks, which are 76mm thick for the 8C and 80mm thick for the 13B, are coated with carbon to prevent soot from peeling off. To prevent it from getting caught in the seal. In the era of 13B, it was not possible to coat the apex seal, but due to technological advances, the 8C can now coat the apex seal up to the very edge. The BC rotor recess is biased toward the leading side, and this is to start and finish combustion quickly. 13B has a symmetrical recess located in the center.

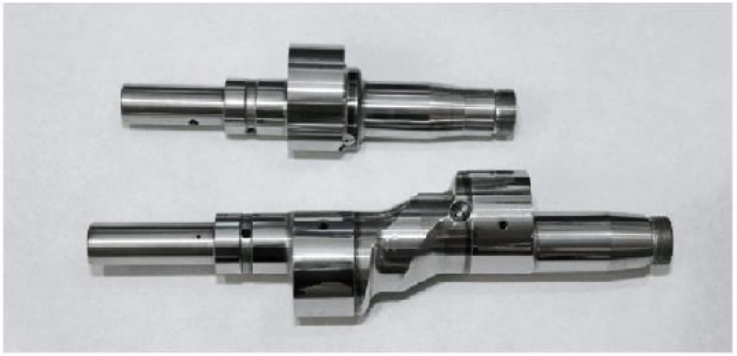
↓ The 8C rotor is on the left, and the 13B rotor is on the right. When you compare them side by side, you can clearly see the difference in size and understand that the influence of rotational balance is even more severe. The recesses on the sides of the three vertices of the rotor were cut to balance the rotation (see PO32 for details).

From the top: side seal, corner seal, apex seal. The one on the left is for 13B, and the one on the right is for 8C. The corner seal diameter of 8C is the same as 13B, but the width of the apex seal (2.0mm for 13B, 2.6mm for 8C) is different. The springs that hold the corner seals in place seem to be the same.



eccentric shaft

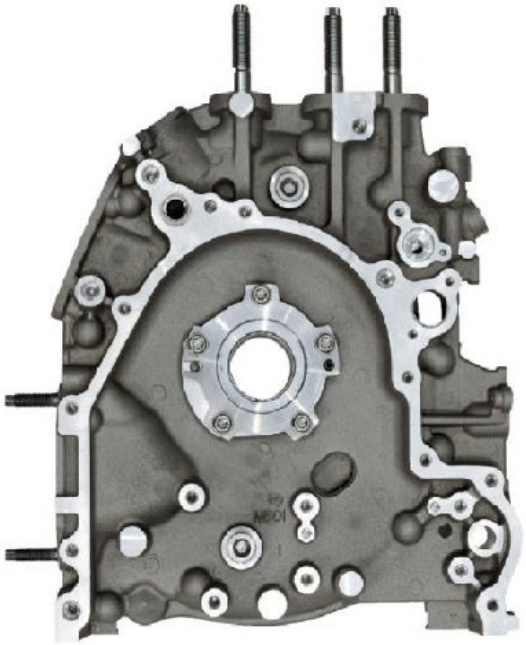
The eccentric shaft (output shaft), which is the crankshaft of a reciprocating engine, is made of the same material. The upper temperature is 8℃, the lower temperature is 138℃, and the particularly thick part is the rotor journal. In line with the shift from two rotors to a single rotor, we reviewed the spray angle of the oil jet used to cool the rotor. In the case of a 2-rotor, there was an intermediate housing, so there was relatively much freedom in selecting the hole position, but with the 8C, positioning was difficult, so we had to find an angle somehow.



An oil passage is provided inside the shaft to lubricate the bearings and the inside of the rotor. 13th is front side and rear Oil was flowing from the side, but the 8C only flows from the front side. The holes on the side of the journal are for removing weight and balancing.

8C

•Table



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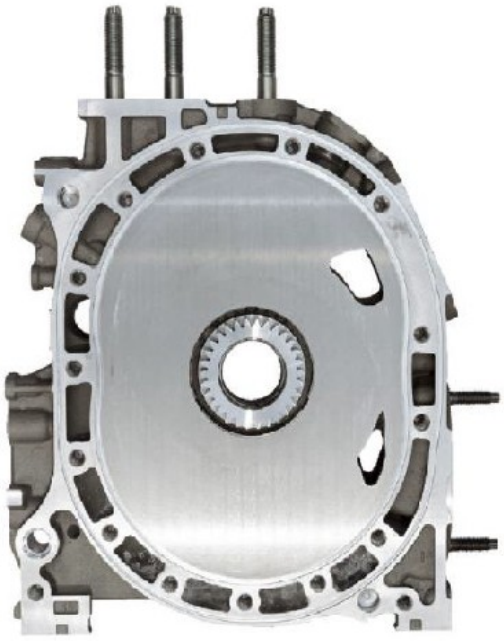

BC's front side housing is located on the far left side when mounted on the vehicle. If we assume that the three pins visible at the top are the same idea as the SKYACTIV engine, they will serve as locators when assembling to the vehicle body. Longer pins allow faster positioning, allowing components around the powertrain to be mounted closer together without interfering with the powertrain.

Front housing

front housing

As you can infer from the rotor comparison photo on the previous page, the size of the side housing is also proportional to the rotor size. BC is much larger. The biggest difference other than dimensions is the material; the 13th is cast iron, while the BC is aluminum. The weight is significantly reduced just by using different materials, and the design is thin to fit into the narrow motor room. The port cross section is vertically shaped to ensure a flow path.

table

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13B

table

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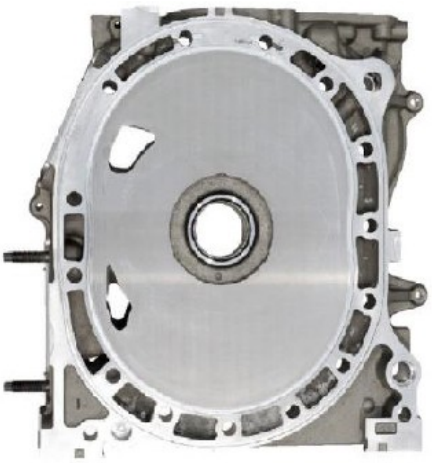

It is not similar in shape to 13B, and the cooling waterways have been revised. 13B has port injection, while 8C has direct injection, so the injector hole is located near the center of the housing. You don't want to make the hole too big because the apex seal will pass through it during the compression stroke.

The true value of the side housing is the cermet sprayed on the rotor sliding surface (see page 033 for details). It is also applied to the R26B of the Mazda 787B, which won the 1991 Le Mans 24 Hours. The engineer in charge says that it is "connected" with the technology of the time. The durability and production technology required for single-piece production for racing and mass production are different. The top left corner of the "table" is cut off to smooth the intake flow according to the installation.

Rotor housing

rotor housing

Rear housing

rear housing

The 13B has two spark plugs, located on the trailing side and leading side on the right side. 8C has one and is located almost in the center. In order to make the plug hole smaller, the diameter of the plug installation screw was M12 on the 8C, compared to M14 on the 13th.

The center of the cast iron side housing is treated with gas nitrocarburizing to ensure durability. Another feature of the 13B is that it has an auxiliary port in addition to the main port for intake (rotor rotates clockwise). While the 13B was aimed at high output, the 8C is aimed at high efficiency. The shape of the intake and exhaust ports, which correspond to the valve timing and lift of a reciprocating engine, reflects the different aims.

table

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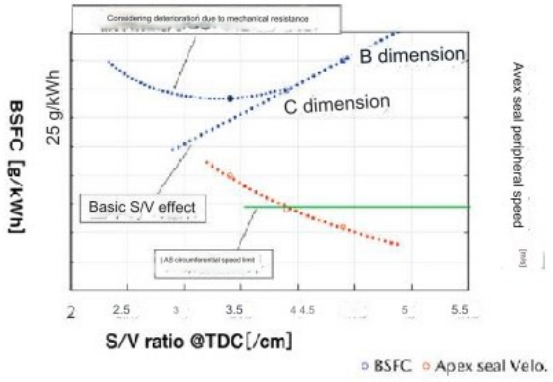
8C structure, thorough dissection

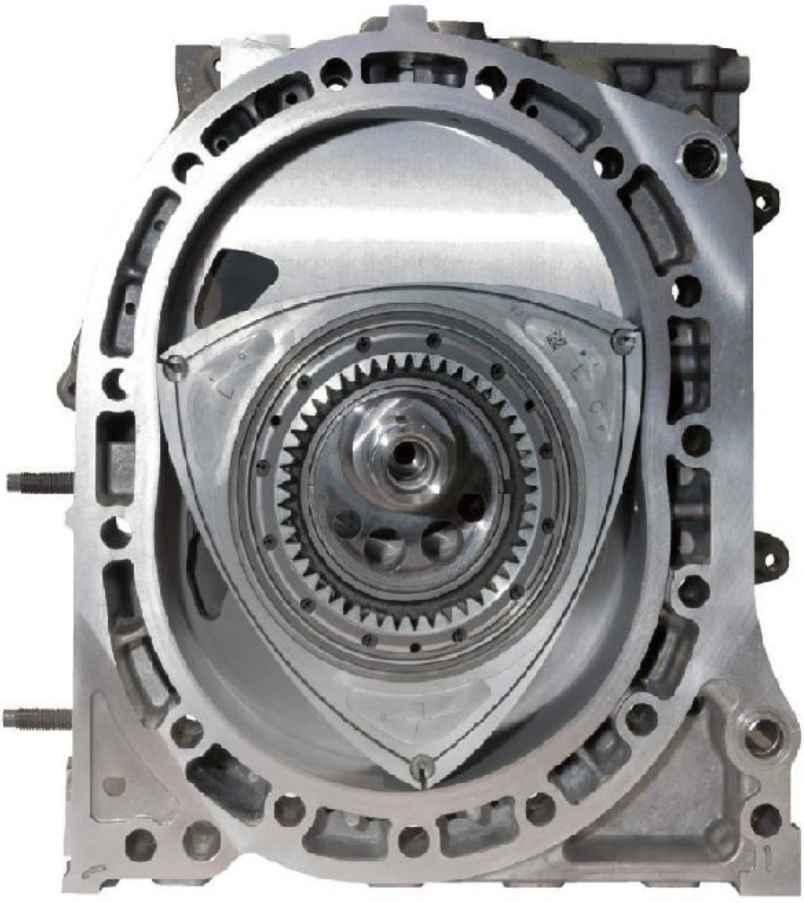
Dimension | Zero-based design

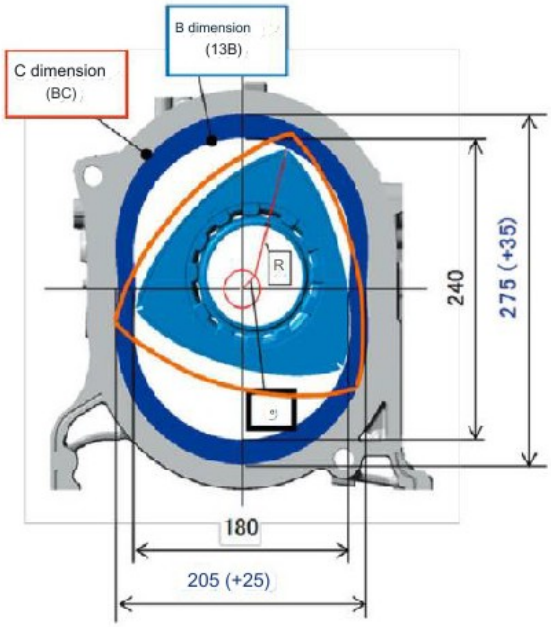
issue I want to increase the thermal efficiency of RE

Reciprocating ICEs in which the piston moves up and down have specifications called S/V ratio and stroke/bore ratio. It is piston stroke length + cylinder diameter, and if it exceeds 1, it is a long stroke ICE where the stroke is larger than the bore. This number also affects the inner surface area of the cylinder, and the smaller the surface area, the lower the cooling loss, so designers should consider

Select the S/V ratio that matches the ICE. As shown in the graph on the right, we set the S/V ratio at just under 3.9, which is closer to the long stroke side than the conventional B-dimension RE, and at the same time, the S/V ratio was set at the limit without deteriorating fuel efficiency due to mechanical resistance. This is the first dimension change since RE was born. The aim is to improve BSFC (net fuel ratio), which means improved fuel efficiency.







Selection of solution C dimensions

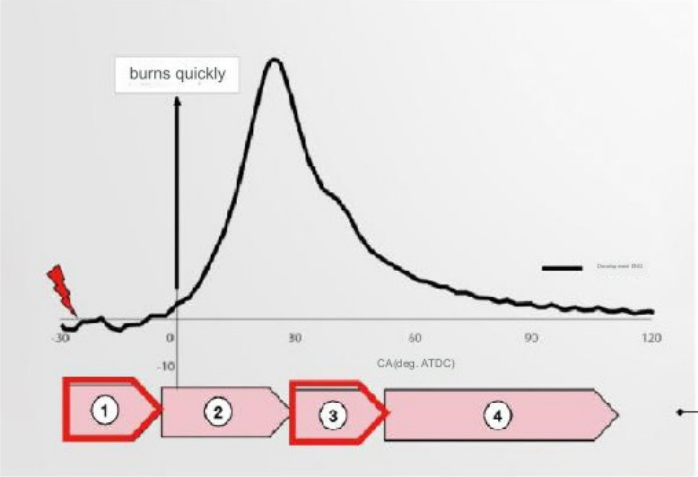
In the case of RE, the K value, which is the distance (R) from the rotor center to the three vertices divided by the difference between the output shaft center and the rotor center (referred to as eccentricity), corresponds to the S/V ratio. 8C is K value increases, the S/V effect reduces fuel consumption, and at the same time Where the circumferential speed of the apex seal does not exceed the limit. The shape of the trochoid curve was determined by

8 represents the displacement of approximately 800cc, and C represents the dimension (shape) of the trochoid curve. 13B means a dimension B type with a displacement of 1.3 liters, and 12A means a dimension A type with a displacement of 1.2 liters.

This is the first time that the C type trochoidal curve has been adopted, and it is a newly designed RE that has changed both the bore and stroke.

TEXT:MFI PHOTO: Shigeo MAKINO/ MFI FIGURE:Mazda

DI : Fast combustion



issue RE's unique way of burning

Compared to reciprocating ICEs, REs have a flat combustion chamber, so the combustion flame spreads more slowly after the plug ignites. This is part of the reason why it is said that REs run smoothly, but have poor fuel efficiency..Therefore, we made the combustion start-up as fast as that of Skyactiv G, and created a combustion chamber shape that smooths out the secondary combustion characteristic of RE that occurs during the subsequent expansion stroke.

① Ignition ~ Initial combustion: Internal combustion in the narrow space of the plug pocket (specific to RE) ② Main combustion: Combustion by flow in the combustion chamber (common to GE)

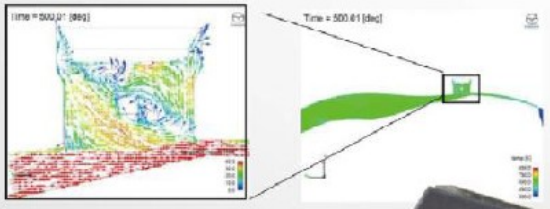
③Secondary combustion: Flow caused by complex changes in the shape of the combustion chamber

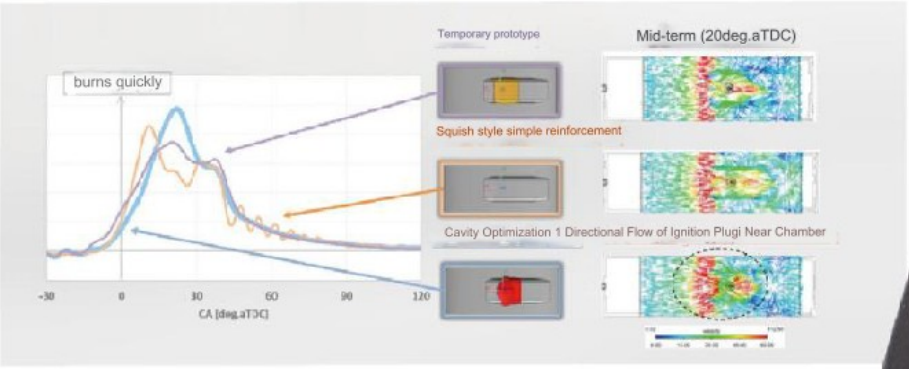
Combustion by (squish flow during expansion stroke) (specific to RE)

④Late combustion: Combustion toward the unburned area (quench zone) (common to GE)

solution 1 Utilizing MBD

This is the first time Mazda has adopted MBD (model-based development), which is being promoted company-wide, into the RE. By modeling the initial combustion within the recess where the spark plug is located, we designed the combustion chamber so that the growth of the flame as it moves through the combustion space contributes to the output.





Solution 2 Innovative combustion chamber shape

The recess provided on the rotor side allows the flame to grow here immediately after the plug ignites, and the rotor

This is to make the flame advance in the direction of rotation. Combustion chamber shape becomes continuous and complex

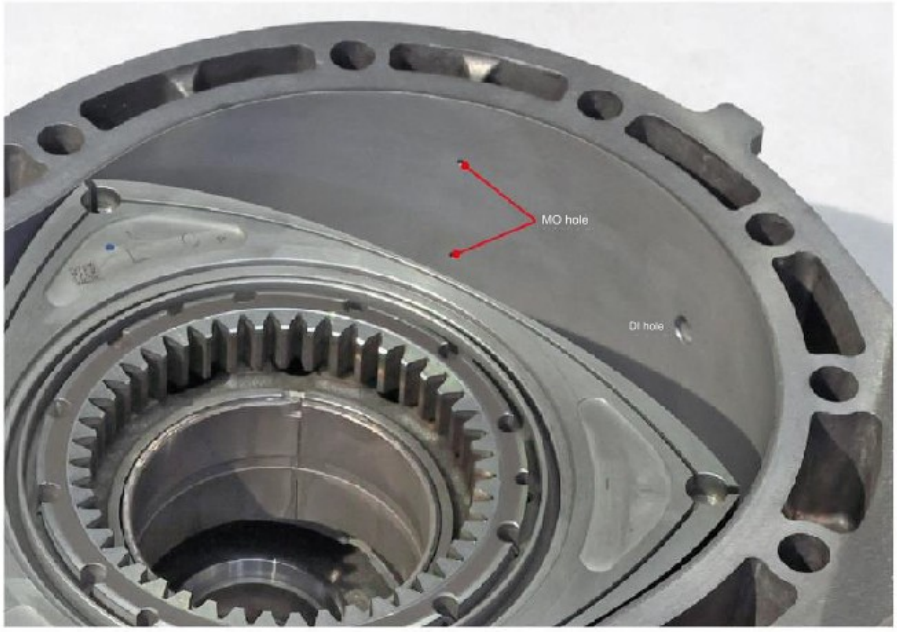
This is the part where the knowledge of SkyActive G/X was poured into the changing RE

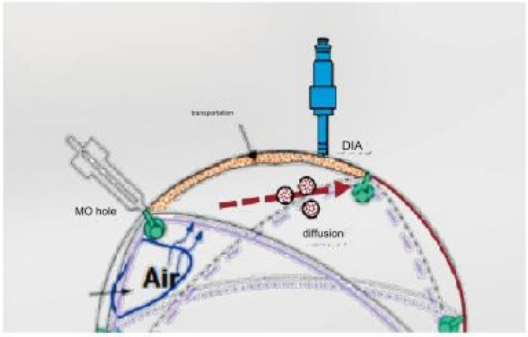
DI : Injection & lubrication

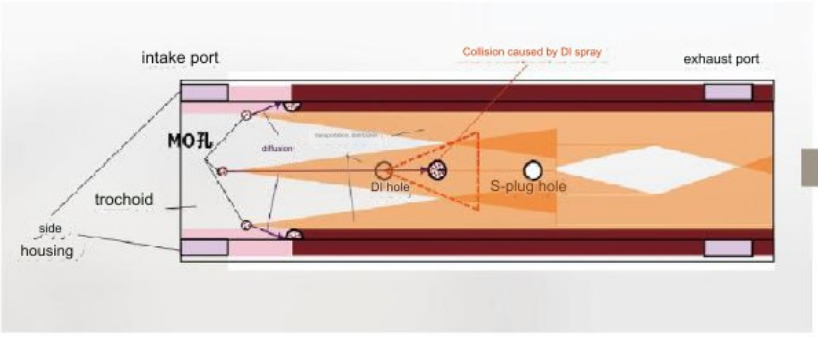
issue

Wall wet measures

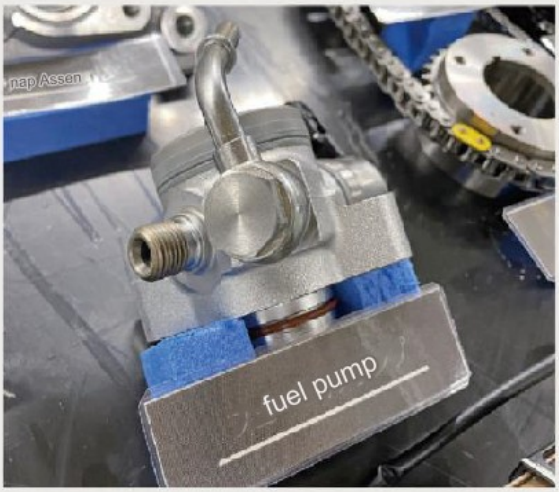
To lubricate the rotor and housing, the RE has a MOP (metalling oil pump) injection hole in the combustion chamber that sprays oil into the housing, and the apex seal on the rotor side carries the oil. However, in the 8C, where the fuel supply is DI (direct injection), the oil is partially washed away by the injected fuel. The schematic diagram below shows this pattern. Among the oil sprays (orange) coming out of the three MO holes, the oil sprayed from the central MO hole collides with the fuel at the fuel DI hole, and as the rotor rotates, an oil film is formed. The apex seal will pass through the cut part.







direct injection system



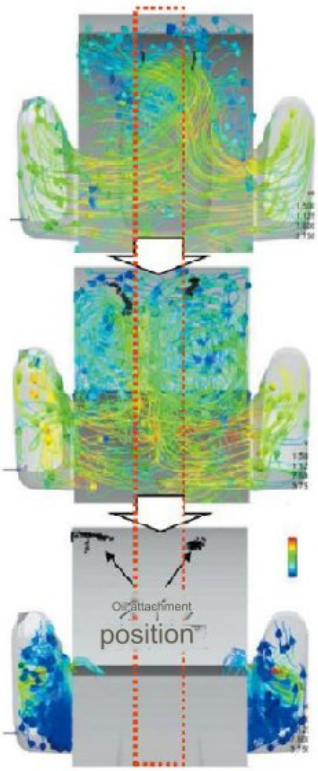
Left: A fuel pump that operates by receiving power from the rotation of an eccentric shaft using gears. Find the injection timing using the tune you see next to it. The fuel injection pressure is similar to that of a typical gasoline direct injection ICE.

Right: Direct injection injector and rail mounted on the rotor housing. At the beginning of development, the fuel pressure was increased and multi-stage injection was applied, but that alone did not seem to solve the problem. The final specification was a maximum pressure of 30MPa/three injections.

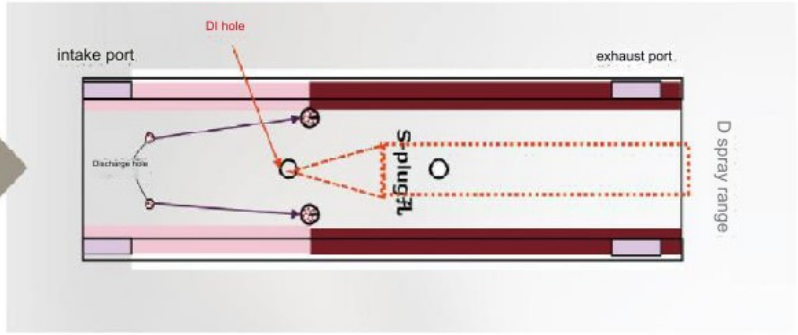
Utilizing solution MBD

Using the latest simulations, we visualized how the lubricating oil emitted from the MO holes diffuses, and searched for MO hole placement and oil injection conditions that would not interfere with the fuel injected into the cylinder. The result is the series of figures on the right. The oil that exits the MO hole is diffused throughout the combustion chamber, but does not interfere with the fuel. This is also a result of MBD, and conversely, MBD is essential for implementing simulations with such high accuracy.

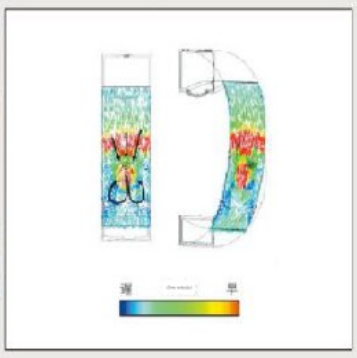
DI spray range



Crank angle20



Stratification of mixture



The fuel injected into the cylinder mixes with air to form an air-fuel mixture that collects near the spark plug. The ignited mixture then becomes a fast combustion flame that spreads. Since the finely divided fuel is sufficiently vaporized even at low temperatures, the amount of fuel injection can be reduced.

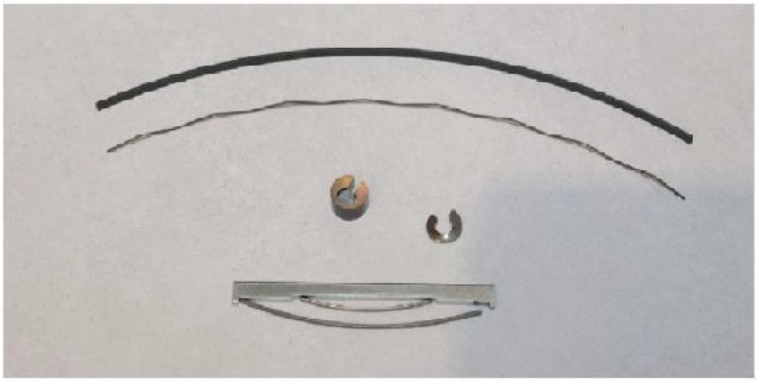
Ignition device located on the side of the rotor housing. Unlike previous REs, there is only one brag. With the introduction of EGR, it appears that the ignition energy has been slightly increased to improve ignition performance.

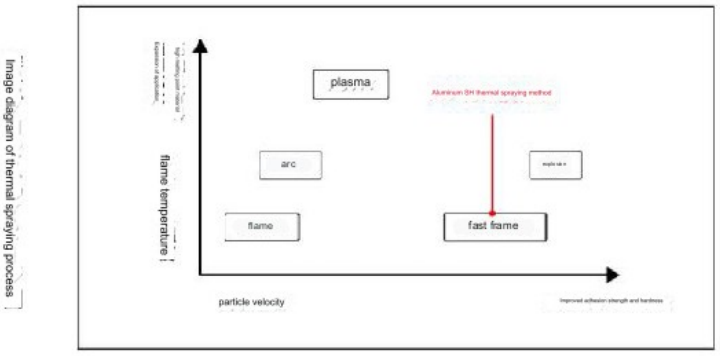
Weight reduction

issue 1 Aluminum side housing

As the rotor rotates, three side seals on each side slide on the side housing surface. Although it uses lubricating oil, it has been said that only a steel housing with a hardened surface treated with nitriding can withstand the heat. Lighter at 8℃

Therefore, we decided to make the side housing aluminum, and by adopting a method of bombarding the soft aluminum surface with molten (ceramic) powder at high temperatures, we were able to meet the requirements of mass production, including cost, and adhesion strength.

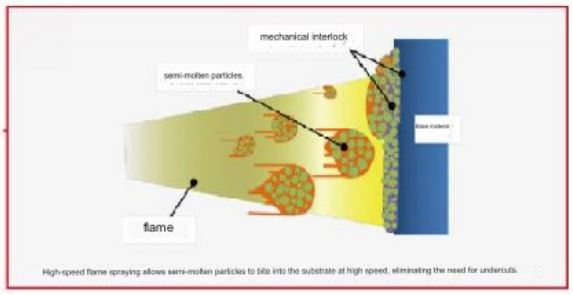




Comparison of various thermal spraying methods for carbide cermet thermal spraying (features, film characteristics)

		input energy		
flame		4	2	2
fast frame	combustion gas	2	4	4
explosion		1	4	4
arc		4	cermet	system is not applicable
Blasma	electricity	3	3	3

1 : Poor 2 : Average 3 : Good 4 : Excellent



High-speed flame spraying allows semi-molten particles to bite into the substrate at high speed, eliminating the need for undercuts.

Arc spraying has a slow particle speed, and undercutting the base ensures adhesion.

solution Ceramic spraying and high speed flame method

There are several methods of adhering cermet to the surface, as shown in the table on the left above, but we determined that the high-speed flame method, which sprays combustion gas at high speed, was the best method, and developed a method that also includes cooling after thermal spraying.

The Mazda 787, which won the overall victory in the 1991 Le Mans 24 Hours, had a gas explosion type

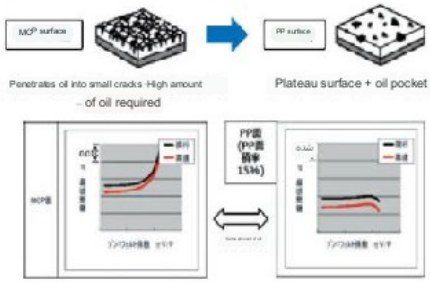
However, due to noise and poor mass production, it cannot be used for commercially available cars.

issue 2

High durability of rotor housing

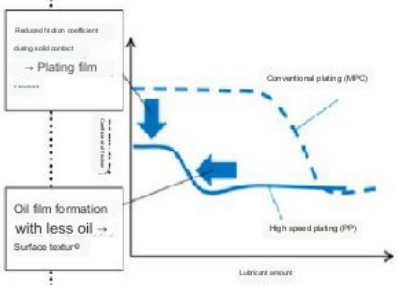
The sliding surface of the rotor housing where the apex seal comes into contact is the most difficult to prevent wear. In the past, I was worried about scratches called chatter marks. The solution to this problem was a new apex seal, but with the 8C, we tried high-speed plating to improve productivity. This produced a by-product, resulting in a low-friction plated surface. As a result, a sufficient oil film was formed even with a small amount of lubricant, and sliding friction resistance was also reduced.

MCP: Microchannel bolus PP: Pinpoint bolus



<Friction evaluation using pin-on disc>

Trochoid vs AS sliding characteristics image



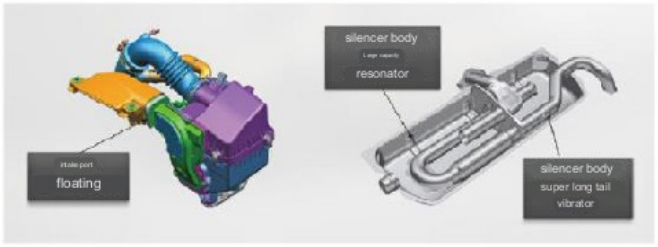
solution High speed plating method

High-speed plating is a manufacturing method that increases the plating deposition efficiency by adding a catalyst to a tank containing a plating solution. This method is used to shorten process time, but in Mazda's Challenge, oil spots were well dispersed on the surface and good film properties were obtained. In particular, the coefficient of friction during solid contact has decreased.

Balancing|Sound/vibration countermeasures

issue 1 Solve rotor vibration

In the conventional 2-rotor RE, the rotors rotate in opposite phases to each other, so rotational vibrations are suppressed to an extremely low level. However, the 8C has one rotor, and when this heavy object rotates, it produces vibrations. Therefore, balance weight etc. I am using it as a countermeasure. In addition, regarding exhaust noise, the intake port and intake pipe The deterioration was prevented by rolling treatment and long tail pipes.



Below: Balance with half a weight attached to the end of the shaft weight. The details are unknown, but the rotor rotation The most common way to use it is to rotate it in the opposite direction. Ma In addition, the flywheel part has a spring-loaded bumper. bar is used.

Above: The rotor weight is biased like this in a triangular shape. As a countermeasure, remove the corner part. 120 degree phase synthesis Since it is a force, it can be taken care of even if there is an imbalance in weight in any part. can. The measurement accuracy is improved to 0.001 grams. Scraping is performed at a certain level.

solution Precision rotor processing and various allowances

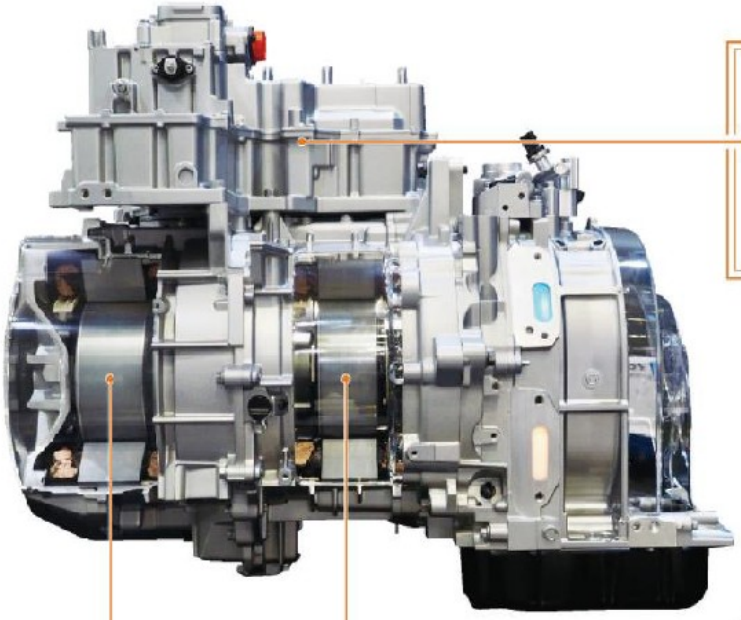
The rotor is a heavy object, and this causes vibrations and small vibrations due to combustion inside the housing If exposed to small torque fluctuations, the entire electric unit will generate noise and vibration. It comes alive. Therefore, the rotor is carefully machined and The exhaust system is also tuned to be optimal for one rotor.

e-SKYACTIV R-EV

Generator-EV option

The rotary engine, which had a strong image of being compact and high-performance, was used exclusively for power generation. Mazda defines the e-SKYACTIV R-EV as an unprecedented new electric vehicle that combines the strengths of EV and series hybrids and expands its usage as an EV.

TEXT:MFi PHOTO&FIGURE:Mazda／MFi



Auxiliary equipment such as control inverters

The engine is a unit that greatly affects the performance of electric vehicles. Barters are not only highly efficient, but also smaller. I focused on it. Adopting FSW for aluminum bonding technology, etc. to make the chassis as small as possible, and to reduce the size of the entire powertrain. Contributes to the compactness of

Drive motor

An AC synchronous motor with specifications of rated voltage 355V, rated output 60.0kW, maximum output 125kW/9000rpm, and maximum torque 260Nm/0-4481rpm drives the front tires. The photo above was taken from the front of the vehicle.

generator

This is also a high-output generator that has been made thinner. It is laid out coaxially with the rotary engine on the right and generates electricity. It can be seen that the drive motor, which is located on the left side, and the reduction gear are arranged perfectly in a straight line.

Power train

e-SKYACTIV R-EV powertrain

In order to keep the vehicle price down, it was necessary to design it so that it could be mounted on the same body frame as the BEV MX-30, rather than using a PHEV-specific platform. In order to achieve the target output of a drive motor of 125kW under these conditions, it would be impossible to use a 4-cylinder or even a 3-cylinder engine due to the overall length of the engine. Therefore, it was decided to install a one-rotor thin rotary engine. The powertrain of Nissan e-POWER, which is the same series hybrid, is a 3-cylinder

In order to mount the engine, the motor/generator is placed in the front and rear.

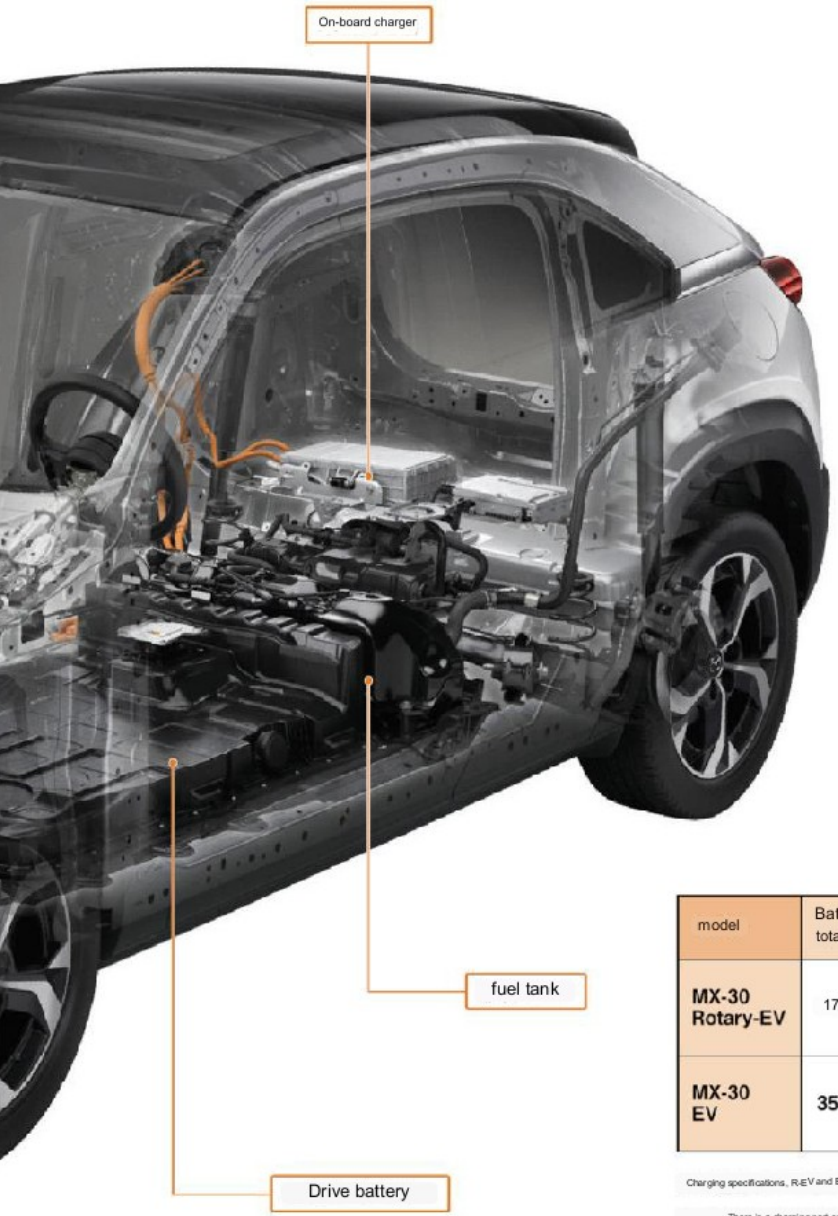
Mazda demonstrated the value of the e-SKYACTIV R-EV by taking advantage of the compactness of the rotary engine, allowing the engine, generator, and high-output motor to be mounted on the same body frame as the BEV model. The company aims to provide customers with the following three benefits. First, it can be used as a BEV on a regular basis, and the rotary engine generates electricity for long-distance travel. The second is a pure and comfortable driving experience powered by a motor. Finally, it has charging and power supply performance that supports a variety of lifestyles.

The compact electric drive unit of the rotary engine first needed to be miniaturized. By placing the motor, generator, and reduction gear on the same axis as the engine, the electric drive unit

It becomes possible to integrate and unify the functions. This creates a huge advantage in miniaturization. The design and production techniques for the engine itself are explained on other pages, but efforts to miniaturize the powertrain are wide-ranging in other areas as well.

The motor and generator are oil-cooled, but the lubrication structure has been thoroughly reviewed. We pursued a homogeneous oil flow in a narrow space for both CAE and visualization, and we also pursued a thinner design for this part. Inverters, converters, junction boxes, etc. have been made smaller by eliminating bolts in the water-cooling seals. Additionally, FSW (friction stir welding) is used to join the aluminum, which again keeps the size down.

Charging and power supply performance has also become particularly important in recent years. Catch up on the current mechanisms. Of course, normal charging can be used, but rapid charging according to the CHAdeMO standard has improved battery temperature management and increased efficiency. Furthermore, V2L (Vehicle to Load), which supplies power to home appliances and other devices from the 17.8kWh large-capacity battery installed in the vehicle, provides an AC power source that can handle up to 1500W in the luggage compartment. Furthermore, if you use a portable external power supply (sold separately), you can supply up to 4500W of power. Of course, it is also compatible with V2H (Vehicle to Home), which supplies electricity to the home via a charging/discharging unit. In addition to using electricity to move the vehicle, it can be charged at night when electricity prices are low, and the vehicle can be used to supply household electricity during the day to save on electricity bills, and in the event of a power outage, it can be used for long periods of time in conjunction with engine power generation. emergency power and It is also envisaged that it will be used as



All drives are motors

The engine only generates electricity and does not drive the tires. Honda e: HEV or Mitsubishi Outlander PHEV has a clutch mechanism that directly connects the engine and drive shaft, and the engine runs in the most efficient range, but R-EV is a pure series type vehicle, similar to Nissan e-POWER.

Fuel filler port (left side of vehicle)

Normal/quick charging port (right side of vehicle)

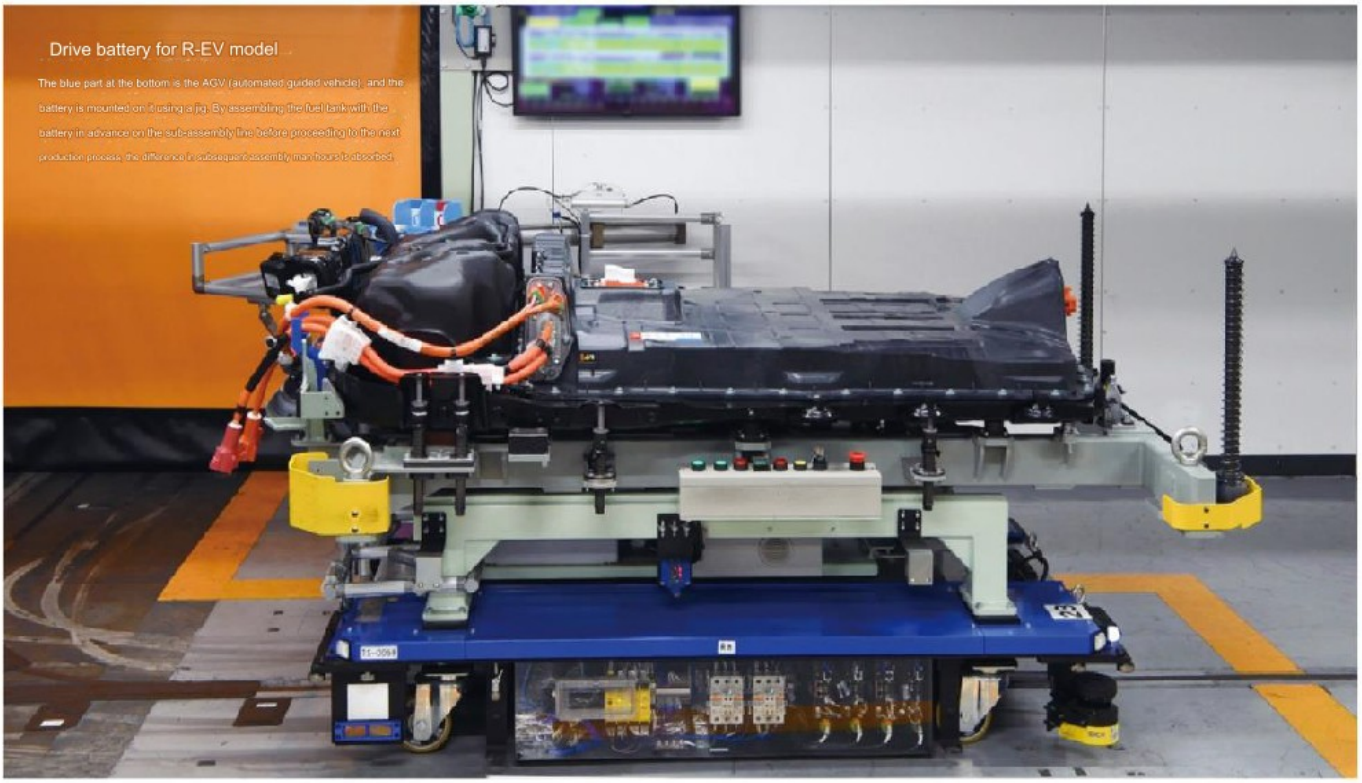
model	Battery total power	Charging method	Charging equipment power	Charging time SOC20 80%	SOC0⇒100%
MX-30 Rotary-EV	17.8kWh	Normal (AC)	3kW	Approximately 3 hours 50 minutes	Approximately 6 hours 20 minutes
			6kW	Approximately 1 hour 50 minutes	Approximately 3 hours
		Rapid (DC)	40kW or more	Approximately 45 minutes	———
MX-30 EV	35.5kWh	Normal (AC)	3kW	Approximately 6 hours 40 minutes	———
			6kW	Approximately 3 hours 40 minutes	———
		Rapid (DC)	Maximum 50kW	Approximately 40 minutes	———

Charging specifications, R-EV and EV model comparison

There is a charging port on the right side of the vehicle, with a CHAdeMO fast charging port and a regular charging port side by side, and a charging indicator on the lid.

A label is attached that indicates what the light on the monitor indicates. The table above is a comparison with the EV model, but it may vary depending on the cable used.

The charging time varies.



COLUMN Hybrid

Drive battery

Commonality and differentiation with EV models

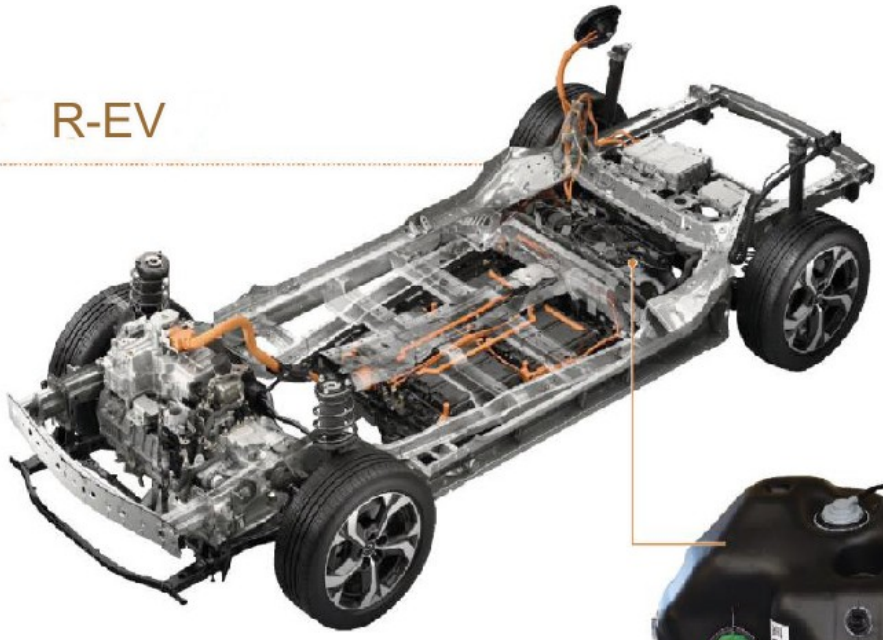
The flexible line that mixes a wide variety of products can be said to be the hallmark of Mazda's production technology, and the same is true for drive batteries. We are focusing on minimizing the dedicated parts for each model on the line, such as by standardizing batteries and assembly pallets for EV models, to improve efficiency and reduce costs.

TEXT:MFi PHOTO&FIGURE:Mazda

A production scene of the battery assembly line at Mazda's head office factory in the Ujina area. In this photo, battery packs are placed one after another on the battery pack frame transported by an AGV, behind the person. After this, the same worker attaches bolts, small parts, and the top cover, before moving on to the next step, which is attaching the fuel tank.

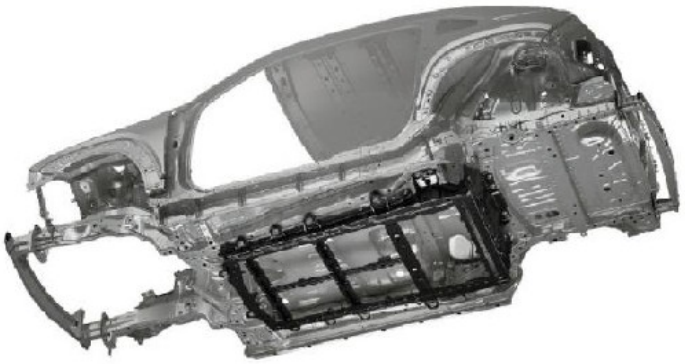
The process of installing a battery pack with a fuel tank attached to the MX-30 R-EV model. After this, different powertrains such as BEV, PHEV, and ICE will be installed, but the installation process and equipment will be the same for all units, and in order to minimize dedicated parts, only the attachment jig will be replaced. ing. Various vehicle models and powertrains can be produced on the same line.

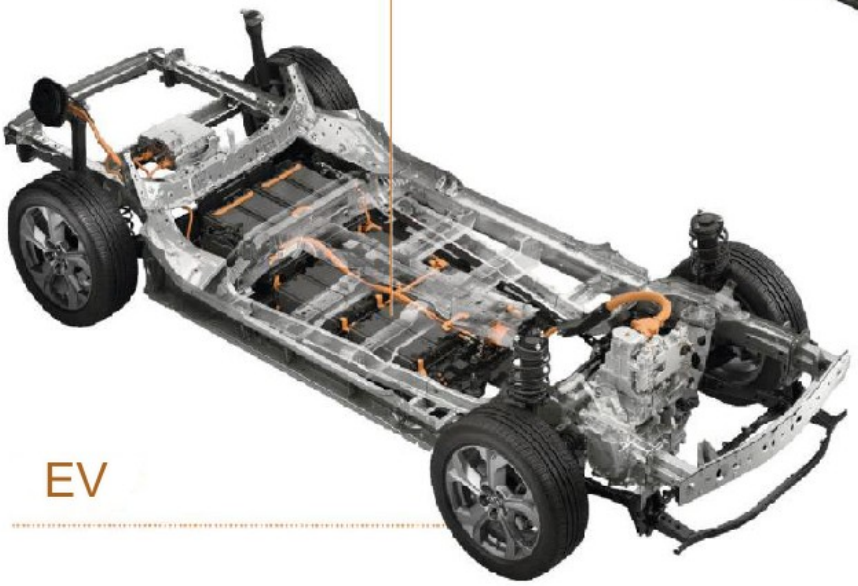
R-EV



↓The fuel tank of the MX-30 Rotary-EV with a capacity of 50 liters. In order to achieve both battery capacity to ensure cruising range and tank capacity to achieve reliable long-distance performance in an EV model that is at the top of the PHEV class, we maximized space efficiency by installing both at the same time. ification. After reviewing the layout of the battery control parts, we can see many improvements such as making effective use of the space under the seats.

↓ Body skeleton of the MX-30 EV model. The battery case is designed with the assumption that it will be used as part of an annular structure, and the frame and body that make up the case are firmly connected at 20 points around the circumference of the case, with cross members connecting the left and right sides placed inside the case. There is. By controlling the rigidity of this battery case fastener, road noise and vibration are also suppressed.





↑ Battery pack for MX-30 EV model. The silver piping is a thin heat exchanger made of refrigerant tubes that is in contact with the pack, and cools the battery as the temperature rises, keeping the temperature within an appropriate range and preventing deterioration due to heat. In the battery pack for the MX-30 Rotary EV, the fuel tank is placed instead of the battery in the two-tiered part on the right side.

EV

-Underbody of MX-30 EV model. The body incorporates Mazda's current thinking, with increased rigidity and energy transmission efficiency based on a straight frame and annular structure. The focus is on the rear trailing arm mounting area, which has also been strengthened with an annular structure to significantly reduce transmission delay, aiming for more precise and enjoyable handling stability.

New generation rotary!

Part 05

Manufacturing Process

Light, strong, and precise. 8C manufacturing site

The rotor and rotor housing, which touch each other at 9 points, are finished to the design precision. Mazda, the only company in the world to have completed and mass-produced the RE as a practical ICE, has always pursued this theme. The manufacturing process for the new 8C model is truly "SKYACTIV RE."

TEXT: Shigeo MAKINO PHOTO: Hiroya YAMAGAMI/Shigeo Makino

single rotor RE

8C is thin. The output shaft direction gives the impression that it is shorter than an in-line 2 cylinder. It's like a V-twin cylinder. The belt-driven auxiliary equipment is no different from a reciprocating ICE. The right side is the side that will be connected to the generator, and you can see the spring-loaded damper in the center. Dividing the rotor into two increases the length. The displacement is 1.8 liters, which is sufficient as a power source for driving a PHEV, but what will happen?

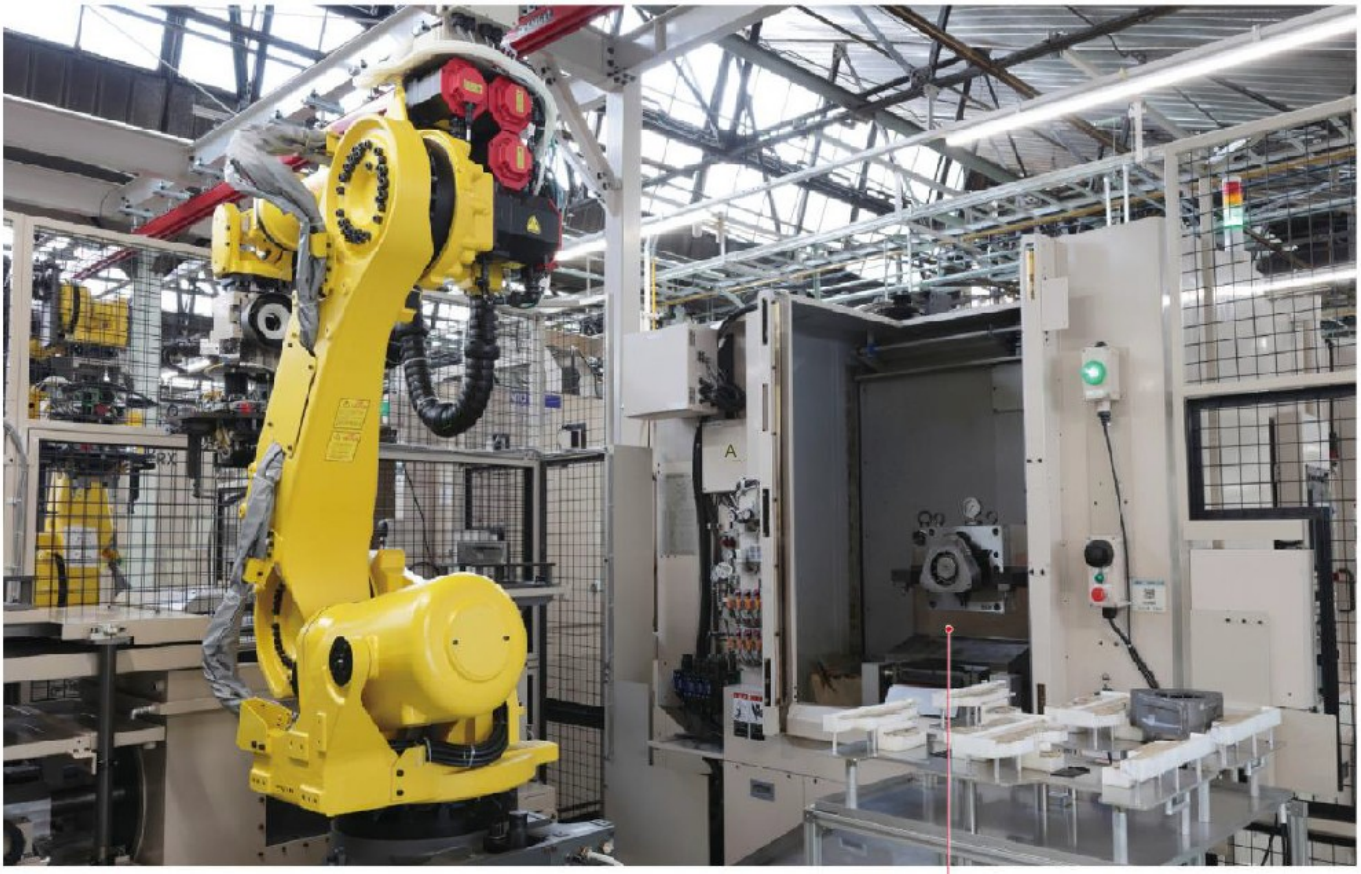
In 2012, Mazda ended production of the RX-8. The Type 13B RE (rotary engine) it was equipped with continued to be produced on a small scale for repair purposes. The author first covered the RE production line in November 1986, and last reported on it in April 2008. In October of the previous year, Mazda exhibited the 16X, the prototype of the next-generation RE, at the 40th Tokyo Motor Show. I applied for an interview on the RE production line partly because of these expectations, but the 16X plan was put on hold due to the global recession triggered by the bankruptcy of Lehman Brothers Securities in September 2008, the so-called Lehman Shock.

However, when I visited the RE manufacturing site in 2023, the scenery from 2008 remained almost the same. The 8C type, which has a "long stroke" like a modern ICE (internal combustion engine), is an enlarged version of the previous 13B type and transformed into a single cylinder (single rotor), so the production line was basically Can be diverted. In addition, I thought that the various methods introduced with the start of production of the newly developed SkyActive ICE group would be applied to the 8C. That prediction was correct, and Mazda will

The production technology was introduced after considering it in a Mazda-like manner.

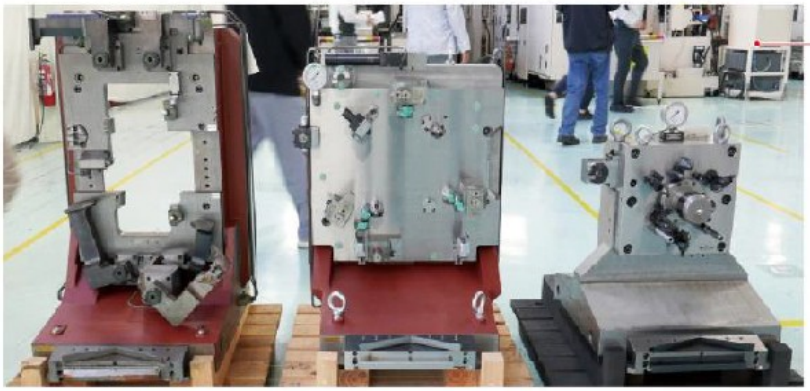
Manufacturing ICEs involves performing precision machining such as ``shaving" and ``drilling" on metal, and then assembling them with high precision, exactly to the design values. Accuracy is now at the level of 1 micron (0.001mm). Otherwise, the targeted thermal efficiency will not be achieved. As highly accurate combustion analysis became possible and the state of combustion could be visualized, ICE manufacturing began to pursue even stricter precision.

RE is especially difficult. With reciprocating ICE,



Thoroughly jig & general-purpose machine

A machining station consists of a pair of a 6-axis robot and a general-purpose machining center. The platform on which the white tray is placed in the lower right corner is a battery-powered AGV for automatic transportation. The robot sets the workpiece (product to be machined) on a jig inside the processing machine, and while it is set, a contact sensor and camera measure the position (bottom right), and machining is performed based on the position data. You can also do other tasks by replacing the jig (bottom).



The stone moves up and down, converting the work of combustion into rotation. The piston and cylinder are in contact with each other through the piston ring/oil ring and oil film, and are not in direct contact with each other. Floating. In RE, a rotor corresponding to the piston rotates within a rotor housing corresponding to the cylinder. It rotates while floating through a seal and oil film that correspond to piston rings. The rotor, which is large and heavy, rotates in a floating state.

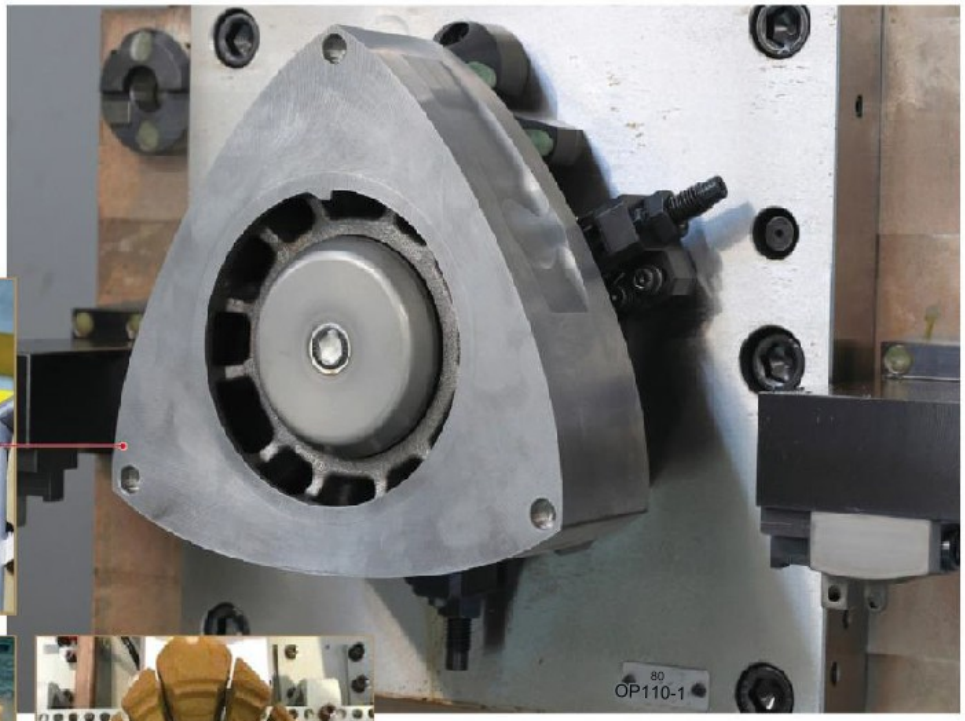
Moreover, the total length of the seal is It's not compared to stone ring. Tightly sealed and sealed to prevent leakage of working gas (air + fuel) and combusted gas, converting combustion energy into rotational power. On the other hand, if the sealing material is selected incorrectly, the housing may be left with minute "scratches." This was extremely difficult, so OEMs (automobile manufacturers) other than Mazda discontinued RE development. This is Madda who solved the sticker problem with tenacity.

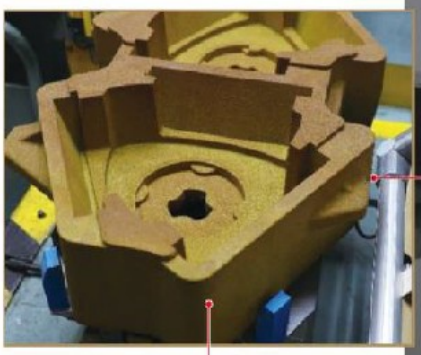
We were able to put injury RE into practical use.

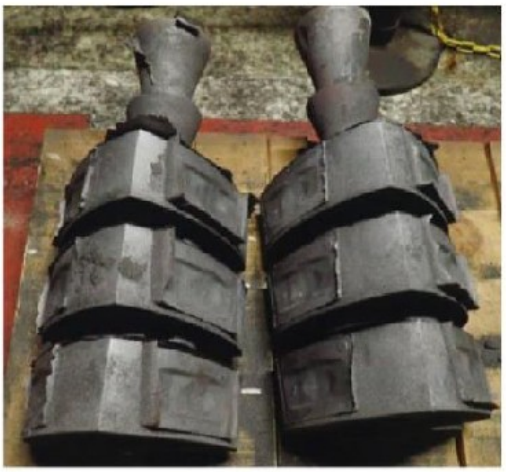
The RE encountered new manufacturing equipment. The idea is as strong as the series of Skyactiv ICEs, It is light, precise, and cheap. By using a general-purpose machining center instead of a dedicated machine to change attachments, and using sensing technology such as contact sensors and camera-based image processing, positioning accuracy during machining can be maintained at an extremely high level, reducing the number of processes and saving energy. and minimize operator errors. With reciprocating Skyactiv ICE, data at the time of manufacture and data at the time of vehicle inspection are compared, and the processing conditions for the most fuel-efficient ICE number are fed back to the manufacturing site, and this process will naturally be carried over to RE.

Iron rotor is gravity cast

The three photos below show the process of casting an iron rotor using a sand mold. The sand mold is automatically molded with high precision, and the core (lower right) is fixed to the outer size mold (upper left) and cast in 2 rows of 3 pieces. The completed rotor is fully machined, including the combustion chamber (right), and the seal attachment area is machined and balanced. For the 13B model, people had to use a drilling machine to drill while looking at numerical values, but for the 8C model, the process is fully automatic, increasing accuracy by 75%.





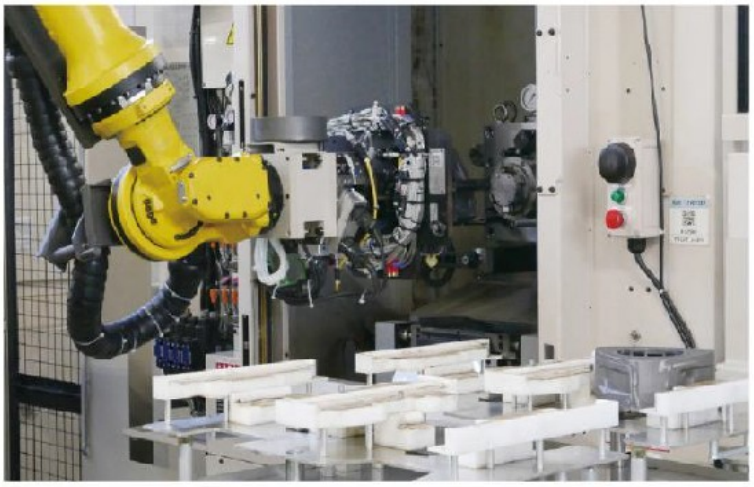


3 piece casting

In gravity casting, molten metal is allowed to fall freely from above the mold. Two rows of three rotors are cast at once. This is a vestige of the two-rotor system. Molten metal has reached areas other than the core inside the rotor. Although it looks rough, it is a precision casting.

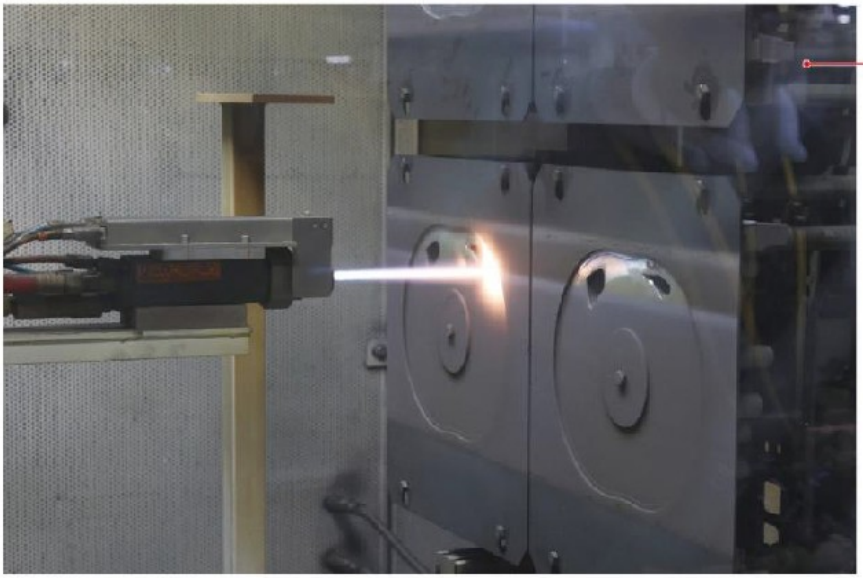
Rotor processing machine in 2008

The 13B type was a wire cutting machine with three rotors mounted on a table inside the processing machine, which moved the cutter up and down as it rotated. The blade was moved back and forth to scrape like a plane. Currently, we use a machining center to align the zero point of the jig with the zero point of the workpiece and machine it with micron-level precision.



Rotor processing machine in 2023

In contrast to the photo on the left, each piece is processed one by one using a general-purpose machining center. A robot arm quickly and carefully carries the product, fixes it to a jig inside the machining center, and when the door closes, processing begins using automatically selected tools.



Surface treatment of aluminum side housing

The left end above is the 13B type iron side housing. After the casting surface is machined flat, it is subjected to gas nitrocarburizing treatment. Above, in the center, is the sand-cast aluminum side housing with its surface polished after being removed from the mold. Typically, aluminum ICE cylinder blocks and cylinder heads are made by high-pressure casting, in which molten aluminum is injected into a durable steel mold at high pressure. Mazda has established the APMC method, in which molten aluminum is poured into a sand mold, and the molten metal is distributed evenly within the sand mold using gravity casting, a slight push, and a half-rotation of the entire sand mold. Although it takes more time to manufacture, the metal structure becomes denser after completion, making it possible to make the product thinner. In this way, cermet powder is bombarded onto the surface of the side housing manufactured using the APMC method at high speeds of Mach 2 or higher, compressing it to the aluminum surface and building a strong layer. Since it is sprayed with combustion gas at several thousand degrees Celsius, the cermet hits the aluminum in a semi-molten state, creating a durable curtain. Naturally, the aluminum material is deformed, but by devising cooling methods after spraying, the product dimensions and sprayed film thickness remain as designed.

Rotors larger than the 13B type have sand as before. It is made by gravity casting by pouring molten steel into a mold that has been solidified. The housings are also made using Madda's unique APMC construction method, which uses sand molds. Mazda was introduced to Cosworth casting during its partnership with Ford, and used sand molds to make the Cosworth DFV racing engine. This technology has been refined and evolved into SkyActive ICE, which is now used at 8°C. Model-based development (MBD) was used to cast the aluminum side housing, and an analysis of the ideal method of pouring molten aluminum into the sand mold was performed.

As mentioned above, the rotor cutting process is performed by a general-purpose machining center. The method we saw in 2008 is quite different, with the 50 steps at that time being reduced to 9. If the number of processes is reduced, the number of times the rotor must be set in a processing machine, removed, and then set in another processing machine is reduced, which reduces the risk of accuracy deterioration. The rotor is set inside a general-purpose machining center. Fixed in a precise position, Machining is carried out by a robot arm linked to an ATC (auto tool changer) that automatically selects several tools.

Although the rotor, rotor housing, and two left and right side housings are machined by separate machining centers, they are the same machine. By replacing the jig and tool, the same machine can perform the same task. The jig mounting structure and standards are also the same. This technology was established in the manufacturing process design of SkyActive ICE.

A process that did not exist in the 13B era was thermal spraying on the side housing. Up to the 13B, the surface of the cast iron side housing was processed using a process called gas nitrocarburizing. The 8C is a lightweight aluminum side housing, and molten cermet powder is sprayed at ultra-high speeds of Mach 2 onto the inner surface of the housing, which is in contact with the six side seals on both sides of the rotor, to create a durable film.

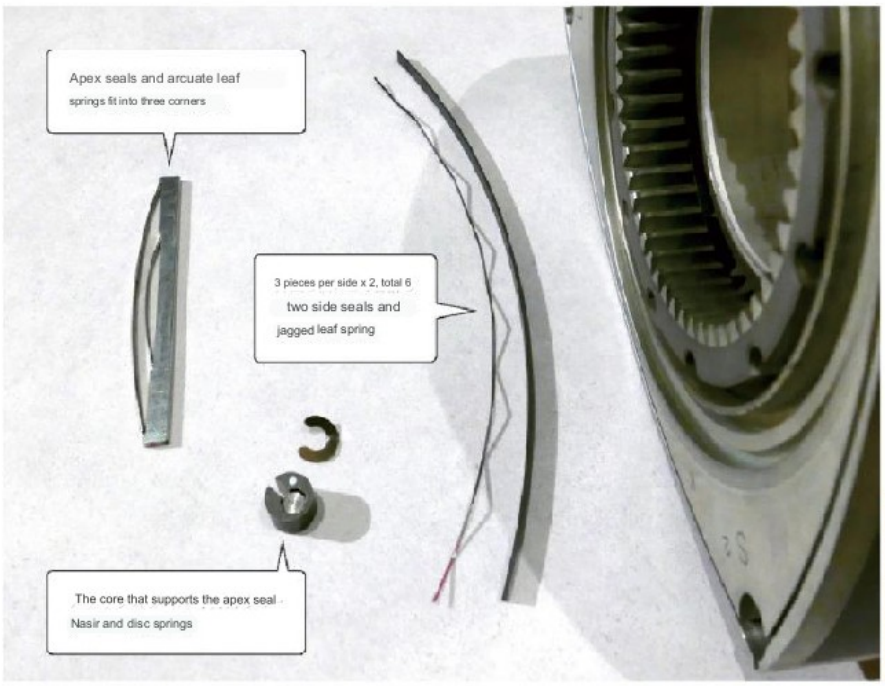
The parts completed in this way are carefully machined. Processed. The rotor, in particular, requires extremely high precision. Since it is a rotating body, if there is an imbalance in its weight, it will move eccentrically. Processing is required to minimize this. The unbalance is measured by rotating the rotor at a constant rate, and the data is sent to the server. The rotor set on the machining center is zero-pointed using a high-precision touch sensor, and the rotor cuts a groove of the specified depth based on server data. Machining on the top and bottom surfaces of the part (ner). All unbalance measurement data becomes a composite balance at the three corners of the rotor, and is input to the machining center as instructions for which corner to cut and by how much. This is a composite balance with a 120 degree phase. The amount to be removed is in grams, but the amount of removal itself is the depth, so it is given as a coordinate instruction for the depth to be removed. The amount to be shaved here is specified in units of 0.001 grams. By carving both sides of the rotor, unbalance in the thrust direction is also eliminated.

Installing seals

First, attach apex seals to the vertical surfaces of the three corners when the rotor is laid down. Compared to the 13B model, the 8C model has a thicker rotor, so the apex seal is longer. On the back side, there are two large and small arc-shaped springs. A spring is used to press the apex seal so that the rotor and housing are always in contact with each other through the oil film, but if you press too hard, it will cause sliding resistance between it and the rotor housing. Check to see if it is properly seated in place by pressing it with your fingertip. The skilled artisans involved in this process set the stickers as designed using just the touch of their fingertips. I've seen this scene many times, and even if REs change generations, the fact remains that they are handmade. Similarly, the corner seals and side seals are assembled by hand with springs placed underneath. After checking the condition of each seal, the rotor is sent to the process of being set in the housing.

Comparing 2008 and 2023

The photo below, taken in 2008, shows the seal assembly station for Model 13B. The one on the left is the 2023 8C model. The things I keep and the things I use remain almost the same. However, compared to before 2000, the gloves worn by artisans are different. In the past, he was definitely a military man. Uniforms have also become cooler (in fact, Japanese corporate managers are not aware that this is an important factor).

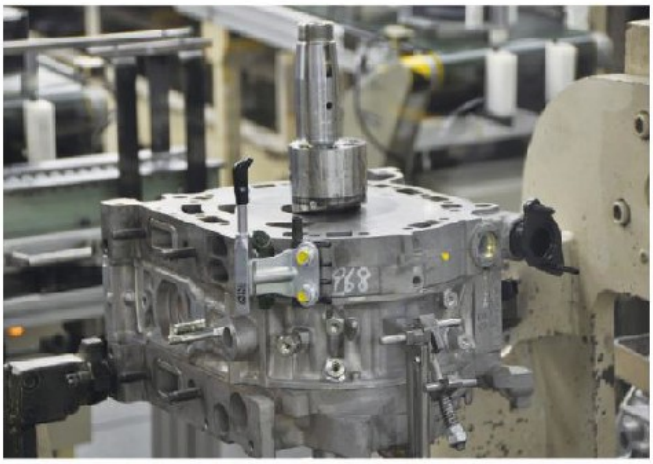


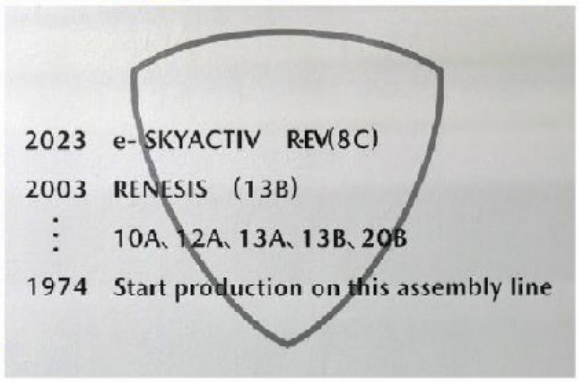
This small part is the key to RE.

Seals are airtight parts. This component maintains a high level of airtightness to prevent combustion gas pressure from escaping and gas from mixing between strokes. The photo was taken with a shadow to make it easier to see the shape of the spring. There is a jagged spring (seal spring) under the longest corner seal. Mazda's know-how lies in the number of mountains and the slope of the mountains and valleys. The apex seal is pressed against the inner circumferential surface of the housing by an arc-shaped seal spring, and at the same time is always pressed against one side of the seal by the gas pressure of the combustion gas. The airtightness of the area where the apex seal and side seal meet is achieved by providing elasticity to the corner seal. The photo below is a comparison of the apex seals of the 13th type (top) and 8C type (bottom). The material remains the same, but the size and thickness have changed. In the past, Mazda's RE development team was troubled by the appearance of chatter marks, the scratches caused by the apex seal scraping the inner circumferential surface of the rotor housing. Even NSU, the originator of Wankel-type RE, was unable to solve this problem.

final assembly line

The scene of workers working on hanging hangers has not changed from 2008. The photo below shows a 2-rotor RENESIS 13B RE with the front rotor assembled and the eccentric shaft installed. The rear rotor is attached here. On the right is the current single rotor 8°C. On the bottom left, exterior parts are being assembled after leaving the clean room. All the necessary parts are made into a kit, and the operator takes the parts in order and assembles them, starting from the front. RE can do this because it has fewer parts. The kit includes the required number of bolts. On the day of this interview, one Model 8C was being manufactured every 7.8 minutes. A work operator learns 7.8 minutes worth of work. This is quite difficult, so we will guide you through the correct steps using the task navigation. When you arrive at the process, work instructions will appear on the monitor screen (as everyone remembers).





There was this writing on the wall inside the factory. RE production began at this location in 1974. In fact, it was 49 years ago. Next year will be the 50th anniversary of this production line. Continuation is power. At the same time, it is also determination and tenacity.

One section of the production line is a clean room that is kept under moderate pressure to prevent dust from entering from the outside. During this process, seals are assembled to the rotor, and the rotor and eccentric shaft (crankshaft in reciprocating ICE) are attached to the rotor housing. Compared to the photo taken in 2008, not much has changed. Because the dimensions of the rotor have changed, the jig used to secure the rotor during work has changed. Seals

The dimensions are also different. However, the working procedure is the same.

When the Type 8C leaves the clean room, the combustion chamber surrounded by the housing is sealed. The sight of the pieces being assembled on hangers is the same as in 2008. But the parts have changed. The 8C type has direct injection in the cylinder, so the fuel pump is on the engine side. There is a gear at the end of the eccentric shaft that rotates the fuel pump and uses a chain to control its movement. Image processing using a camera was introduced in order to assemble the engine so that the timing of combustion and the timing of fuel pressure rise could be matched.

This means that accuracy and operation are guaranteed by the production system, rather than by the operator. This is the most significant change at the manufacturing site. Checks and records are performed at each important process, and only passing products are sent to the next process. Rather than testing at the end, we accumulate OKs. The production system manages this flow and guarantees the product. Mazda also utilizes MBD in the area of production technology.

Finally, all units are cold tested (electronic). (use a motor). most efficient

Measure intake pressure (negative pressure), lubricant pumping force, rotational resistance, sound vibration, and compression pressure at the power generation rotation speed of 2300 rpm. Next, we measured at 1200 rpm, which has a lot of assumed data for the RENESIS 13B type. Furthermore, at the very end, a hot test was performed by filling the engine with fuel, igniting it, and operating the ICE at 250 rpm. If it passes the test, the 8C will be sent to the vehicle production line where it will be assembled into an electric motor and reduction gear.

The single rotor RE, an improved version of the 16X model, saw the light of day after many twists and turns. The 16 years since the 16X was announced were packed with nostalgic scenes and scenes seen for the first time. Naturally, there has to be a next step. It seems like this hunch is correct.

New generation rotary!

Part 06

New model for rotary engine

A car called MX-30 Rotary-EV

The rotary engine, which can be said to be Mazda's identity, has been revived after an 11-year hiatus. The MX-30 is equipped with this powertrain. A new option has been added to the unique freestyle door, which has been previously released as a mild hybrid and electric vehicle.

TEXT:MFI PHOTO: Hiroya YAMAGAMI/MAZDA FIGURE:MAZDA

Crossover model belonging to the C segment

The body size of MX-30 Rotary EV is 4335mm in length, 1795mm in width and 1595mm in height. The vehicle weight is 1780kg. The most distinctive feature of the exterior is the double-opening ``Freestyle Door", the first since the RX-8. The lineup includes three powertrains: a PHEV equipped with a rotary engine, a BEV, and an ICE.

The Mazda MX-30 is equipped with a rotary engine that has been revived for a new era. The MX-30, which was unveiled to the world for the first time as the company's first mass-produced BEV at the 2019 Tokyo Motor Show, is notable not only for its powertrain, but also for its ``freestyle door," which has a center-opening structure with no center pillar. It also stands out. It belongs to the same segment as the MAZDA3 and CX-30, but the frame has undergone considerable improvements in conjunction with the aforementioned fleece-style doors and electrification. Initially, it was thought to be a BEV-only model, but when it was introduced to the Japanese market in the fall of 2020, it expanded its variation by also offering an ICE vehicle that combines the SKYACTIV-G 2.0 gasoline engine with a unique mild hybrid system. Now, we have released the MX-30 ``Rotary-EV," a series plug-in hybrid model that uses a rotary engine exclusively for power generation. Pre-orders will begin in Japan from September 14, 2023, with deliveries beginning in early November. Vehicle price is 4,235,000 ¥4,917,000. The battery capacity is 17.8kWh, ensuring a driving range of 107km in WLTC mode on batteries alone. Furthermore, the fuel tank of the rotary engine used as a generator has a capacity of 50 liters, making it suitable for long-distance driving. This structure was achieved by thoroughly improving the space efficiency of both a battery pack and a 50-liter fuel tank.

A credit plan with a residual value set at 55% after three years is also available, ranging from

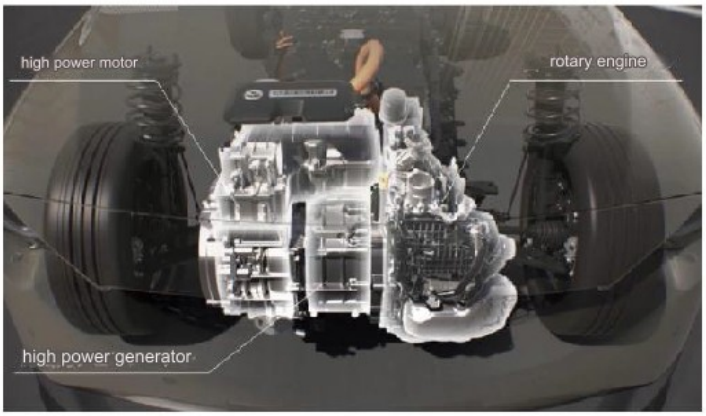
The motor drives the front wheels in all driving situations, and when high power is required such as sudden acceleration, the rotary engine is equipped with logic that starts the rotary engine according to the accelerator opening depending on the battery level, even if EV mode is selected. . It is also equipped with the ``Electric G-Pectering Control Plus (e-GVC Plus)" that was used in the BEV model, and the ``Motor Pedal" that can perform high-precision torque control based on human characteristics. It is said that he pursued the unique, one-on-one running style. The MX-30, which offers three powertrains, is a model that represents Mazda's ``multi-solution strategy that provides options for the right person in the right place." The focus is not only on the return of rotary, but also on many other features.

1 rotor rotary and electric unit

Engine room of MX-30 [Rotary-EV]. Not only does it take full advantage of the rotary, which is much more compact than a typical engine, but it also uses only one rotor for power generation, changing from the conventional two-rotor unit to one.

Right: Mild hybrids are leading the way in the domestic market

In the fall of 2020, the first MX-30 model for the domestic market was an ICE vehicle that combines a 2.0-liter straight-4 SKYACTIV-G engine with a 24V integrated starter generator. The transmission is combined with a 6-speed AT, which is common to the 7th generation product group.



Left: PHEV with coaxial arrangement of main units

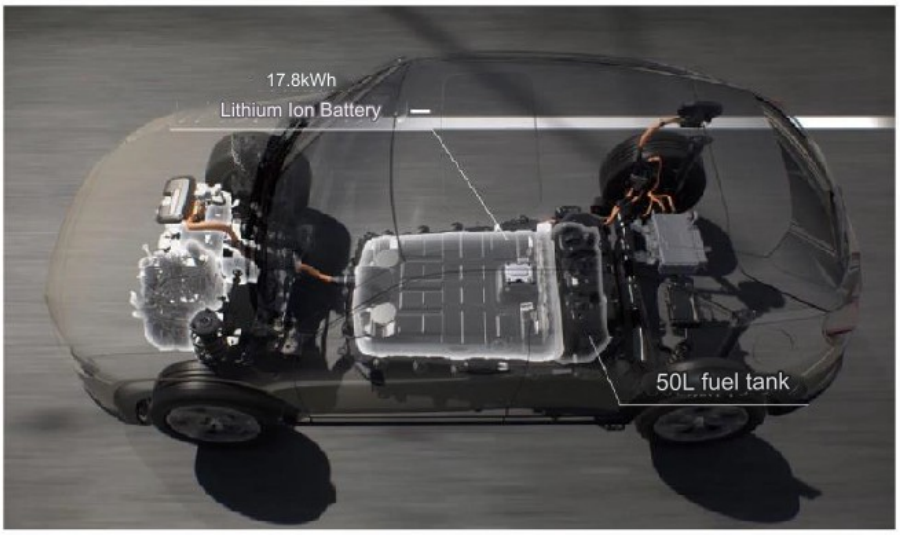
MX-30 Rotary-EV" powertrain layout. A compact 1-rotor engine was chosen because it was to be mounted in a C-segment class engine room and on the same body frame as the BEV model. Taking advantage of its compact size compared to a typical reciprocating engine with similar output, it is placed coaxially with the generator and motor, increasing space efficiency.

Above: BEV model's spacious engine compartment

There is no engine or generator, only the drive motor fits in the engine room of the MX-30 ``EV-MODEL," which has an aluminum mount that appears to be highly rigid on the passenger side. . Because there are few heavy objects in the front of the vehicle, the handling is characterized by a so-called ``lightness at the nose".

Right: Large battery and large capacity fuel tank coexist

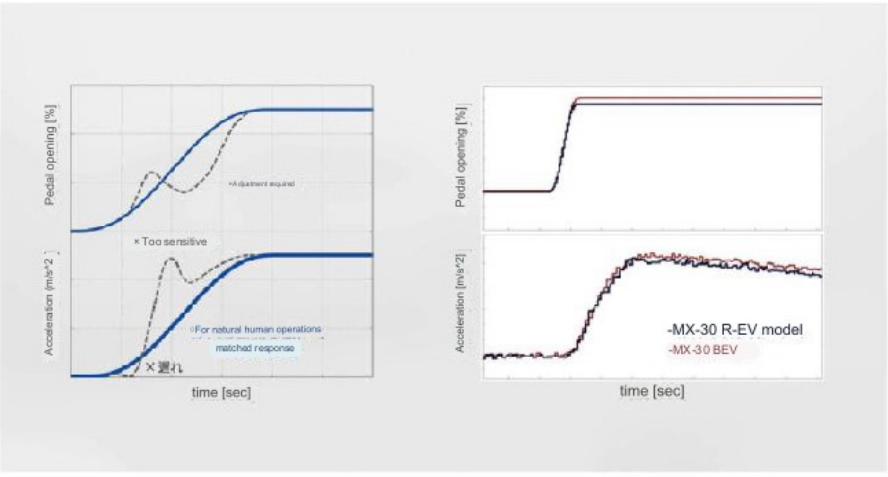
In order to eliminate concerns about cruising range, it is equipped with a 50 liter fuel tank (uses regular gasoline). This is almost the same as the MX-30ICE 2WD model's 51 liters. Another key point is that the height of the battery case is kept low through high-density mounting of battery modules and a thin structure with a refrigerant cooling system. It firmly connects the body and battery pack, contributing to improved vehicle body rigidity.

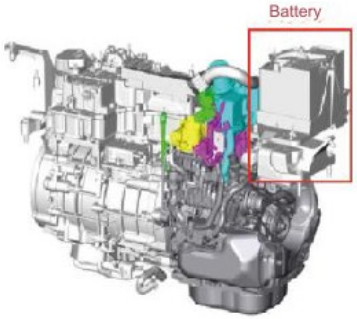


Bottom: Control pursuing human-centered acceleration characteristics

If the motor's high responsiveness is demonstrated, it will be able to provide a completely different level of power compared to ICE vehicles.

It is not difficult to bring out quick response, but Mazda has incorporated into the MX-30 EV model acceleration characteristics that match human senses. This idea has been firmly inherited in the MX-30 R-EV model, which is a PHEV, and the hardware and controls have been built to ensure that it has the same characteristics as the EV model despite changes in vehicle specifications.





To avoid interference with lead batteries

The power generation rotary is laid out at the transmission position, so the engine Interference with lead battery in gin room. Therefore, a veteran rotary packaging engineer devised a "bent loop package" that assembled the upper part related parts to solve this problem.

GM, Toyota, NSU (the predecessor of today's Audi), and the Soviet Union all gave up on RE development in the 1970s. Madda was the only company to put it into practical use and move into mass production. In the 2000s, Austria's AVL, inspired by the RENESIS 13B, developed a small RE for power generation.Chinese private company Chery Automobile showed interest in this and developed a range extender BEV, but in the end it was only a prototype. It ended in

For RE, this is extremely unfortunate. Madda is the only company in the world with such extensive knowledge. In the case of a typical reciprocating ICE, millions of engineers have probably been involved in the past. Recipe ICE grew up in a sea of wisdom tactics. The SIP (Strategic Innovation Program) under the jurisdiction of Japan's Cabinet Office has finally achieved net thermal efficiency of over 50%. lab stage

However, the figure exceeding 50% is slowly approaching the 64% of the most efficient natural gas power generation turbine.

The Mazda 8C model's net thermal efficiency and BMEP have not yet been announced. The first difference from the 13B type is the longer stroke. This was made clear in 2007 when the development of the 16X was announced. In the case of RE, the amount of eccentricity between the internal rotating gear carved in the center of the rotor and the fixed gear on the output shaft side = e value is divided by the distance from the output shaft center to the top of the triangular rotor = R. The K value corresponds to the stroke in reciprocating ICE. Like the series of Skyactive ICEs, a longer stroke was designed.

Another improvement would be combustion. This is my impression after seeing the disassembled 8C, and Mazda's comments.

Although not a real engine, the combustion chamber (referred to as the working chamber in RE) has a round cavity similar to the Skyactiv G, increasing the compression ratio to 11.9 and directing the fuel supply directly into the cylinder rather than into the intake port. It started to erupt and the number of spark plugs changed from two to one. In other words, it can be interpreted that the evolution in Skyactive G has been transcribed. Combustion should be even better than the RENESIS 13B type.

Also, this is an ICE for power generation only, so do not use it at high speeds. It is said that the most efficient power generation speed is 2300 rpm. In other words, downspeeding. The displacement is increased, the rotation is lowered, and the input fuel is fully burned and used up. This is exactly the ICE improvement plan that Mazda has always talked about. Although the form is different, the idea is the same as Sky Active G.

new generation rotary!

Part 07

Epilogue

Whereabouts of the rotary engine?

Will Mazda's RE, which has been revived as a power generation ICE for BEVs, develop into a drive ICE?

Since Mazda views RE from a management perspective, this can be considered a high possibility.

Series HEV, PHEV, or hydrogen combustion RE...

TEXT&PHOTO:Shigeo MAKINO

Sea that has caused a lot of trouble for the RE development team

Class. It's a small part, but don't let your guard down.

Then, both unburned gas and combusted gas

Extremely important for leaky RE

It is a unique part. In the 1960s, beef bones

It was tried until It's called tribology

The academic field is established and its importance is recognized.

This will improve the future potential of this part.

potential has emerged. If the RE-only special

Separate oil is made and set with the seal.

If you can use it with... this?

These REs contain the opportunities that humans have accumulated.

I think the basics of the machine will be useful.

So what if we move on from here?

Mazda has conducted some experiments with RE in the past. What made a strong impression was the HEV (hybrid vehicle), which combines a hydrogen-burning RE and an electric motor, and its development began in 1990. The show car HR-X exhibited at the 1991 TMS (Tokyo Motor Show) was an HEV that used hydrogen RE. The HR-X2 exhibited at TMS in 1993 attracted attention for its ``body made of easily recyclable structures and materials," but its hydrogen-burning RE was also improved. At TMS in 2003, an HEV that combined an electric motor with a hydrogen-burning RE that uses an electric assist turbo was exhibited.

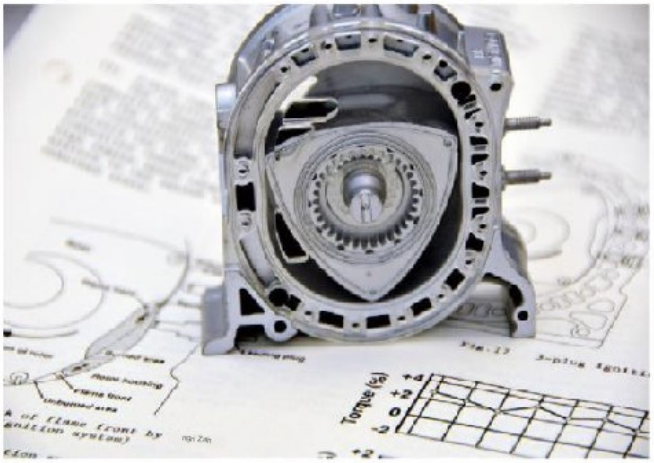
In other words, Mazda started research on hydrogen combustion in RE around 1990, and confirmed that cooling loss, which was a disadvantage of RE, was an advantage in hydrogen combustion. There it was. The culmination of these efforts was the Premacy Hydrogen RE hybrid concept exhibited at TMS in 2005. It is a series HEV that uses a hydrogen-burning RE exclusively for power generation, with the RE and electric motor arranged in parallel and horizontally mounted. The newly released MX-30 rotary EV can be said to be a RE-HEV for the 2020s, replacing the fuel with realistic gasoline and arranging the RE for power generation and the electric motor for drive in series. That's what I think when I follow the flow from the past.

Another thing that is attracting attention at the new 8℃ is the thermal spraying of the side housing surface as a tribology (friction, wear, and lubrication) technology. Considering the current situation where everything is aided by peripheral technologies, we have high expectations for RE performance to jump from technological innovation in the tribology field. ADAS and autonomous driving functions are semi-

It has been supported by advances in conductors. Closer to home, advances in smartphone cameras and image sensors have changed entertainment and news reporting. Videos shot with smartphones are the first to tell us what is happening on the front lines of the war in Ukraine. Who would have imagined something like this 20 years ago? Chat LLMs (Large-Scale Language Models) like GPT were unimaginable even a year ago. As mentioned at the beginning, RE's misfortune was that there were not many engineers involved, and Mazda was the only company that had accumulated knowledge. The only way to recover from this is to incorporate more and more peripheral technologies. Mazda fully understood this, which is why 8℃ became SkyActive RE. The latest results in reciprocating and MBD (model-based development) have entered RE. But still reciprocating

- Takumi Muroki, a member of the first RE development team, the so-called 47 RE, showed us a single-rotor air-cooled RE for small aircraft. It might be used as a drone somewhere. This is an example of RE being used in places we are not aware of.

→This is a RE model that was previously sold at Mazda's in-house shop. The rotor rotates with the handle. I haven't seen it much, but I'd like to see it resold based on BC's design data. This is an important missionary activity and a means of increasing interest in RE.



is lagging behind.

If there is a way to recover, I think it would be because the seal size is mind-bogglingly long compared to reciprocating. Just as cooling loss became an advantage when hydrogen was used as a fuel, advances in tribology technology may prove to be a ``disaster". That's what I felt when I actually saw the thermal spraying technology used in the Model 8C.

We can also expect great things from combustion control technology. Skyactive ICE enables control in 50 milliseconds. This is early. However, it is still a long way from reaching the torsional resonance frequency of the drive shaft. I feel like there is a different world out there if we can shorten control time. For example, instead of combusting three times per revolution, I think that ``thinning ignition", which is similar to reciprocating cylinder deactivation, may be effective when considering an ICE dedicated to constant rotation power generation, although this is my amateurish idea.

The fact that only Mazda has the knowledge of RE may turn out to be a disaster. Always connect the improvements in reciprocating to ``what would happen with RE" and never leak anything outside. At the same time, the fact that many students still join the company because they want to do RE is a great asset. RE research and development cannot be done outside of Madda. I think there are probably many people who have ideas that they would like to use in RE.

These young people should be given the opportunity to participate in RE development without being assigned to the RE development department. In one word, it's a company that is no longer an old man. Some people are already saying that ``automobiles are boring." I don't think so, but it's unfortunate for cars that people think that way. To dispel this, we must abandon all ideas such as ``this is the way things have been done up until now" and ``this is my way," and give full force to young people who have a rebellious spirit and want to do RE.

Have them perform. Otherwise, it would be easy to quit.

It's pretty far-fetched, but I sometimes think about ``a company that will put a time machine into practical use in the future." It's just for fun, but I think Mazda might be able to pull it off. It's not about technical ability, but about determination and tenacity. We have been working on RE since the 1960s, and the latest model was released in 2023. There is determination and tenacity in management decisions. It's stunning.

Also, there are researchers overseas who are fascinated by RE. At the beginning, I wrote ``Soviet Union," and that was actually the case. There are remnants in Russia today as well. To commemorate the release of 8C, an RE world conference will be held on the web, and someone will launch a crowdfunding campaign for the development of "16C", and someone else will launch an RE startup on their own. Only young people can do this kind of thing. Old men should just laugh and watch.