Rotary History 102

Many companies besides Mazda have developed rotary engines. This is the second of a two part series on the history of the others who have explored the rotary.

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CURTISS-WRIGHT'S ORIGINS can be traced directly back to the famous flying Wright brothers. Therefore, they were primarily an aviation oriented company. After World War II, the jet engine industry was blossoming, but Curtiss-Wright's jet development was lagging behind competitors Pratt & Whitney and General Electric. In the late 1950s, a model of an NSU rotary engine found its way to Curtiss-Wright and eventually to German born engineer Max Bentele. Bentele took the model home to study one weekend and "arrived at a positive conclusion." He also expressed confidence when he learned Felix Wankel had been the designer.

After meetings with NSU in 1958, Curtiss-Wright purchased a license from NSU for the rotary engine for $2.1 million and a commission on all engines sold. This made Curtiss-Wright the first company to purchase a rotary engine license. Bentele was put in charge of the new department for rotary engine development. The engineers involved began a thorough analysis of the engine, with the intent to "design out" the problems. As they continued to work, Hurley took out ads in newspapers in November of 1959 going public with the rotary concept. Curtiss-Wright stock quickly rose and Hurley also found himself in front of the Securities and Exchange Commission explaining that the rotary was indeed a real engine and not a ploy to raise stock prices. NSU and Wankel were also displeased that Curtiss-Wright seemingly tried to take credit as if the rotary was theirs, since Curtiss-Wright had neglected to mention NSU's and Wankel's prior work.

The first prototype was the single rotor IRC6, which displaced sixty cubic inches and produced 100 hp @ 5500 RPM. Curtiss-Wright also experienced the chatter marks on the rotor housings that had plagued others and formed an interesting theory on the mark's origins. They believed the chatter marks were the result of high speed bouncing of the apex seal as it passed over the reinforcing ribs of the rotor housing. To test this theory, they made rotor housings with oblique reinforcing ribs, so that the apex seal would always be passing over a portion of one. Prototypes were also built that featured alloy rotors, but they then switched to cast iron rotors. And while NSU had stuck to peripheral ported rotaries, Curtiss-Wright chose to locate the ports in the end housings for better low RPM torque and less mixing of the fresh charge and exhaust gases. The new test bed RC1-60 sported three years worth of research and development. A special peripheral port version created 155 hp @ 7000 RPM, all from one rotor.

A two rotor came along in the form of the RC2-60, which was running in test beds by September of 1963. The usual problems were still present - apex seal wear, chatter marks and hard cold starting. Rotor oil seals had also been developed to the point where a small amount of leakage had to be designed back in to lubricate the sides of the rotor. At this point, a fully developed RC2-60 was ready for automotive testing. The car of choice was a 1966 Ford Mustang, which retained its stock three speed automatic transmission, even though it was not well suited to the rotary's torque characteristics. Curtiss-Wright expected engine life to be around 100,000 miles and gave an oil consumption figure of one quart every 1100 miles. Journalists were allowed to test the car, but were not allowed to report on what car the engine had been installed in, so as not to start rumors about a potential rotary Mustang. The RC2-60 equipped Mustang had similar performance numbers to that of the stock Mustang equipped with a 289 cubic inch V8 despite the poor transmission choice. The RC2-60 produced 185 hp @ 5000 RPM and 192 ft-lb @ 3750 RPM.

Curtiss-Wright also built the first multi-rotor (three or more rotors) rotary engine ever. The engine was a four rotor which featured a one piece eccentric shaft supported by bearings along the way. The four rotor produced 425 hp @ 6500 RPM. The stable of rotary engines at Curtiss Wright's disposal was quite impressive. In addition to complete RC1-60 and RC2-60 engines, they had produced several others as well. Among these were a 4.3 cubic inch single rotor that put out 3.5 hp @ 4000 RPM. They had also produced the largest Wankel to date. To top it off, they had a series of Direct Injected Stratified Charge (DISC) engines capable of running on JP4, JP5, diesel, or gasoline. They were hopeful the DISC engines could be put into military use due to their multi fuel abilities.

4-rotor Corvette

With such a wide range of engines, Curtiss-Wright was simply waiting for a big contract to finally come. Feeling that his work was done, Max Bentele left the company in 1967. They did sign two small contracts, one with Westinghouse for a rotary powered generator and one with Outboard Marine Corporation. However, the big contract never materialized, which was blamed on conservative marketing of the rotary's advantages. In 1984, Curtiss-Wright sold their rotary engine program to Deere and Company (John Deere) for a mere $14 million, which represented a significant loss.

The second company to purchase a rotary license was Fichtel and Sachs. They also became the first licensee to begin producing engines for commercial consumption. That engine was a small single rotor KM37, displacing 103 cc and producing 6.5 hp @ 5500 RPM. The unique item about the engine is that it was air cooled (as was Curtiss-Wright's 4.3 cubic inch rotary). The air entered the rotor through a port in the side housing near the center of the rotor, it then traveled out of a port in the rotor, around the side housing, and

finally entered the rotor housing for combustion. The rotor housing was coated with a steel and bronze alloy. The KM37 began production in 1965 and was used in snowmobiles and all terrain vehicles.

French automaker Citroen also manufactured rotaries. They formed two joint companies with NSU, Comobile and Comotor. Comobile was to market a car designed by Citroen that was powered by an NSU rotary. Comotor was to build and market rotary engines for all applications. Comotor used very precise techniques to build their engines. Apex seals were built in eight lengths, so that the closest tolerances could be adhered to. All parts underwent ultrasonic cleaning before assembly. Rotors were classified in groups of 20 gram margins and only rotors from the same class could be put into the same engine. The Comobile program resulted in two different cars. One was the Citroen M35, of which about 250 were built purely for testing purposes.

Citroen M35

The other was the Citroen GS Birotor, which was not much of a sucess. A total of just over 800 vehicles were produced with most being recalled and destroyed by Citroen. Comotor's engines were also extremely expensive due to the high manufacturing costs in assembling such a precise engine.

Mercedes-Benz C111

Daimler-Benz also had a rotary program. They had test engines running in 1959, two years before they had a signed contract with NSU in October of 1961. Their rotary program also lead to yet another theory on chatter marks. Wolf-Dieter Bensinger, head of Daimler-Benz's rotary development believed that the leading apex seal would push oil, carbon, fuel, and combustion byproducts past its edge. As the build up accumulated and the resistance became higher, the leading apex seal would then lift over the obstruction and off of the working surface. When the trailing apex seal struck the surface again, small particles would break off. Daimler-Benz's engineers also proposed filling the rotor tips with sodium for better cooling, but it was eventually deemed unnecessary. Mercedes Benz introduced the C111 concept in 1969. It was powered by a fuel injected three rotor engine producing 330 hp. The car had impressive acceleration, 0-60 mph in 4.9 seconds and 0-100 in 14.9 seconds. The 1970 version came with a four rotor capable of 400 hp. The automotive press loved it. Sadly, the car

never saw production. The United States was a large market for Mercedes-Benz, and doubts still lingered over whether the rotary could be emissions compliant.

Mercedes-Benz C111

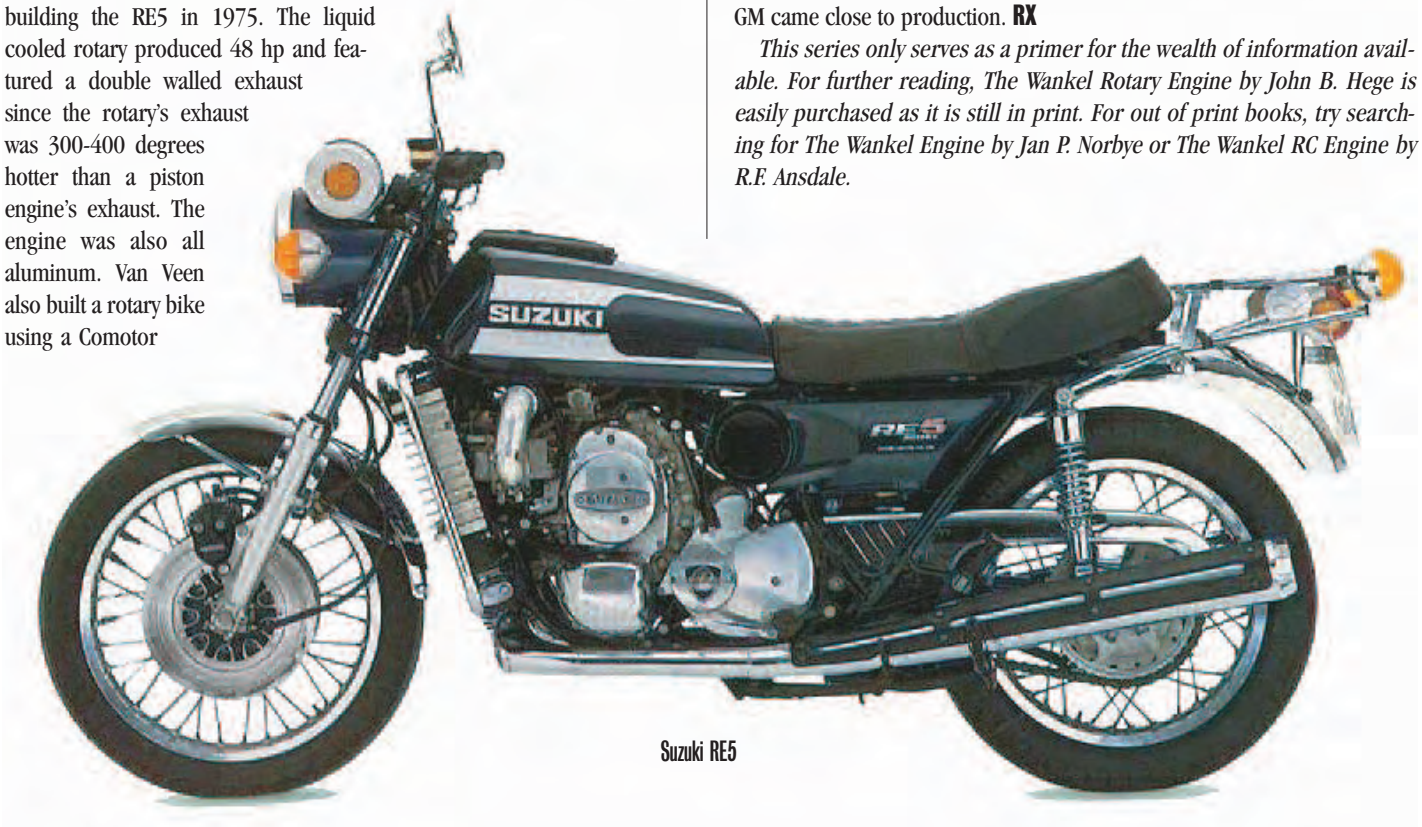
Rolls-Royce would undertake the building of one of the more interesting rotary engines. Rolls-Royce sought out to build a true compression ignition diesel rotary. While Curtiss-Wright had built an engine capable of running on diesel fuel, it used spark ignition, which did not make it a true diesel engine. In 1965, Rolls-Royce obtained a license for diesel rotary engines. Building a rotary to have such a high compression ratio that is necessary in a diesel would have resulted in a very large engine. To overcome this, they stacked two engines on top of each other. The larger of the two acted as a compressor for the smaller engine where combustion would take place. At high pressures, their apex seals were lifting, so they redesigned the apex seal into an "L" shape, so that pressures would force the seal outward towards the surface. The engine they built was the 2-R6. It consisted of two air pumping rotors and two combustion rotors. The 2-R6 produced 325 hp @ 4500 RPM and weighed 929 pounds, which was about half the weight of a comparable piston diesel engine producing the same power. Work proceeded until Rolls-Royce went bankrupt. After the British government picked up the pieces, rotary development began again for a short time, before being stopped completely in 1974.

Due to its compact nature, it was only natural motorcycle manufacturers would pick up on the rotary. Hercules produced the W 2000, which was powered by a larger Fichtel and Sachs air cooled rotary. Norton acquired all of Hercules tooling and manufacturing equipment and produced more rotary powered motorcycles. They also added another passage for the air to be recooled before entering the combustion chamber. Suzuki got into the rotary act as well, building the RE5 in 1975. The liquid cooled rotary produced 48 hp and featured a double walled exhaust since the rotary's exhaust was 300-400 degrees hotter than a piston engine's exhaust. The engine was also all aluminum. Van Veen also built a rotary bike using a Comotor two rotor. The bike was quite heavy, but also fast with a top speed of over 130 mph.

General Motors arrived late in the game. Then GM President Ed Cole liked the rotary and a special license was agreed upon in 1971. Through the terms of their license, GM would avoid paying royalties, only two installment payments. They also were not obligated to share their research with the other licensed companies, but would not be entitled to receive information either. GM pushed for possible introduction of the rotary into a Vega in 1973, which was later pushed to 1974. GM's early rotaries were all cast iron to try and contain costs. They also wished to rid the engine of an external oil cooler to further trim spending. The rotary housings were not plated, but sprayed with a metallic coating. However the apex seals were ceramic. The engine was further developed to include a chrome plated aluminum rotor housing with iron side housings. GM produced two rotary Corvette concepts. One was powered by a two rotor and the other a four rotor. Both cars were mid-engined. The four rotor engine was simply a pair of two rotor engines joined together. Ed Cole wanted the new Corvette to become a reality, but it was not to be. GM's official line in 1974 was that they were having problems getting the car to meet emissions for the 1975 standards, and they couldn't envision it having a chance of passing the 1977 standards. GM's rotary program would eventually disappear.

The other American manufacturers never put serious development into the rotary. Ford had tried to buy a share of Mazda in 1971, but talks eventually broke up. They then began shopping for motors with a potential plan of offering them in Capris, Mavericks or Mustangs. One option was to use their European arm, Fordwerke, which had a rotary license, but Ford would still have to pay royalties to Curtiss-Wright. Chrysler paid even less attention. One Chrysler executive called the rotary engine "one of the most unbelievable fantasies ever." It should be noted Chrysler devoted their time developing turbine engines for automobiles. However, Chrysler was shopping for rotary engines in the event General Motors made a move to production. American Motors also was looking for engines with plans to phase in the rotary engine if necessary. In the end, none of the American automobile companies except GM came close to production. **RX**

This series only serves as a primer for the wealth of information available. For further reading, The Wankel Rotary Engine by John B. Hege is easily purchased as it is still in print. For out of print books, try searching for The Wankel Engine by Jan P. Norbye or The Wankel RC Engine by R.F. Ansdale.



Suzuki RE5