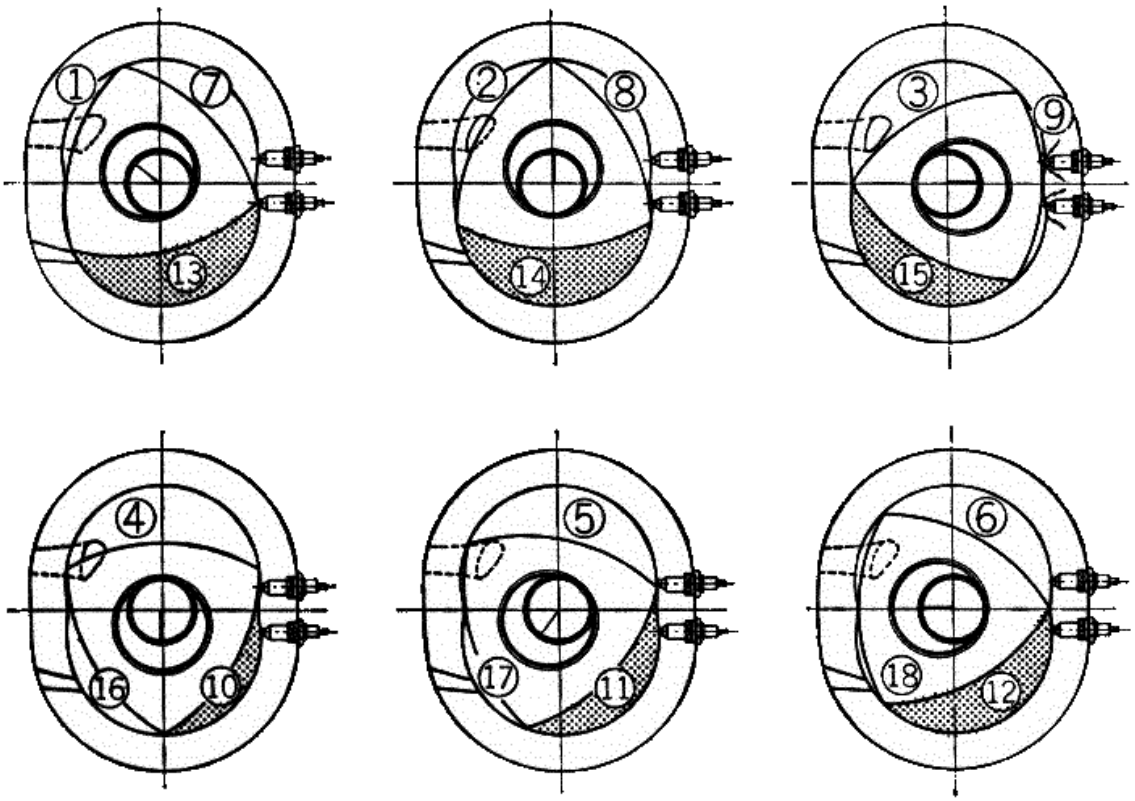
written by Paul Yaw at YawPower

After a great deal of thought, I decided that this first article should cover the basic workings of the rotary engine. In my experience, most people have the hardest time understanding port timing, and how it relates to engine operation. The accompanying illustration from "The Rotary Engine" by Kenichi Yamamoto will make this much easier to understand. At first, it may seem a bit confusing, but if you simply follow the numbers in order it is actually quite simple.

Before going into detail, it is critical that the reader understand some basic terminology. The various timing events of an internal combustion engine are typically stated in degrees of crankshaft rotation. In our case, output shaft, or eccentric shaft rotation. This terminology comes from the piston engine. Top dead center, or TDC refers to the working chamber being at its smallest possible volume. In a reciprocating piston engine, this occurs when the piston is at the very top of its stroke, hence the term top dead center. Bottom dead center, or BDC refers to the chamber being at its largest possible volume. In a reciprocating piston engine this occurs when the piston is at the very bottom of its stroke. All chamber volumes between TDC, and BDC, are referred to as Before TDC (BTDC), after TDC (ATDC), before BDC (BBDC), and after BDC (ABDC). For instance, 45° ATDC refers to the point at which the eccentric shaft has rotated 45° beyond top dead center. This is the situation in the first picture, looking at the chamber numbered 1. The line in the center of the picture extending from the crosshairs illustrates the angle of the eccentric shaft. This line corresponds with the keyway in the front of the shaft.


①
⑦
⑬
②
⑧
⑭
③
⑨
⑮
④
⑯
⑩
⑤
⑰
⑪
⑥
⑱
⑫

Below is a description of the complete process. Each description corresponds to the number in the illustration.

1. 45° ATDC The intake stroke is just beginning. The exhaust port has just closed, and on a stock or street ported engine, the intake port has been open for approximately 15°.

2. 90° ATDC The intake port is almost completely open, and the chamber is starting to expand at a fairly rapid rate.

3. 180° ATDC The intake port is all the way open, and has just passed the point of maximum flow. Maximum flow occurs at approximately 135° ATDC, which corresponds with the maximum rate of chamber volume increase.

4. BDC of the intake stroke. The intake chamber is now at its largest possible volume. The intake port is partially open, and the port is still flowing in the forward direction, even though the chamber is no longer increasing in volume. This is due to the inertia of the column of air flowing in the induction system. This effect is referred to as inertial supercharging, and is described in further detail in the airflow section of my webpage. This will also be addressed in a later article.

5. 45° ABDC The chamber has started to decrease in volume, and with the exception of a stock US model 12A, which has an intake port closing of 40° ATDC, the intake port is still partially open. At high rpm, the intake port is still flowing in the forward direction due to inertial supercharging. At low rpm, airflow in the port has reversed, and some of the intake charge is being squeezed back into the induction system by the pressure of the intake chamber which is decreasing in volume. This is the result of the low velocity in the induction system. This is a very important point to consider, as this alone affects the operating range of the engine more than any other factor.

6. 90° ABDC The intake port is completely closed, and air fuel mixture is being compressed.

7. 135° ABDC Same as #6.

8. 180° ABDC More of the same.

9. TDC of the compression stroke. The mixture is fully compressed, and ignition has started.

10. 90° ATDC The expansion cycle has started, and is already 45° past the point of maximum torque transfer to the eccentric shaft, which occurred at 45° ATDC.

11. 135° ATDC The expansion stroke continues, but the torque transferred to the output shaft is now down to about 35% of its peak.

12. 180° ATDC The exhaust port is still closed, and the torque transfer to the eccentric shaft is approximately 15% of its peak.

13. 225° ATDC At this point, the exhaust port has been open for approximately 30°, and exhaust flow is quite high.

14. BDC of the exhaust stroke. This is typically the point of maximum flow through the exhaust port. Even though the chamber volume is not decreasing at an appreciable rate, the chamber pressure is very high, and this is responsible for a large percentage of the total exhaust flow.

15. 90° ABDC The chamber volume is decreasing, and is 45° away from the point of maximum rate of decrease of the chamber volume.

16. 180° ABDC The exhaust chamber volume continues to decrease, and at approximately this point, a bridge ported, or peripheral ported engine will have started to open the intake port.

17. 225° ABDC The exhaust port is still open, and the chamber volume is decreasing at a relatively slow rate. At this point, a mildly bridge ported engine will have just opened the intake port.

18. TDC of the intake stroke. Here we are at the beginning, ready to start all over again. Note that the exhaust port is still open, but the intake port, for a non bridge ported engine has not opened yet.

I have included the port timing for all RX-7 engines, and some alternative ports, so that you can make comparisons, and gain a greater understanding of how the rotary engine operates.

This information may seem very basic to some readers, but it is critical to the understanding of performance tuning. As most of you know, changing the port timing of the rotary engine can result in large horsepower gains. Further articles will discuss this in detail, and without this knowledge base, the upcoming articles will make very little sense.

Next months article will cover the exhaust cycle, and its effect on engine performance and efficiency.

Paul Yaw.

Port Timing

IO = Intake opens
IC = Intake closes
EO = Exhaust opens
EC = Exhaust closes

US Model First Generation RX-7

IO 32° ATDC
IC 40° ABDC
EO 75° BBDC
EC 38° ATDC

European Model First Generation RX-7

IO 32° ATDC
IC 50° ABDC
EO 75° BBDC
EC 48° ATDC

First and Second Generation 6-Port 13B

Primary intake (Part throttle/cruise)
IO 32° ATDC
IC 40° ABDC
Secondary intake (Part to full throttle)
IO 32° ATDC
IC 30° ABDC
Auxiliary high speed ports (Full throttle above approximately 4000 rpm)
IO 45° ATDC
IC 70° ABDC
EO 71° BBDC
EC 48° ATDC

Second and Third Generation Turbo 13B

IO 32° ATDC
IC 50° ABDC
EO 71° BBDC
EC 48° ATDC

Racing Beat "Street Port"

IO 25° ATDC
IC 60° ABDC
EO 84° BBDC
EC 48° ATDC

Racing Beat "J-Bridge Port"

IO 115° BTDC
IC 72° ABDC
EO 88° BBDC
EC 57° ATDC

Mazda Factory Peripheral Port

IO 86° BTDC
IC 75° ABDC
EO 73° BBDC
EC 65° ATDC