# The Pressure Wave Process

- To explain the conventional pressure wave process, we follow one cell in the unrolled schematic view of the rotor during its movement through one cycle (see also figure 1).
- At the beginning (on top) the cell is filled with fresh air at approximately atmospheric pressure and ambient temperature. The process starts as soon as the cell is moved by the rotation of the rotor to the port edge of the exhaust inlet channel (3) in the gas casing. The pressure in the exhaust inlet channel (3) is significantly higher than in the cell. This difference results in a pressure equalisation process. Changes of state in a compressible medium expand by way of pressure waves. When the cell during its motion through the cycle passes the edge of the exhaust gas inlet port ③, a pressure equalisation process starts which generates the pressure wave ① travelling through the cell at the speed of sound. During this process the cell is continuously moving downwards. The path of the wave constituted by the vectors sonic speed $a_1$, medium velocity $c_1$ and rotor circumferencial velocity u, slants away from the axial direction as shown by the triangle of velocities at the bottom of the schematic illustration in Figure 1. The pressure wave ① travelling through the cell in this manner compresses the fresh air in the cell to the significantly higher pressure level of the exhaust gas and accelerates it across towards the charge air port (2). The exhaust gas itself follows the pressure wave with much lower velocity. In Figure 1 the exhaust gas is shown in red colour and the boundary between fresh air and exhaust gas is shown by the dotted line. The pressure wave process is matched in a way that the pressure wave ① reaches the air side at the moment the cell passes the opening edge of the charge air port (2). The equalisation of the different states in the exhaust port (3) and the charge air port (2) (density, velocity) induces a second pressure wave ②. This pressure wave travels bock through the cell, compresses the cell contents again and slows it down at the same time. The pressure wave ② results in a higher pressure at the opening of the charge air port (2) compared to the pressure in the exhaust port (3), thus resulting in a positive pressure difference over the rotor.
- The pressure wave ② travelling back in the cell, reaches the end of the rotor at the moment the cell passes the closing edge of the exhaust port (3). Because the charge air port is still open at that moment, the exhaust gas still flows in the opposite direction of the pressure wave ② by its inertia, which is towards the air side. This results in a strong depression at the now closed cell end, generating an expansion wave ③ travelling through the cell. This expansion wave slows down the cell contents and decreases the pressure in the cell, still being higher than the pressure in the exhaust outlet port (4).
- When the cell in its continuous motion passes the opening edge of the exhaust outlet port (4), a strong expansion wave ④ is generated due to the different pressure levels and travels through the cell towards the air side. The pressure level in the cell is decreased to the pressure level in the exhaust outlet port and the cell content is accelerated towards the exhaust outlet port (4). As soon as this expansion wave reaches the air side, the cell passes the opening edge of the air inlet port (1). Due to pressure loss in the intake air filter, a depression is created in the air intake port (1). Consequently a further expansion wave ⑤ is generated which in effect slows the cell contents down.

- In spite of a further slow-down of the cell contents by pressure wave ⑥, expansion wave ⑦, pressure wave ⑧ and expansion wave ⑨ (at open ends of the rotor expansion waves are reflected as pressure waves and pressure waves are reflected as expansion waves) the original expansion wave ④ was strong enough to evacuate the cell completely, draw in fresh air and even push a certain amount of scavenging air through the cell. The scavenging air cools the rotor and secures the complete filling of the cell with fresh air before the pressure wave cycle starts again.
- The entire pressure wave process is repeated twice per revolution of the rotor and lasts between 3 and 6 milliseconds at rated speed. This ideal pressure wave process takes place only at perfect tuning conditions. If the speed of sound or the rotating speed of the rotor changes, the pressure wave process would deteriorate rapidly as the perfect tuning range is left.
- To avoid this, the so-called pockets were developed. The pockets are depressions in the gas and air casing's main flanges which through changes in boundary conditions gene-rate new pressure waves and modify the already existing ones. This enables the control of the pressure wave process over a wide speed and load range. There are 2 pockets per cycle on the air side; the compression pocket (CP) stabilising the process at low speeds and the expansion pocket (EP) maintaining sufficient scavenging over the entire operating range in interaction with the gas pocket (GP) on the gas side.
- The introduction of the pockets made it possible to maintain the advantages of the pressure wave supercharger, the immediate response and the high air surplus, over the entire speed and load range of the engine.

**Figure 1: Generation of the pressure wave process. Schematic illustration of the unrolled air casing (left), rotor (middle), and gas casing (right).**