General Principles

Piston Ring Functions and Operation

Piston rings act as metallic seals and assure the flow of heat from the piston to the cylinder by sealing the combustion chamber from the crankcase. Piston rings have several functionalities some of them includes prevention of oil from passing from the crankcase to the combustion chamber when the lubrication is not required and also provide uniform oil film on the cylinder bore surface.

In order to function properly, the piston rings must stay in contact with the cylinder wall as well as with the piston groove sides. Usually, this radial contact is attained through inherent spring force of the ring.

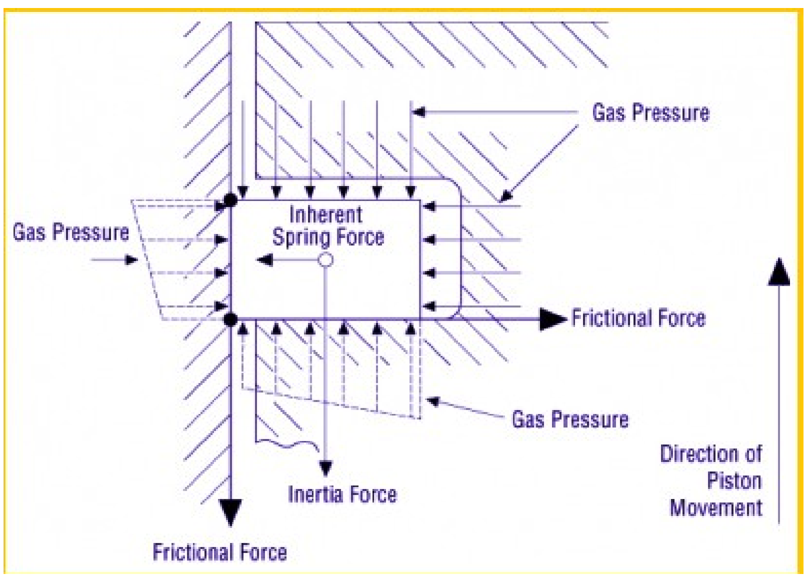

Figure-1 showcases the force acting on the piston rings.

In the combustion chamber, gas pressure plays a vital role in improving the contact between the radial and the axial. It actually means that the activity of the gas pressure enhances the sealing capacity of the piston ring. While the axial contact works alternatively between the top and bottom of the groove and it actually happens due to the interaction of gas, inertia and friction forces.

Apart from the functionality of internal combustion engine in the piston cylinder system, the piston rings are also deployed as metallic seals for rotating shafts and both functions as a contracting and expanding seals.

Theoretical Relationships

Contact Pressure

The piston ring is pressed against the cylinder wall under a contact pressure p which is administered by the dimensions, the total free gap of the ring, modulus of the elasticity of the material which is used. The total free gap is interpreted as the distance which is measured between the ends of a piston ring in its uncompressed state along the neutral axis. As demonstrated in Fig. 2.

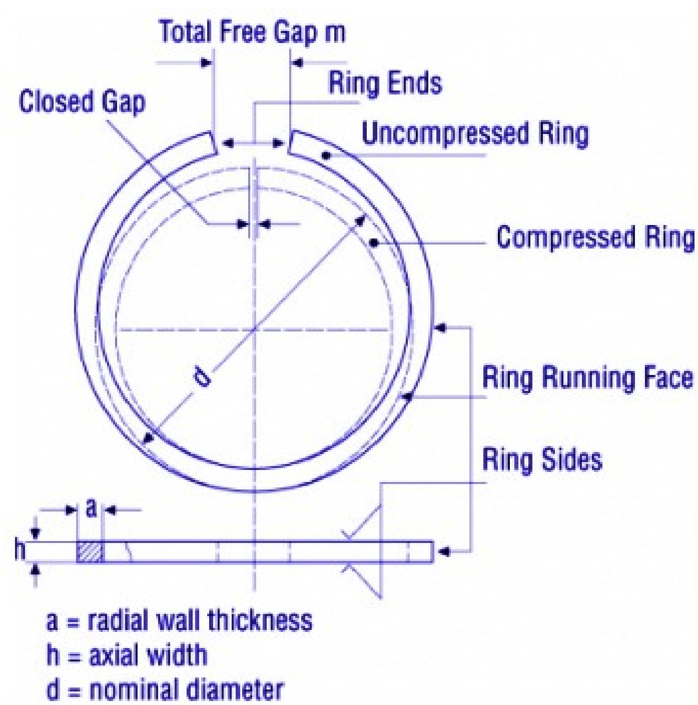

Figure 2: Piston Ring Nomenclature

A piston ring can be a constant or a variable contact pressure [2, 3] while later is a function of the angle (Phi) as in Fig. 3

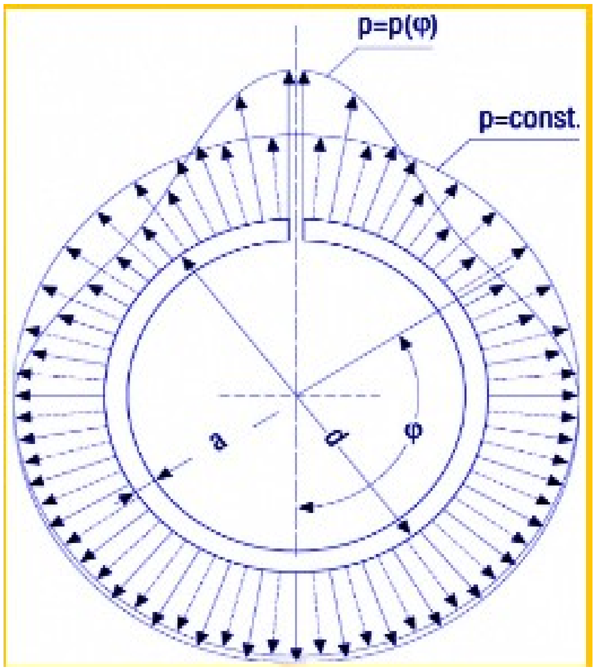

Figure-3 Constant and Variable Contact Pressure of a Piston Ring

The measurement of the contact pressure is highly tough. Therefore, practically it is calculated through the Tangential force. This is actually a force that is when applied tangentially at the ends of the ring, is ample to compress the ring between the specified closed gap. When bending moment of the tangential force is compared with the constant contact pressure, the below-given relationships are developed (Fig-4)

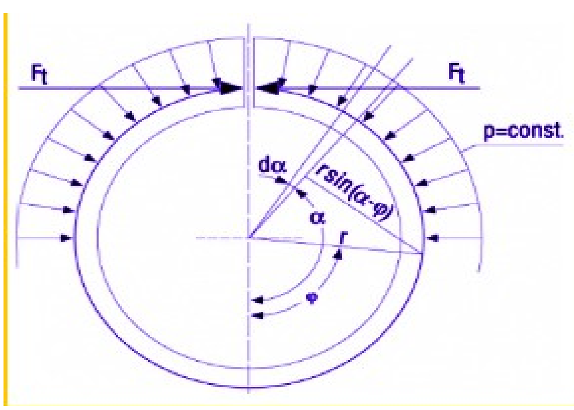

Figure-4 Relationships between Constant Contact Pressure and Tangential Force

Case- When p is constant, e.g. the ring is enclosed inside a flexible tensioning tape, the following interpretation is attained for bending moment M:

$$dM = p\ h\ r^2 \sin(\alpha - \varphi)\ d\alpha \qquad 1$$

$$M = p\ h\ r^2 (1 + \cos \varphi)$$

M is the bending moment which is expressed in terms of the tangential force Ft:

$$M = F_t\ r\ (1 + \cos \varphi). \qquad 2$$

From (1) and (2)

$$p = \frac{F_t}{r \cdot h} \qquad 3$$

Theoretical Relationships

Tangential Force

The tangential force is measured with the help of a flexible tensioning tape that unwraps the ring and compresses it between the gap. (The friction effects are ignored for commercially sized rings.) The tangential force Ft, actually acts as the fringe of the ring. By substituting in Fig (3) the diameter of the ring d for the radius r, the pressure that is exerted by the ring radially outwards against the wall of the cylinder is stated in following ways:

$$p = \frac{2\ F_t}{d \cdot h}\ \text{[N/mm}^2\text{]} \qquad 4$$

As per DIN/ISO standard, the contact pressure of the compression rings on account of their instinctive tension usually lies between 0.12 and 0.25 N/mm2 for rings. The gas pressure acting behind the ring makes the actual contact pressure umpteen times greater.