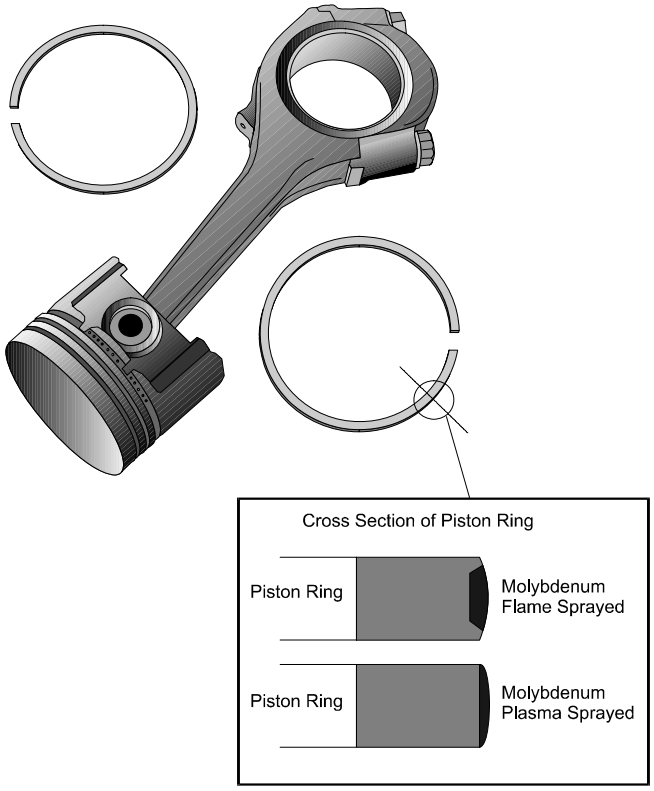
Metallisation
Thermal spray equipment and consumables

THERMAL SPRAYING OF PISTON RINGS

Application Data Sheet AU-WR-001

Molydenum Spraying of Piston Rings



INTRODUCTION

A piston is defined as a 'cylindrical piece moving to and fro in a hollow cylinder as in engines or pumps'. To seal the gases during the compression and work strokes of an engine, piston rings are used to provide an effective seal as well as preventing excessive lubrication oil from reaching the combustion chamber and providing a heat conduction path from the piston to the cylinder.

Requirements of a Piston Ring

The piston ring is required to operate in temperatures above 450°F with friction free capabilities to achieve in excess of 6000 revolutions per minute, as well as to remain dimensionally stable throughout its working life. More recently, new challenges with respect to performance and durability of piston rings have arisen, due to legislation in various Continents concerning emissions control.

These challenges are being faced with the technological improvement of the manufacturing process and the development of new base materials, coatings and ring profiles.

Coating Types

Back in the 1940's piston rings were in the main Chromium plated for wear resistance. Although still used in the mid 1960's, this was superseded by the thermal spray process to overcome Fretting wear in the chromium plated rings. The development of the Thermal Spray Process since its introduction has gone from Flamesprayed coatings to include Plasma sprayed coatings and High Velocity Oxygen Fuel Sprayed Coatings. This progression has been matched with the development of various coating materials.

Conventional 100% molybdenum coatings are usually sprayed into a shallow channel on the peripheral surface. This method is used to provide a better "grip", however in many applications, eg. turbocharged engines, where extreme shock loading combined with severe heat exists, this is unable to prevent the material from "flaking off".

Due to these limitations, continuous research and development of coatings is on-going to provide a coating with properties that would provide even superior engine performance. The nett result to date is a "super chromium" called "channel chrome" and a "super molybdenum" applied by the plasma or high velocity oxygen fuel (HVOF) System.

Piston rings are manufactured in large quantities. The normal manufacturing process involves the pre-grooved and dimensionally correct rings being loaded onto a pre-formed mandrel and compressed to form a compact cylinder. Once loaded onto the mandrel, it is gritblasted usually using Aluminium Oxide grit to prepare the surface prior to the application of a thermal spray coating.

Following the application of the thermal spray coating, the time required to deposit the coating and the nature of its application instills a quantity of heat into the mandrel which, due to production times, usually requires cooling by the use of air jets prior to being manually unloaded for subsequent grinding. Grinding of the rings on the mandrel is carried out until the piston ring is revealed leaving the thermal sprayed coating in the ring channel.

Flamesprayed Piston Rings

When a Flamespray Pistol is used to deposit molybdenum on the peripheral surface of a piston ring, the resultant coating contains a mixture of molybdenum and oxides of molybdenum. This coating is harder and more resistant than wrought molybdenum which does not contain oxides or porosity. In automobile engines, wire sprayed molybdenum coatings have been used successfully for many years. When this same coating is deposited on compression rings for heavy duty internal combustion engines, the operating conditions may cause premature coating failures due to flaking off the coating. Failure is usually attributed to the presence of lamellar oxides and radial stress cracks in the coating.

Molybdenum coatings which were plasma applied overcome the problem of premature coating failure. Protective carrier gases used in the plasma operation reduce the number of oxides formed during spraying and retain the excellent bond strength of molybdenum.

Plasmasprayed Piston Rings

Plasma sprayed deposits provide a wide range of compositions that may be used in the design of a piston ring coating. Any material that does not sublime or decompose in the plasma may be sprayed. This includes metals, metal alloys, cermets, oxides and some non-metallics. The constituents may be aggregates or dry blended mixtures of the above materials.

Selections are based on the required properties of the coating. First and foremost for piston ring coatings is the mutual wear compatibility between the ring coating and the cylinder bore.

Most often, this decision is based on past experience. Because of its anti-welding properties, besides a good adhesive and cohesive strength, it is a common practice to improve the bond strength of the coating by adding NiCr, CrNiSiB or cobalt. The hard phase is provided by the addition of carbides or oxides.

Plasma sprayed deposits have sufficient strength and ductility to be fully face sprayed on the ring. Full face spraying eliminates the cast iron edges of conventional channel moly, and at the same time minimises the possibility of oxidation by eliminating corners and crevices where oxidation and erosion of the base metal begin.

Elimination of the cast iron edges prevents the possibility of scuffing occurrences under extreme temperature situations.

GENERAL COMPARISON OF CHROMIUM PLATED VS. PLASMA COATED TOP PISTON RINGS

	Chromium		
Parameter	**Hard**	**Channel**	**Plasma/Cermet**
Basic Constituents	**Electroplated**		**Infinite metallic or cermet powder combinations**
Wear Resistance			
Scuff Resistance	Good	Very Good	Excellent
Adhesive Bond	Excellent		Very Good
Heat Resistance	Low		Excellent
Oil Carrying Capability	Poor	Regular	Excellent
Fuel/Lubricant	Restricted		Highly Adaptable
Ring Cost	Low to Moderate		Moderate to High