INDUSTRIAL TRAINING PROJECT

AT

SHRIRAM PISTONS & RINGS LTD.

A TECHNICAL OVERVIEW OF

PISTON MANUFACTURING AND INSPECTION PROCESSES

Submitted by :

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Sincerely,

Kashvi Agrawal

Company Profile

Shriram Piston and Ring Ltd. (SPR) is a leading manufacturer of pistons, piston rings, and allied components for the automotive industry. Established in 1972, the company has emerged as a trusted engine component supplier, catering to domestic and international markets. With a strong commitment to quality, innovation, and customer satisfaction, SPR has established itself as a key player in the industry. The products are sold under the USHA/SPR brand in the market.

SPRL manufacturing unit is located at Meerut Road in Ghaziabad (25 km from Delhi). The plant has been recognized as one of the most modern and sophisticated plants in north India in the field of automobiles the production capacity of the plant is as under:

- Piston : 21 million per year Actual Production in 2024-2025
- Pin : 21 million per year Actual Production in 2024-2025
- Rings : 95 million per year Actual Production in 2024-2025
- Engine valves: 45 million per year Actual Production in 2024-2025

Key Information:

- History and Establishment: Shriram Piston and Ring Ltd. was founded in 1972 as a joint venture between Shriram Industrial Enterprises Ltd. (part of the Shriram Group) and Ring Plus Aqua Ltd. The company started its operations in collaboration with NPR of Japan and AE of the UK.
- Product Range: SPR specializes in the manufacturing of pistons, piston pins, piston rings, and engine valves. Their products are used in a wide range of applications, including passenger cars, commercial vehicles, tractors, two-wheelers, and stationary engines.
- Quality Assurance: SPR has implemented a robust quality management system to ensure the highest standards in its products. The company has obtained various certifications, including ISO/TS 16949:2009, ISO 14001:2004, and OHSAS 18001:2007, demonstrating its commitment to quality, environmental sustainability, and occupational health and safety.
- Research and Development: SPR recognizes the importance of continuous innovation and invests significantly in research and development activities. The company has a dedicated R&D Tech center that focuses on developing new products, improving manufacturing processes, and enhancing overall performance.
- Market Presence: Over the years, SPR has expanded its market presence globally. The company supplies its products to renowned automotive manufacturers and aftermarket distributors worldwide. It has established long-term relationships with customers, based on reliability, timely delivery, and technical expertise.

- Sustainability Initiatives: SPR is committed to sustainable manufacturing practices and environmental stewardship. The company has implemented various initiatives to minimize its environmental footprint, conserve resources, and promote a safe working environment.
- Corporate Social Responsibility (CSR): SPR actively participates in CSR initiatives, focusing on education, healthcare, community development, and environmental conservation. The company believes in giving back to society and strives to make a positive impact on the communities in which it operates.
- SPR is the “Largest Exporter of Pistons of India” and has been recognized as an “EXPORT HOUSE” by the Government of India.

COMPANY POLICIES:

The policies which are followed by the SPR are given as follows:

SPR 5 S POLICIES

In this policy, there are five words starting from the letter 'S' on which the company pays more attention

➢ S	SHITSUKE	DISCIPLINE
➢ S	SEIKETSU	CLEANLINESS
➢ S	SEISO	CLEANING
➢ S	SEITEN	ARRANGEMENT
➢ S	SEIRE	PROPER SELECTION

The 5-S Practice is a Technique used to establish and maintain quality & environment in an organization

SPR TPM POLICY

T.P.M Means

T: - Total (Including of all employees)

P: -Productive (Running the M/C With Full efficiency)

M: - Maintenance

T: - Total

- Maximization of Total efficiency.
- The entire life cycle of the production system.
- Cover all departments.
- Participation of all Employees.

P: - PRODUCTIVE

- Pursue the maximization of the efficiency of the production system by making all losses zero.
- Zero Accidents, Zero defects, and Zero Breakdowns are the real meaning of maximization of efficiency.

M: -MAINTENANCE

- Maintenance Cover the entire life cycle of the Production system. It refers to the maintenance of individual processes, plant & Production management systems.

"ZERO FAILURE", "ZERO DEFECTS" & "ZERO ACCIDENT"
Through the Introduction Of TDM, With the Participation Of All Employment
Maximum Profit Through Improvement OF Overall Equipment Efficiency, Reduction In Cost & Increase In Customer Satisfaction

TOTAL CUSTOMER SATISFACTION THROUGH QUALITY MANAGEMENT AND CONTINUOUS IMPROVEMENT:-

- An organization that is sensitive & interactive to the needs of customers.
- Work to international norms of Quality & Management.
- The company has successfully practiced the best work ethics & technology along with the TPM & kaizen approach & harmony through teamwork.
- Continuous upgrading of quality & process to meet changing customers.

DIVISION OF COMPANY PREMISES:

The company premises is divided into the following groups :-

- **P.T.E. - Production Technology and Engineering.**
- **C.A.A. - Commercial Administration and Accounts.**
- **R & D - Research and Development**

In the PTE group, all manufacturing departments are covered. These are :

- Aluminum Foundry
- Piston Plant
- Ring Foundry
- Ring Plant ¬
- Steel Ring Plant
- Pin Plant

- Engine Valve
- Forging
- Engine Valve
- Machining
- Chrome Plating Plant
- Works Engineering
- Tool Room

In the CAA group, all commercial & administrative departments are covered. These are as:

- Administration
- Purchase
- Accounts
- Projects
- Quality Assurance
- InfoTech
- Stores
- H.R.D.
- A.& P.O.
- Personnel Safety
- MIS
- Sales Coordination

UAD (Users Acceptance Department) is covered with R & D group

At Shriram Pistons & Rings Ltd., quality is an integral part of whatever they do which is reflected in company's policy :

COLLABORATORS:

PISTONS	-	KOLBENSCHMIDT	-	GERMANY
RINGS	-	RIKEN CORPARATION	-	JAPAN

ENGINE VALVE - FUJIOOZX - JAPAN

TECHNICAL SUPPORT M/S HONDA FOUNDRY JAPAN

The company supplies its products to several Original Equipment Manufacturers (OEMs) like Ashok Leyland, Tata Cummins, Tata Motors, Maruti Suzuki, Mahindra & Mahindra, Tafe Tractors, SML (Swaraj), Kirloskar Oil Engines, Bajaj Auto, Honda Siel Cars, Sundaram Clayton, Honda Scooter, International Tractors, Standard combine in addition to all the Honda Joint ventures in India. SPRL is also supplying its products to international OEM's like Renault, Nissan, Ford and Riken etc.

Achievements in terms of quality:

SPR received the ISO-9001 certificate from RWTUV, Germany in 1994. Technology from the collaborators was supplemented with In-house efforts andby implementing world-class practices.

- The company received a QS-9000 certificate from TUV, Germany in the year 1999.
- The company received an ISO-14001 certificate in the year 2001.
- SPR received the TS-16949 certificate in the year 2003.
- The company received the OHSAS-18001 certificate in the year 2003.
- Best foundry awards from the Institute of Indian Foundry Men in the year 2003.
- Green rating award by CII, U.P. Pollution Control Board & World Bank in 2004.
- The company received the TPM Excel Award in the year 2004.
- Received Diamond Award – the overall Best performance in QCDDM, outstanding performance in cost, bronze award for delivery, gold award for 5S from Honda Siel Cars(I) Ltd. In 2006.
- SPRL has received the Best Vendor Awards from Maruti Suzuki for 4 consecutive times, and Best supplier performance awards from Tata Cummins Ltd for 3 consecutive years. And has self-certified status with most of the OEMs.

- Excellence award in Export by the government of India.
- Excellence award in productivity by ACMA in 2007-08.
- Excellence award in quality by Honda Scooters and Motor Cycles Limited,
- Excellence award in technology by ACMA in 2007-08.
- Excellence award in manufacturing excellence award by ACMA in 2007-08.
- Received silver trophy- technology from ACMA in 2007-08.
- Received outstanding supplier for technology award from Cummins in 2007-08.
- Received vendor performance award Kaizen, vendor performance award overall commendation, and overall achievement trophy from Maruti Suzuki in 2007-08.
- Best foundry award received from the Institute of Indian Foundry Men.
- Received star performer (IC Piston Engine & Parts) award from Engineering Export Promotion Council (EEPC) India.
- Received silver award – Quality & Bronze award – spares from Honda Siel Cars India Ltd. In 2007.
- The company received TPM special award in March 2008
- Received Best Quality Vendor award from Tata Motors Ltd. In 2008-09.
- Received best vendor award for overall performance (QCLDM) from Ashok Leyland in 2008-09.
- Received overall achievement trophy from Maruti Suzuki in 2008-09.
- Received best explorer award from FIEO- Federation of Indian Export Organization in 2009-10.
- Received Trophy from EEPC "STAR PERFORMER IN PRODUCT GROUP OF ENGINES, TURBINES & PARTS" in recognition of outstanding contribution to engineering exports during the year 2008-09.
- ISO/TS 16949 achieved for SPR Unit-II – Ghaziabad in the year -2009.
- ISO/TS 16949 achieved for SPR Unit V Pune in the year 2010.
- Received performance award from Honda Seil Power Products Ltd. In March
- -2012.
- Kirloskar Oil Engines Ltd. - Dependable Long Association, 2016
- TAFE Motors & Tractors Ltd Commitment To Quality, 2017
- Mitsubishi Heavy Ind. – VST Diesel Engines Pvt. Ltd.: Best Supplier – Supply Performance in 2018-19.
- Daimler India Commercial Vehicles Pvt Ltd.: Winner Under Category "Quality "2019
- Honda Car India Ltd.: Gold Award For Quality 2020
- Mahindra & Mahindra: Annual Commodity Award For Engine Proprietary (Farm Division) 2020

- Nissan Motors India Pvt. Ltd.: Global Award for Quality 2020
- Kirloskar Oil Engines Limited- Letter of Appreciation for demonstrating a strong partnership in developing new product platforms.
- Ghaziabad & Pathredi plants have been awarded TPM Excellence Award from JPIM, Japan 2022
- Institute of Directors, London (UK) - 'The Golden Peacock Award' for "Excellence in Corporate Governance - 2022"
- British Safety Council: Sword Of Honor
- Engineering Export Promotion Council (EEPC): Star Performer - Engine Parts".

Features of SPR factory:

- Total area covered by the factory is 27 Acres.
- The factory has manufacturing facilities for piston, rings, pins and engine valves.
- Classification of the premises:
- P.T.E- Production Technology and Engineering C.A.A- Commercial Administration and Accounts
- R & D- Research and Development
- Total strength of the company is 6230 nos. consisting of officers, staff and workers.
- The turnover/sales for the year 2022-23 are Rs. 5000.00 Cr.
- The company is exporting or more than 35 countries.
- Exports sales are of Rs. 250 Cr. year 2022-2023.
- Over 10% of the production is exported to sophisticated markets such as Europe, U.K., Egypt, U.S.A., Latin America etc.
- SPR has been investing 30% of its retained earnings in quality up-gradation and modernization every year.

VISION

- World Class Company, Preferred by World Class Customers
- Motivated, Dedicated and System Oriented Employees
- Safe and Healthy Work Place

MISSION

- Sales and profit growth/leadership
- Strong leadership with collaborators
- Preferred OE supplier
- Employee development

- Superior returns to stakeholders
- Care for the environment and society.

<u>OTHER MANUFACTURERS COMPANY IN INDIA: -</u>

There are the following Manufacturers Company of piston, piston ring, piston, pin and engine valves in India which is given below

- SAMKRG Piston & Rings – Andhra Pradesh
- (IPL)India Piston Limited (A Group of Amalgamations) – Chennai
- (SSPPL) Sintered Product Pvt. Ltd. –Headquartered in Kosi Kalan (North India)
- (AIP) Abilities India Piston & Rings Ltd – Ghaziabad
- Shriram Piston & Rings Ltd – Bhiwadi.

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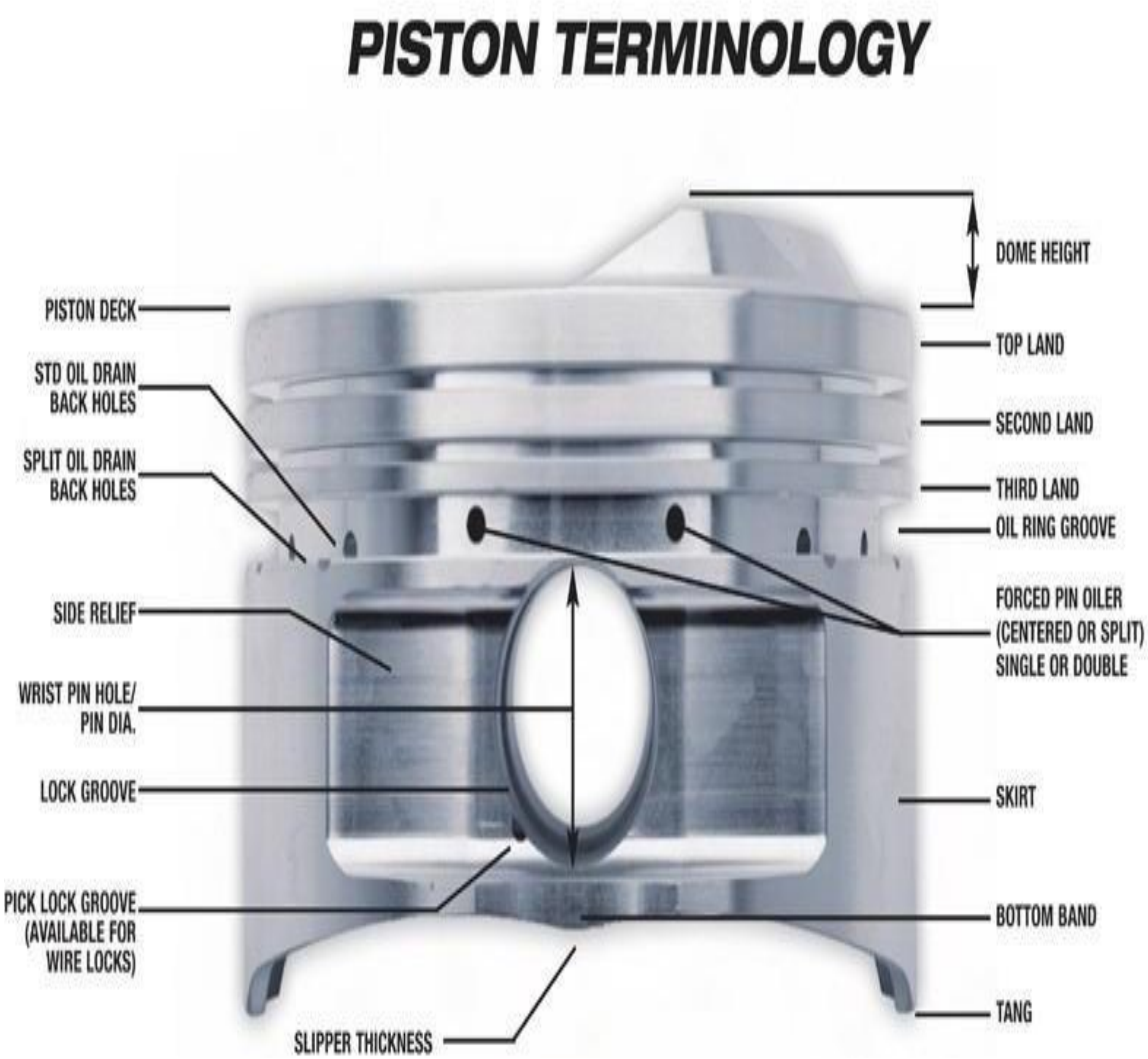
Description of a General automobile Piston



PISTON: -

A piston is a cylindrical, hollow aluminum or iron part closed on top and open at the bottom, fitting closely within the engine cylinder/sleeve, capable of being driven alternately up and down in the cylinder.
The piston acts as the heart of the engine. Its primary function is to transfer force/thrust generated by expanding combustion gases during power stroke to the crankshaft through the piston pin and the connecting rod.
Additionally, the piston serves as a platform for holding piston rings.

In both gasoline and diesel engines, aluminum alloys are the preferred choice of material for pistons due to their specific characteristics. These include low density (lightweight), high thermal conductivity (efficient heat transfer), easy machinability, high reliability, and excellent recycling properties. Achieving the desired mechanical and thermal performance, particularly high thermal fatigue resistance, relies on precise control over the chemical composition, processing conditions, and final heat treatment of the piston. This results in a microstructure that ensures the required performance of the piston.

A) Land: The land refers to the portion of the piston located above the top ring or between the ring grooves. Its purpose is to confine and support the piston rings within their respective grooves.

B) Heat Dam: Some pistons feature a narrow groove known as a heat dam, which is cut into the top land. The heat dam helps reduce the transfer of heat to the top ring groove. During engine operation, this groove tends to fill with carbon, further limiting heat flow to the top ring.

C) Compression Distance (or height): Compression distance refers to the measurement from the center of the pin hole to the top of the piston where the grooves for the rings are machined. It determines the position of the piston within the cylinder and influences the compression ratio of the engine.

D) Ring Belt: The ring belt is the area between the top of the piston and the pin hole. It provides space for the installation of piston rings.

E) Piston Head: The piston head is the top surface of the piston that faces the combustion chamber. It experiences the pressure exerted by the combustion gases during the power stroke. The piston head can have various shapes such as flat, concave, convex, or irregular, depending on the engine design.

F) Piston Pins (Wrist pins or gudgeon pins): Piston pins are the connections between the upper end of the connecting rod and the piston. They can be held in three ways: anchored in the piston with the bushing in the connecting rod oscillating on the pin, clamped in the rod with the pin oscillating in the piston, or fully floating in both the connecting rod and piston with lock rings or other devices preventing the pin from contacting the cylinder wall.

G) Skirt: The skirt is the lower portion of the piston located between the first ring groove above the pin hole and the open bottom end. It forms a bearing area that contacts the cylinder wall and helps to stabilize the piston within the cylinder.

H) Pin Hole: The pin hole is an opening through the piston skirt that accommodates the piston pin. It serves as the pivot point for the connection between the piston and the connecting rod.

I) Oil Ring Groove: The oil ring groove is a groove cut into the piston around its circumference, typically located at the bottom of the ring belt or the lower end of the piston skirt. It is wider than the compression ring grooves and often incorporates holes or slots to facilitate oil drainage to the interior of the piston.

J) Compression Ring Groove: The compression ring groove is a groove cut into the piston around its circumference in the upper part of the ring belt. Its depth varies based on the piston size and the type of rings used.

K) Groove Depth: Groove depth refers to the distance from the cylinder wall to the bottom of the ring groove when the piston is centered in the cylinder. It determines the space available for the rings and influences their sealing performance.

L) Groove Root Diameter: The groove root diameter refers to the diameter of the piston measured at the bottom of the groove. The root diameter can vary for each groove on a piston, depending on the specific type of ring that will be installed. The groove root diameter is important for ensuring the proper fit and functioning of the piston rings.

M) Land Diameter: The land diameter is the diameter of the land, which is the area of the piston between the ring grooves. In certain piston designs, all lands have the same diameter, while in others, the land diameter increases gradually from top to bottom. The land diameter is a critical parameter for maintaining stability and proper functioning of the piston rings.

N) Skirt Groove: The skirt groove is a groove cut into the piston around its circumference below the pin hole. This groove is specifically designed to accommodate an oil ring, which helps in lubricating the cylinder wall and piston assembly.

O) Offset Pin Hole: In some piston designs, the pin hole is offset to one side of the piston centerline. This offset configuration allows for optimized piston motion and improved engine performance under specific operating conditions.

P) Top Groove Spacer: When the top grooves of a piston become worn out, they need to be re-machined before installing new rings. In such cases, a steel spacer is inserted above the ring in the reconditioned groove. This spacer helps reduce the side clearance to the recommended dimension, ensuring proper ring sealing and performance.

Q) Piston Skirt Taper: Piston skirt taper refers to the difference in diameter between the top and bottom of the piston skirt, with the diameters measured in the thrust direction. The taper is designed to provide optimal contact and running clearance between the piston skirt and the cylinder wall, taking into account variations in temperature and load conditions.

R) Piston Cam: The piston cam refers to the circumferential shape in which a piston skirt is manufactured. The cam shape is carefully designed to ensure proper contact and running clearance between the piston skirt and the cylinder wall, allowing for efficient operation and minimizing friction and wear.

S) Cast-In Groove Insert: A cast-in groove insert is a steel or cast iron insert that is chemically or mechanically bonded into an aluminum piston during the manufacturing process. This insert is specifically incorporated to provide a longer wearing surface for the top ring. The insert is machined to create the top groove, enhancing the durability and performance of the piston ring in that location.

Material Composition of Pistons

Pistons are predominantly manufactured from aluminum-based alloys due to their favorable strength-to-weight ratio, excellent thermal conductivity, and suitability for high-performance engine environments. These alloys contain several key elements:

1. Aluminum (70–85%) – The base metal, valued for its lightness and thermal conductivity.
2. Silicon (10–23%) – Increases hardness and wear resistance. It also improves dimensional stability under thermal stress, which is critical for maintaining piston shape during high-temperature operation.
3. Copper (0.8–5.5%) – Enhances strength, machinability, and wear resistance.
4. Nickel (0.8–2.3%) – Maintains strength at high temperatures.
5. Magnesium (0.8–1.3%) – Improves hardness and strength without adding much weight.
6. Titanium (0.2–0.3%) – Refines grain structure and improves material homogeneity of the alloy.
7. Phosphorus (70–250 ppm) – acts as a deoxidizing agent ,used in trace amounts to purify the alloy.
8. Iron (<0.7%) – An impurity that may enter during processing; kept below threshold to prevent adverse effects on ductility and fatigue strength.

Classification of Pistons

1. Diesel
   i. Non-Ring Carrier Piston
   ii. Ring Carrier Piston (RCP)
      - Ring Carrier with Strut
      - Double Ring Carrier
      - Oil Cooling Gallery Piston

2. Gasoline

   On the basis of features:
   i. KS Lite
   ii. Non-KS Lite

   On the basis of uses:
   i. Two-wheelers
   ii. Four-wheelers

Diesel Engine Pistons
Used in high-compression, high-torque applications like trucks, tractors, and some passenger cars. These pistons are built to withstand extreme pressures and thermal loads.

- May include cast iron ring carriers in the top groove
- Thicker crown and top land for thermal resistance
- Deep bowl or cavity on the crown to aid in combustion swirl
- often feature deeper valve pockets
- May include cooling galleries or internal cavities for oil circulation

Non Ring Carrier Piston: A simpler piston without a separate ring carrier. Typically used in lower-load applications.

Ring Carrier Piston (RCP): Includes a separate ring carrier, often made from cast iron, fitted in the top groove for added wear resistance and strength. Variants include:

- Ring Carrier with Strut
- Double Ring Carrier
- Cooling Gallery Piston

Gasoline Engine Pistons
Used in passenger cars, motorcycles, scooters, and small generators. These pistons operate under relatively lower compression ratios and combustion pressures. They are more responsive under high RPM and suited to high-speed applications.

- Shorter compression height
- 2–3 ring grooves (usually two compression rings and one oil control ring)
- May have shallow valve pockets in the crown
- Flat-topped or slightly domed to suit spark-ignition combustion
- Heat dissipation via cylinder walls and oil spray on the underside
- Generally, air- or water-cooled indirectly

On the basis of features:

i. KS Lite
Designed with weight reduction in mind, these pistons feature thin wall sections and optimized design to improve performance.

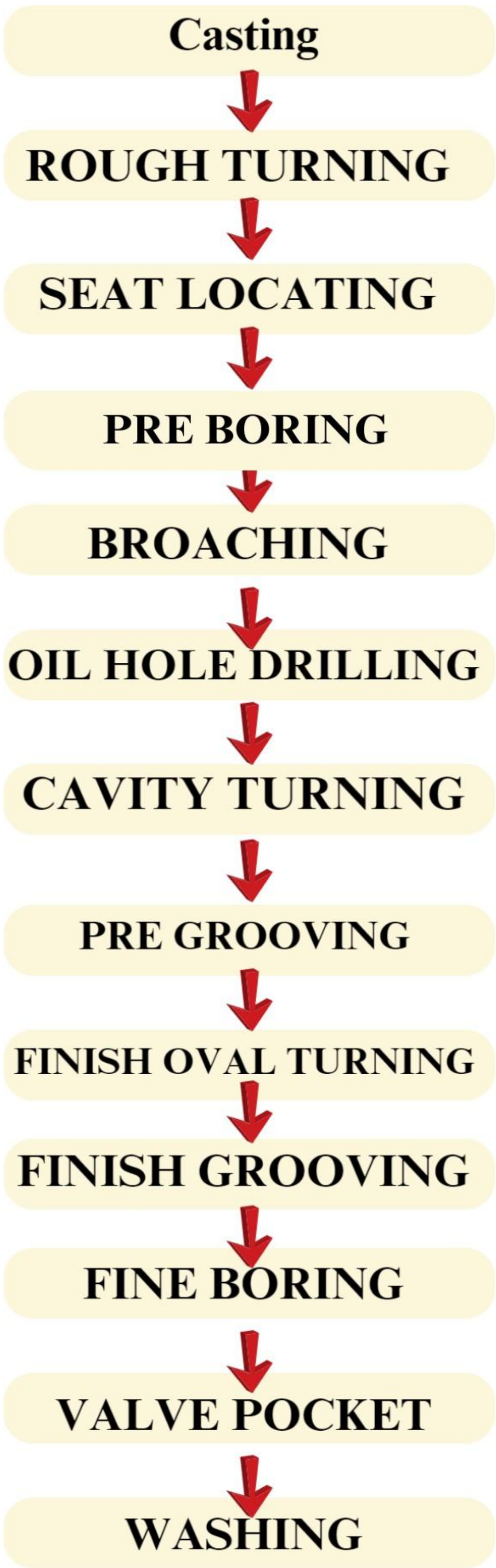
ii. Non-KS Lite
Heavier and more robust pistons

On the basis of uses:

i. Two-wheelers
Compact and lightweight pistons suited for smaller displacement engines.

ii. Four-wheelers
Larger and more complex pistons designed for higher output.

Process Piston manufacturing



CASTING: -

For casting, pistons are produced at the aluminum casting plant in SRPR, which operates as a foundry shop.

Aluminum (FOUNDRY) Casting plant

PLANT OVERVIEW

Melting capacity – 3ton/hour

Dia meter range – 39mm~128mm

Number of alloys – 7NOS (KS Alloy-5nos, Honda alloy-2 no's)

Number of Induction Furnace – 1ton -3NOS, 5ton – 2NOS

Casting capacity -1.9 million /month

Gasoline capacity – 1.3 million /month

Lite piston capacity – 0.1 million /month

Diesel capacity – 0.5 million /month

OGC Capacity – 0.15million

Die Casting Machine – 61NOS

No of Auto power Cell – 6 NOS (18 Diesel Casting machines)

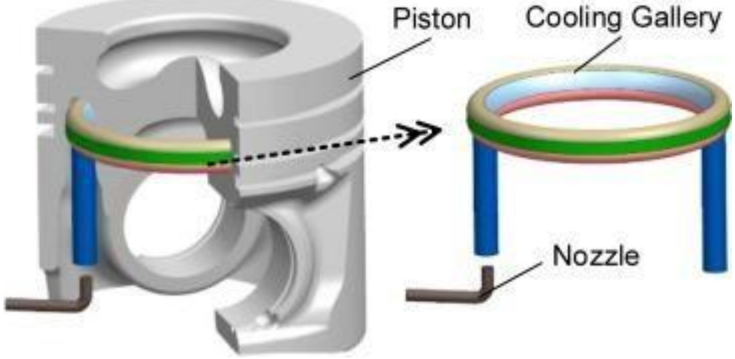
No of cavity machine – 15NOS

Heat treatment – Single HT /Double HT

In the foundry shop, we engage in the process of melting raw materials such as aluminum, silicon, copper, and nickel, which serve as the primary components for our alloy production. Once the materials are melted, we proceed to cast the molten alloy into molds, thereby obtaining the desired shape for pistons. Within this foundry shop, SRPR specializes in manufacturing a range of specialized pistons, including OCG pistons (Oil Cooling Gallery), non-OCG pistons, and CI ring pistons. These pistons serve distinct purposes and are tailored to specific applications.

Additionally, SRPR also manufactures standard pistons suitable for commercial and various other vehicle types. It is important to note that while the foundry shop is responsible for the initial production of the pistons, the piston plant plays a crucial role in further refining the quality and characteristics of the pistons through machining processes.

b) <u>OCG Piston</u>: - OCG pistons, or Oil Cooling Gallery pistons, are specifically engineered pistons designed for heavy-duty vehicles that generate substantial heat during operation. These pistons incorporate a unique cooling system to ensure efficient heat dissipation and prevent overheating.



The cooling gallery is a crucial feature of OCG pistons, which is created by utilizing a salt tube during the casting process.

To manufacture OCG pistons, the salt tube is carefully inserted into the mold before casting. The tube acts as a placeholder, creating a void within the piston where the cooling gallery will be formed. During the casting process, the molten alloy surrounds the salt tube, encapsulating it within the piston structure. Once the casting is completed, the piston goes through a washing process to remove the salt tube.

The removal of the salt tube reveals the oil cooling gallery inside the piston, which allows for the circulation of cooling oil. This gallery enhances the heat dissipation capability of the piston, effectively regulating the temperature and preventing excessive heat build-up during operation. OCG pistons are critical components in heavy vehicles where the continuous cooling of the engine is essential to maintain optimal performance and durability.

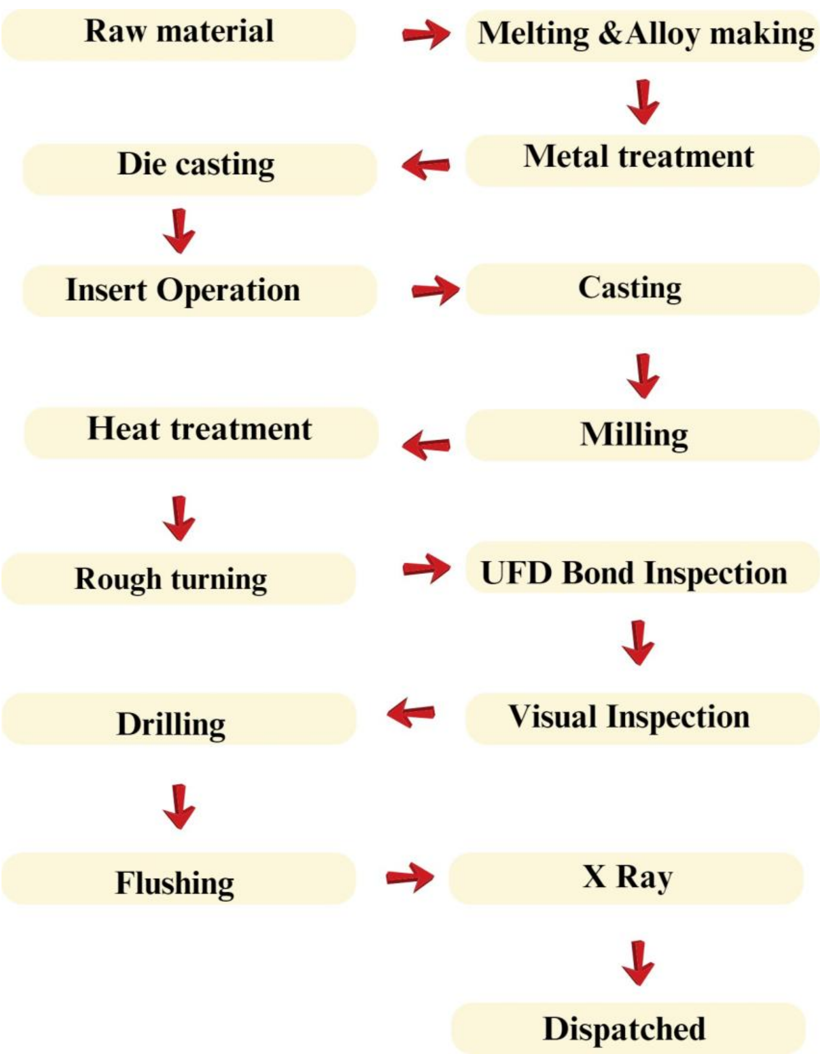
By incorporating the oil cooling gallery feature, OCG pistons offer superior thermal management, reducing the risk of piston failure due to overheating. This design enables heavy vehicles to operate reliably under high-stress conditions, contributing to enhanced efficiency and extended engine life. The implementation of OCG pistons in such applications is a testament to their effectiveness in managing heat and ensuring the smooth functioning of heavy-duty engines.

c) <u>NON-OCG Piston: -</u> Non-OCG pistons are smaller-sized pistons that do not incorporate an internal cooling gallery. These pistons are designed for applications where the cooling gallery feature is not necessary, typically in engines that generate lower levels of heat. Due to their reduced size and heat generation, alternative cooling methods such as improved piston design and external cooling systems are sufficient for maintaining optimal operating temperatures.

Non-OCG pistons undergo meticulous design and material selection to ensure effective heat dissipation, making them suitable for various engine applications where smaller pistons are used.

d) CI Ring Piston: - Cast iron ring pistons have the advantages of superior shock absorbance and efficient heat distribution. The cast ir … tons can effectively handle dynamic loads and vibrations, ensurin… operation. Additionally, they act as a thermal barrier, limiting heat transfer to the lower part of the piston and maintaining its structural integrity. These features make cast iron ring pistons ideal for demanding applications where robustness and reliable performance are required.

PROCESS OPERATIONS SEQUENCES OF OCG PISTON



The process operation sequences of OCG pistons in the foundry are highly automated.

A robot pours the molten metal into the casting cavity, ensuring precision and consistent quality control.

The mold is prepared with the desired cooling gallery feature, and the molten metal, comprising aluminum, silicon, copper, nickel, and other alloying elements, is poured into the mold.

After solidification, the mold is opened, and the salt tube, which created the cooling gallery, is removed. The freshly cast piston then undergoes subsequent manufacturing processes in the piston plant.

1) Raw material: - The foundry for piston manufacturing utilizes a range of raw materials to produce the required alloy. These materials include aluminum, silicon, copper, nickel, tin, zinc, manganese, magnesium, and phosphorus. Each material contributes specific properties to the alloy, enhancing its flowability and other desired characteristics.

Aluminum serves as the primary component of the alloy, providing lightweight properties, good thermal conductivity, and corrosion resistance.
Copper enhances the alloy's strength and heat resistance.
nickel contributes to its durability and wear resistance.

Silicon, for example, is added to improve the flowability of the molten metal during the casting process. It helps reduce the viscosity of the alloy, allowing it to fill the mold more efficiently and accurately capture intricate details of the piston design. Silicon also enhances the alloy's heat resistance and helps control the formation of undesirable microstructures.

Tin is commonly added to improve the wear resistance of the piston. It forms a self-lubricating layer on the piston surface, reducing friction and minimizing wear during operation. This helps to extend the lifespan of the piston and ensure smoother movement within the cylinder.

Zinc is added to enhance the castability of the alloy. It improves fluidity during the casting process, allowing for better mold filling and capturing of intricate details. Zinc also aids in reducing the formation of defects such as porosity in the castings.

Manganese is added to improve the strength and hardness of the alloy. It enhances the alloy's ability to withstand high pressures and mechanical stresses encountered during engine operation, reducing the risk of deformation or failure.

Magnesium is known for its lightweight properties and is added to reduce the overall weight of the piston. It helps improve the engine's fuel efficiency and reduces the reciprocating mass, leading to improved performance and reduced emissions.

Phosphorus is added to enhance the alloy's resistance to corrosion. It forms a protective oxide layer on the surface of the piston, acting as a barrier against corrosive elements in the engine environment. This helps to prolong the lifespan of the piston and maintain its performance over time.

In some cases, the raw materials are imported as pre-made alloy compositions. These alloys are carefully selected based on their specific properties and compatibility with piston manufacturing requirements. Alternatively, the alloy composition can be custom-made by combining the raw materials in specific ratios to achieve the desired alloy characteristics.

Suppliers for Raw material: - HINDALCO, VEDANTA, NALCO.

Supplier for Alloy: - GR METALS, SARKAR, PHONIX.

The proper casting of the piston involves precise control of the raw material composition and its properties. The alloy's flowability, solidification behavior, and mechanical properties are critical factors in achieving high-quality piston castings. Through meticulous material

selection and alloy formulation, the foundry aims to optimize the casting process, ensuring the alloy fills the mold effectively, solidifies without defects, and provides the necessary performance and durability for the piston application.

2) MELTING AND ALLOY MAKING: -

To create the desired alloy, the raw materials are introduced into an induction furnace. The induction furnace heats the materials, transforming the solid alloy into a molten or liquid phase. This molten alloy can then be smoothly poured into the casting cavity to achieve the desired shape and structure of the piston.

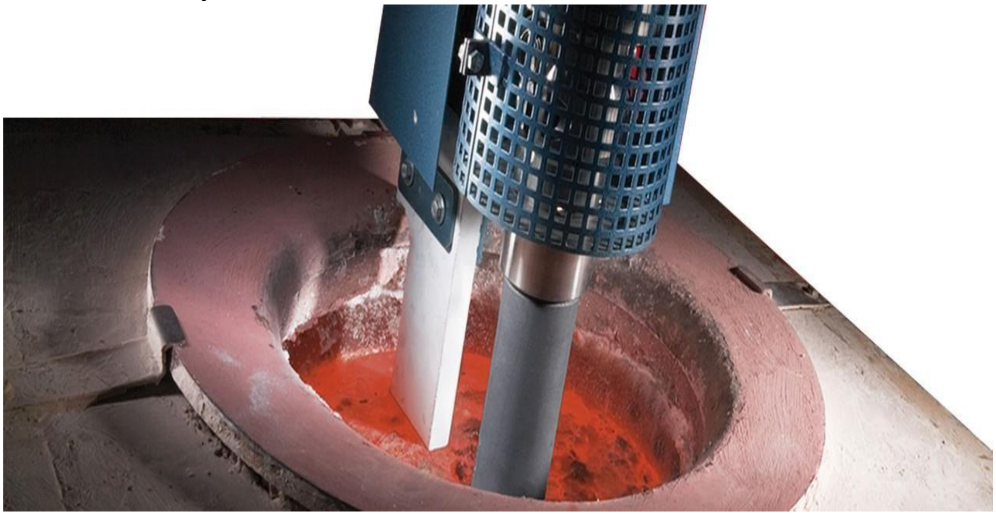
In addition to the raw materials, scrap from previous castings is also added to the furnace. This scrap serves as a cost-effective solution by reducing wastage. The scrap is typically used as a runner. This recycling of scrap helps minimize material waste and contributes to a more sustainable and efficient production process.

Chips generated within the piston plant can also be recycled and added to the induction furnace. These chips are often remnants or excess material from machining processes. By reintroducing these chips into the furnace, their value is maximized, and the overall material utilization is improved.

The induction furnace is controlled by a PID (Proportional-Integral-Derivative) system. This system ensures precise temperature control by adjusting the heat output based on feedback signals. It maintains the desired temperature profile and ensures the molten alloy remains at the optimal temperature throughout the casting process. The temperature inside the furnace can be monitored using a thermometer, and the temperature readings are displayed on a Programmable Logic Controller (PLC) board, providing real-time information for process control and monitoring.

3) METAL TREATMENT: -

After the alloy is melted, the molten metal is transferred to a holding furnace constructed with silicon carbide. In this holding furnace, the molten metal undergoes a process known as Gas Bubble Flotation (GBF). The GBF process is widely employed in the industry to ensure the production of high-quality molten metal .During GBF treatment, argon or nitrogen gas is introduced from the bottom of the bath, while a rotating impeller creates vigorous turbulence and generates a uniform distribution of fine bubbles throughout the melt. This intense agitation helps in lifting dissolved hydrogen and nonmetallic impurities, known as inclusions, to the surface of the molten metal. By utilizing this mechanism, the GBF process achieves exceptionally low hydrogen levels, typically ranging from 0.05 to 0.12 cm3/100 g Al. Moreover, it eliminates up to 90% of nonmetallic impurities from the molten metal.



The use of a holding furnace made of silicon carbide ensures the necessary thermal stability and resistance to the corrosive nature of the molten metal. Silicon carbide exhibits excellent refractory properties, maintaining structural integrity and preventing contamination of the molten metal during the GBF process.

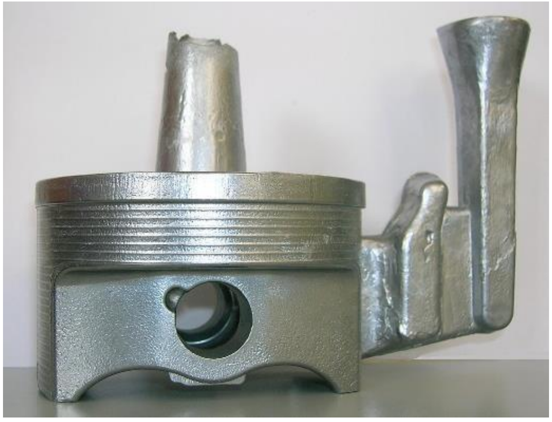
4) DIE CASTING: -

Once the metal treatment process is complete, the molten metal is prepared for die casting. In some instances, manual pouring is employed, where an operator manually pours the molten metal into the die. However, in the case of large pistons and to alleviate operator fatigue, a robotic system is utilized for metal pouring. During the die-casting process, an OCG ring is formed when necessary. To achieve this, a salt tube is inserted into the die before casting. The salt tube acts as a core for creating the cooling gallery feature in the piston. There are three main types of casting methods employed in the industry: low-pressure die casting, high-pressure die casting, and gravitational die casting. In the aluminum foundry shop, the gravity die-casting method is commonly used. This casting method is chosen due to the increased flowability of the molten metal achieved by incorporating silicon into the alloy. The improved flowability eliminates the need for additional pressure during casting.

5) Milling: -

After the die casting process, the piston is formed using molten metal. However, it also contains attached components called the runner and riser, which need to be removed. This is done through a milling process.

Milling involves using a milling machine with rotating cutters to remove material from the piston. The first step is securing the piston in a fixture or vice for stability. Then, the milling machine is set up with the appropriate tooling, such as end mills or ball mills.



The milling machine is programmed with a CNC system to guide its movement. The cutter removes material from the runner and riser until they are separated from the piston. The removed material becomes chips or swarf, which are cleared from the machining area.

6) Heat Treatment: -

Heat treatment is a vital process in foundry shops, primarily used to eliminate internal stresses and enhance the hardness of materials. In SPR Foundry, there are two fundamental processes involved in the hardening of alloys:

- Solution Treatment, also known as **Solutionizing**, serves as the initial step in the precipitation-hardening process. During this phase, the alloy is heated above the solvus temperature and held there to allow for the formation of a homogeneous solid solution (α). The θ precipitates present in the alloy dissolve, while any segregation initially present in the alloy is reduced.
  temperature- 500~550 C
  Soaking Time – 55min -110min
  Water Temperature- 60-80 C
- **Quenching** represents the subsequent stage, in which the solid α is rapidly cooled, leading to the formation of a supersaturated solid solution called αSS. This supersaturated solution is not in equilibrium and contains an excess of copper. Due to the rapid cooling, the atoms within the material lack sufficient time to diffuse to
- **Aging** constitutes the final step in the hardening process. During this stage, the supersaturated αSS is heated below the solvus temperature, causing the formation of finely dispersed precipitates. At the aging temperature, atom diffusion occurs only over short distances. As the supersaturated α is inherently unstable, the excess copper atoms diffuse towards numerous nucleation sites, leading to the growth of precipitates. The objective of the precipitation-hardening process is to achieve a finely dispersed precipitate within the alloy. These fine precipitates impede the movement of dislocations by either forcing them to intersect the precipitated particles or maneuver around them. By restricting dislocation movement during deformation, the alloy is strengthened. temperature- 210~230 C.
- cycle Time– 5 hours.

7) Rough Turning: - Rough turning is sometimes performed in the foundry shop for large pistons to reduce machine time in the piston plant.
Rough turning involves removing excess material from the piston to bring it closer to its final dimensions. By conducting rough turning in the foundry shop, the need for extensive machining in the piston plant is minimized, leading to reduced overall manufacturing time. Large pistons often require significant material removal, making rough turning in the foundry shop a more efficient use of resources and equipment.

8) UFD (Ultrasonic Flaw Detection):-this is a non-destructive testing technique used to identify and evaluate flaws in materials. By transmitting high-frequency sound waves into the material, flaws such as cracks, voids, or inclusions can be detected. The reflected waves are analyzed to determine the characteristics and location of the flaws. UFD plays a critical role in quality control, ensuring the reliability and safety of components by identifying potential defects that could compromise their structural integrity.

9) Visual Inspection: - After the manufacturing process, it is crucial to conduct a thorough visual inspection of pistons to detect any potential defects that can be identified with the naked eye. In the foundry shop, the visual inspection focuses on various common defects that may arise during piston production. These defects include cold shut, miss run, point break, metal sticking, engraving issues, pin closure problems, blow holes, window fins, oxidation, over riser, and cracks. By carefully examining the pistons, these defects can be promptly identified, ensuring the production of high-quality pistons that meet the required engineering standards.

10) Flushing: - During the casting process, a crucial step involves the insertion of a salt tube to create the oil cooling gallery within the piston. Once the manufacturing is complete, it becomes essential to remove this salt tube to ensure optimal functionality and performance of the piston. This removal process involves a meticulous washing procedure, where the salt tube is thoroughly cleansed using running water. This thorough cleaning ensures that the salt dissolves and is flushed out, leaving behind a clean and clear oil cooling gallery. By effectively removing the salt tube and ensuring the cleanliness of the oil cooling gallery, the piston can operate efficiently, facilitating efficient heat dissipation and maintaining optimal performance.

11) X-Ray- This process is employed to thoroughly scan and examine the oil cooling gallery to detect any remaining particles or analyze minor defects that may not be visible to the naked eye.

After the completion of X-ray detection, all the high-quality pistons are sent to the piston plant for precision machining and meticulous design refinement. This step ensures that the pistons undergo further processing and optimization in accordance with engineering standards

Safety and Quality Improvement

POKA YOKE: -

A poka-yoke is a mechanism that is put in place to prevent human error. The purpose of Poka-yoke is to inhibit, correct or highlight an error as it occurs. Poka-yoke roughly means "avoid unexpected surprises" or "avoid blunders" in Japanese. In English, a poka-yoke is sometimes referred to as "mistake-proof" or "fool-proof."

Essentially, a poka-yoke is a safeguard that prevents a process from proceeding to the next step until the proper conditions have been met. Poka-yokes can be either warning mechanisms or control mechanisms.

Poke Yoke methods from the foundry plant are: -

Name of Operation	Parameter	Control Method	Poka-yoke
Melting Alloy	Alloy Temp	PID Controller	The furnace stopped if the temperature is higher than the set temperature
	Chemical Composition	Spectrometer	
Holding and Degassing	Nitrogen pressure	PLC control programming	GBF drop if pressure drop from min requirement
	Degassing Time		GBF Stops after the Compilation of Cycle time
	Density Index	Density index Instrument	
	Alloy Temp	PID Controller	Die Casting machine stops if the temperature of the alloy is Low/High from set(+/- 10 C)
	Cycle time	PLC control programming	
	Die temperature	PID controller	Die casting machine stops if the temperature the of

Casting			Die is low from set temperature
	Ring placement Time	PLC Control Programming	Auto Pouring of Metal in sump if ring Placement is more than set time (40sec)
	Alfin Temp	PID controller	Die casting machine stop if the temperature of the alfin is low/high from set temperature
	OCG – salt core Placement	PLC control programming	Auto-pour the metal in the sump if salt core placement is more than set time (60sec)
Heat treatment	Solutioning Temperature	PID controller	Machine blow alarm when temperature goes higher than set temperature
	Ageing Temperature	PID controller	Machine blow alarm when temperature goes higher than set temperature
	Quenching of piston	Presence of Operator	Quenching Position is confirmed by the worker
	Hardness of Piston	Hardness checking instrument	
	Online monitoring of piston	SCADA	Online display of temperature
Rough Turning	Toll Life	PLC Control Programing	Machine blow alarm while toll reaches its max life
Bond Inspection	Bond Strut	Ultrasonic Flow Detection	Machine indicate red light while piston rejected
X – Ray	Checking Blockage of Cooling gallery	X-Ray	100% CG Inspection

The dispatched pistons, identified as meeting the required quality criteria through the X-ray detection process, are transferred to the piston plant. At the plant, they undergo a series of fine machining operations, where intricate adjustments are made to enhance their dimensional accuracy and surface finish.

Piston Plant at Glance

Dial Range:- 40mm ~ 140mm
Capacity:- 18 million

No of lines -24 16- gasoline 8 – Diesel

Honda Line	4,6,7,9,10,11,15A,15B,16,23,24
KS Line (Germany)	1,2,3,5,8,14,21
Export Line	17,18,19,20,22,12

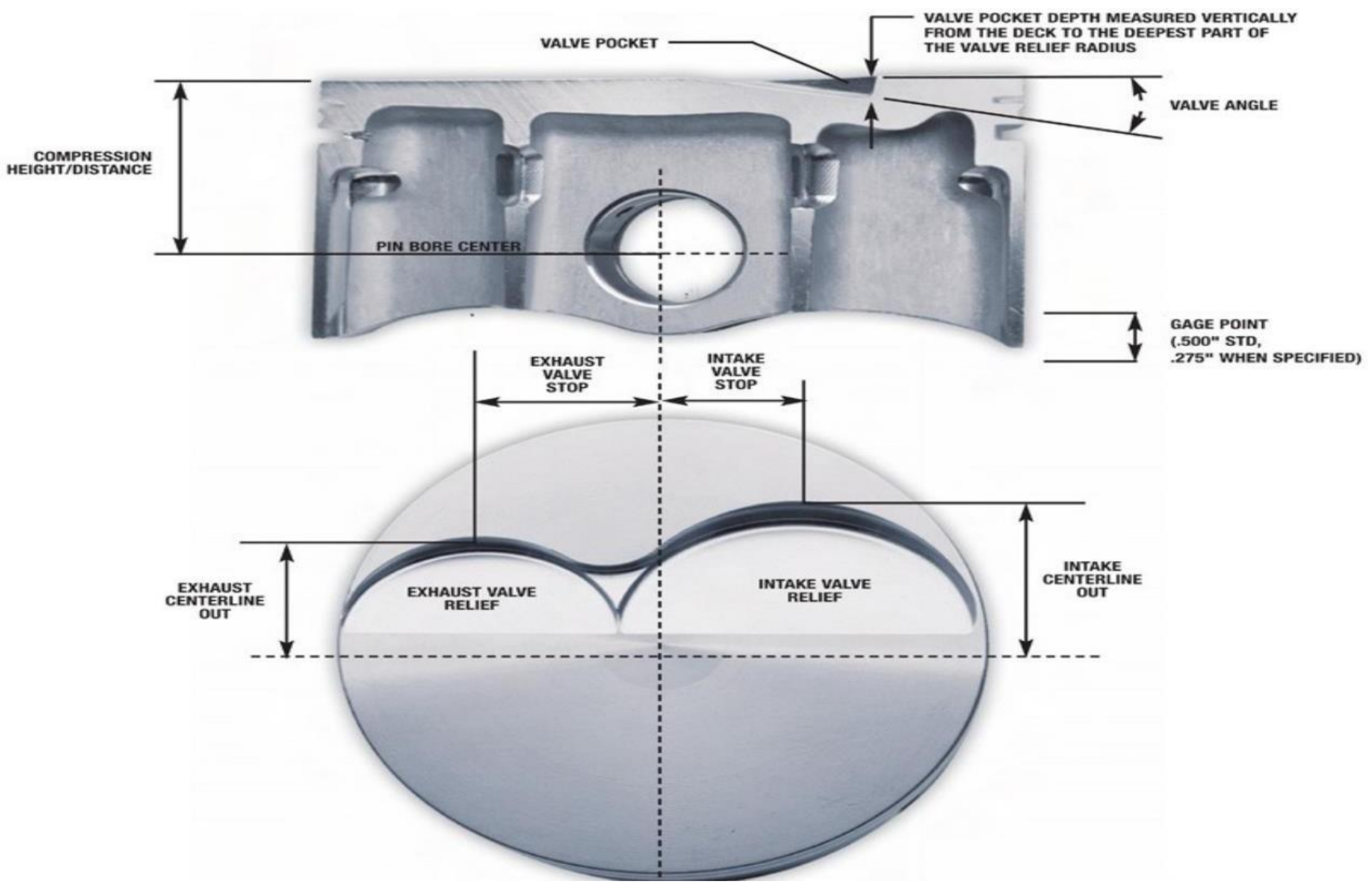
Types of Piston

Gasoline – 2-Wheeler, 4-Wheeler

Diesel — 4-wheeler, passenger vehicle, LCV, Generator sets, compressor, or agricultural vehicle

Alloy Features

Gasoline	Diesel
KS1275/KS1295	KS1275/KS1295
AC8H/AC8A	281.1
A351	V4
KS309*	KS312*
*new alloy under development	



Process Piston machining

Rough Turning

rough surface piston

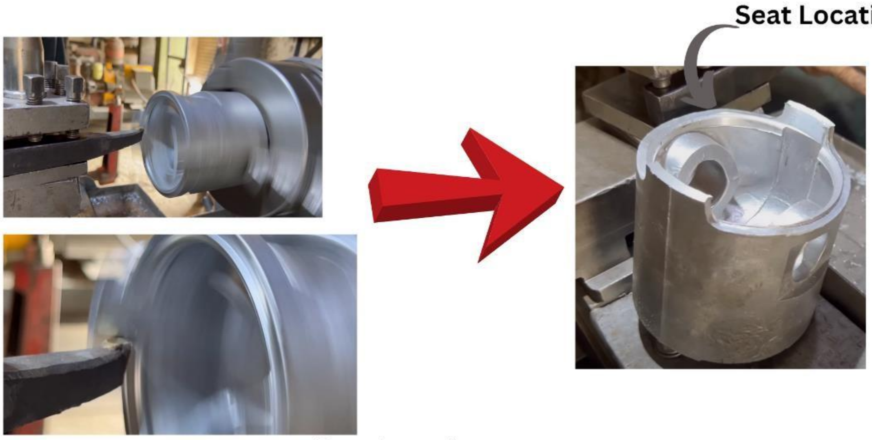
Fine surface piston

Rough Turning:-

Rough turning involves removing excess material from the piston to bring it closer to its final dimensions. Metal only removed from the outer surface of piston like skirt.

Operation 1: Locating Seat, Facing and Skirt Turning

Seat Locating



Seat Locating process

Seat locating is an essential step in piston manufacturing as it allows for various subsequent operations to be performed on the piston. It enables the piston to be securely clamped in the jaws of a machine, facilitating precise machining and assembly processes.

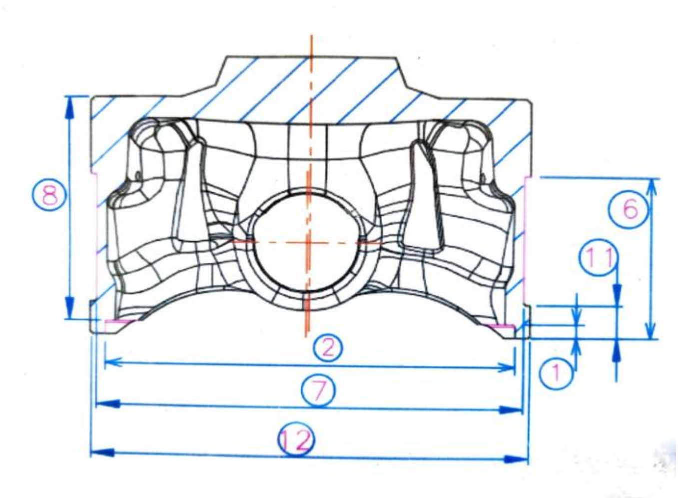
The accurate seat locating of the piston ensures that the piston remains fixed in its desired position, allowing for consistent and repeatable machining. This precise positioning is particularly important when machining critical features such as ring grooves, wrist pin holes, and valve reliefs. It enables the machine to work on the piston with utmost precision, resulting in the desired dimensions and tolerances.

Machine make – ACE CNC

Operation	Cutting tool	Cutting speed (mm/min)	RPM	Feed (mm/rev)	Life	Radius	material
Turning & Rough facing	VCMW	600-800	2400-2800	0.2-0.3	5000max	0.4	Diamond
Rough seat boring							
Finish boring and facing	CCMT	600-800	2400-2800	0.1-0.15	5000max	0.2	Diamond
Ring turning	VNMG	600-800	2400-2800	0.06-0.10	400/corner	0.4	Carbide
Centre Drill	Center drill	NA	2400-2800	0.02-0.08	5000max	-	Carbide

Process:- Number of operations are performed during the seat locating process

1) **Loading the Piston:**
The process begins with obtaining the piston after the rough turning operation. An experienced operator loads the piston into a CNC milling machine, which has been set up beforehand. The setup involves adjusting and customizing the program and tools to match the specific model requirements.
2) **Initiating the Program:**
Once the piston is loaded, the operator proceeds by pressing the start cycle button to initiate the program. This signals the CNC milling machine to begin automated operations.
3) **Turning & Rough facing:**
As per the programmed instructions, the first tool, usually a VCMW (V-shaped Cutting and Machining with Wiper) tool, is engaged. This tool removes excess material from the piston based on the predefined dimensions and specifications provided in the program. The tool follows a predetermined path, ensuring precise material removal.
4) **Finish boring and facing:**
Following the rough turning operation, the turret of the CNC milling machine rotates to position the CCMT (Diamond-Shaped Turning) tool. This tool provides the final depth and facing of the piston. By accurately following the programmed instructions, it ensures the desired dimensions and smooth finish.
5) **Ring turning :**
Next in line is the VNMG (Negative-Geometry Turning) tool. This tool is responsible for the fine removal of the remaining material, based on the feed rate specified in the program. It meticulously shapes the piston, achieving the desired contours and finishes.
6) **Center Drilling:**
In the final operation of the seat locating process, a center drill is employed. This tool creates a punch or indentation on the piston head, serving as a reference point for further machining or assembly processes. The center drill ensures precise positioning and alignment of the piston in subsequent operations.



Important parameters :-

1) Locating seat depth

2) Locating seat diameter

6) Skirt turning length

7) Skirt turning diameter

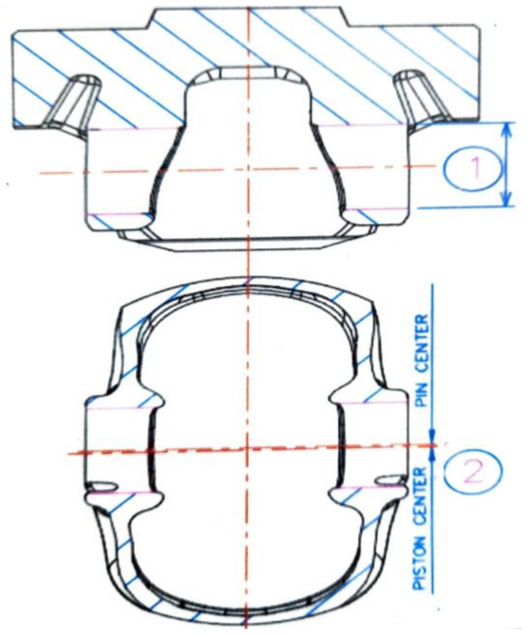
8) Total height

11) Lag enforcement height

12) Lag enforcement diameter

Operation 2: Pre- Pre- Boring

- This operation involves a rough cut through the pin bore area to remove bulk material.
- Prepares the piston for subsequent precision boring steps i.e. reduces machining load and allows smoother tool entry in fine boring.
- Tool used is a Quill, made of carbide.

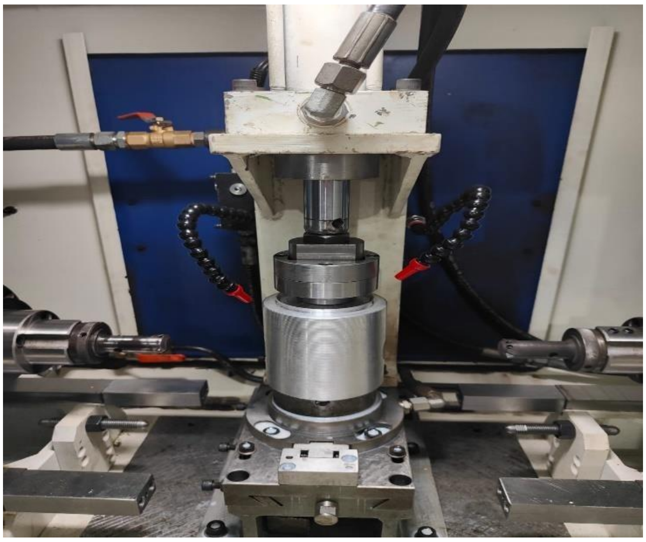


Important parameters are:

1) Pre- pre- bore diameter
2) Pre- pre- bore height
3) Pin bore offset
4) Bore flatness

NOTE: pin bore offset is the distance between piston center and pin bore center. This offset shifts the center of gravity of the piston towards one side, which ensures it doesn't interfere with cylinder wall during operation(as the piston moves in an 8 figure motion) and the engine functions with soundless thrusts.

Operation 3:-Pre-boring, Circlip Grooving, Outside Chamfer



The pre-boring process plays a crucial role in machining casted piston bosses to achieve the desired shape and dimensions. It serves as a preparatory step for subsequent operations, such as gudgeon pin fitting and circlip groove manufacturing. The primary objective of pre-boring in piston manufacturing is to refine the casted piston boss to its final state. This involves the use of a single-point cutting tool made of diamond, which significantly improves the quality of the casted boss. By removing excess material, applying pre-cuts, and shaping, pre- boring prepares the boss for the final fine boring operation, achieving precise dimensions.

Machining of Pin Boss:

During the pre-boring process, the diamond single-point cutting tool is employed to machine the pin boss of the piston. This operation ensures that the pin boss attains the necessary inner diameters for accommodating the gudgeon pin. By utilizing the diamond tool, a superior surface finish is achieved, enabling subsequent operations to proceed seamlessly.

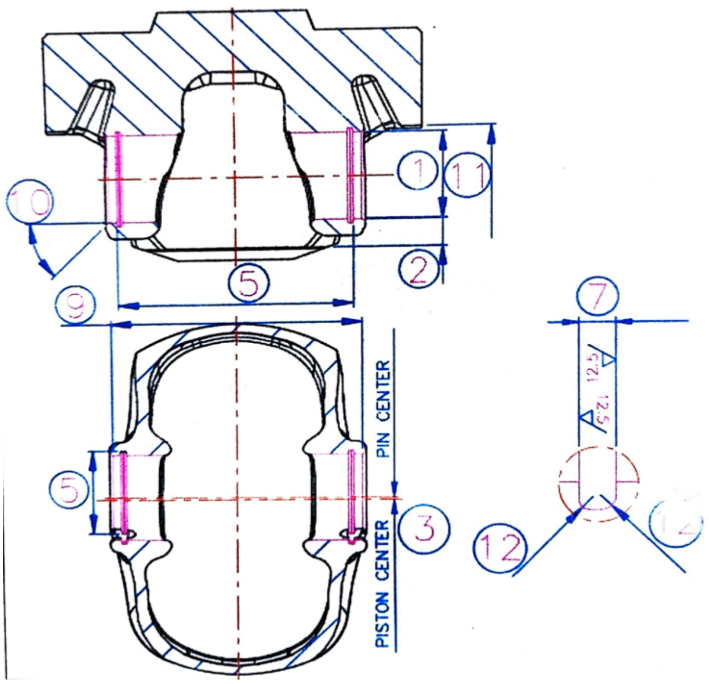
Circlip Grooving:

Concurrently with pre-boring, circlip grooving is performed on the pin boss of the piston. The pre-boring quill is equipped with the required tools, including a firm carbide tool designed specifically for manufacturing the circlip groove. This facilitates efficient and precise grooving, providing a secure location for the circlip, which is essential for retaining the gudgeon pin.

Machine number:- P 148 Machine make :-TAURUS

Outer Chamfering:

Chamfers added to external edges to remove burrs and ease insertion during engine assembly.



Important parameters are:

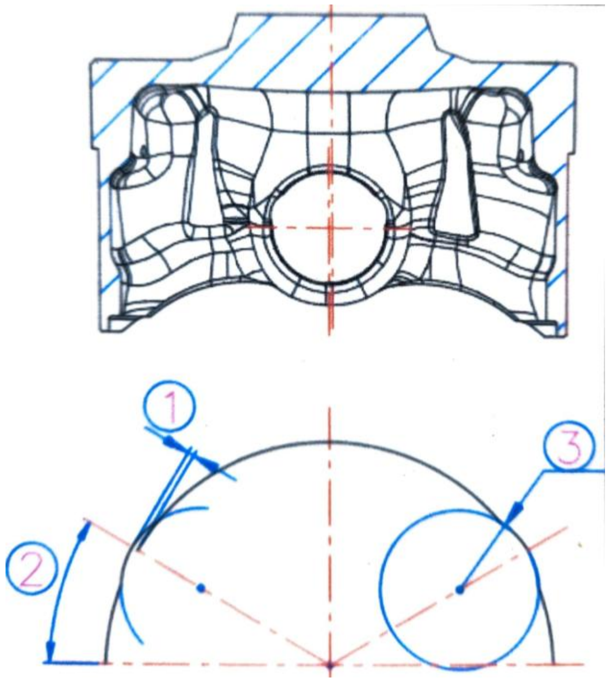
1) Pre- bore diameter
2) Pre- bore height (from seat)
3) Pin bore offset
5) Circlip distance
7) Circlip width
9) Outside chamfer distance
10) Outside chamfer angle
11) Pin bore enlargement diameter
12) Circlip radius

NOTE: C.G.C or circlip groove concentricity, is an important parameter which needs to be maintained at this stage to ensure that the circlip groove is concentric with the pin bore.

Sub operation	Cutting speed	RPM	Feed	Life	Tool	Material
Pre boring	N.A	1200-1700	250-400	10000 max	Single point C.T	Diamond
Circlip grooving	N.A	700-1200	40-80	10000 max	Firm tool (2.7 R)	Carbide
Insider chamfer	N.A	700-1200	40-80	10000 max	Firm tool (2.7 R)	Carbide
Outsider chamfer	N.A	1200-1700	250-400	10000 max	Firm tool	Carbide
Clamping pressure	3.5-5 bar					

Operation 4:-Broaching

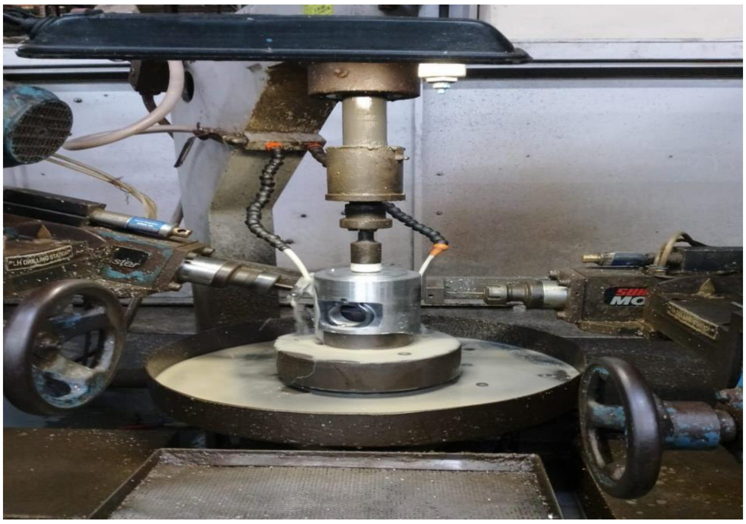
- Creation of internal slots in the pin bore using a linear motion carbide tool with multiple cutting teeth.
- Significant for bore lubrication.



Important parameters are:

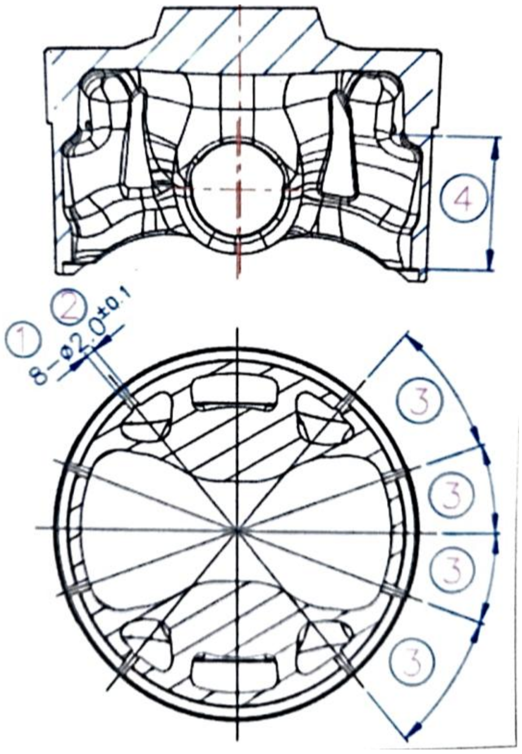
1) Broach depth
2) Broach angle
3) Broach radius

Operation 5:- Oil Hole Drilling



The piston oil hole drilling process is a crucial step in piston manufacturing. It involves securing the piston onto a seat, applying clamping pressure, and using a drilling tool to create the required oil holes. The number and placement of the holes are determined by design specifications and engine model. Careful attention is given to tool selection, drilling parameters, and quality control measures to ensure accurate and efficient hole creation. This process enables effective oil distribution and lubrication within the piston, enhancing its performance and longevity. They also facilitate lubricant drainage back to the crankcase, preventing oil accumulation.

Poka-Yoke method: laser beam sensors are used to detect drill breakage after every cycle, preventing incomplete or missing holes.



Important parameters are:

1) Drill diameter
2) Oil hole number
3) Oil hole pitch
4) Hole height (from seat to hole's lower flank)

Operation 6: Pre-Grooving, Finish Cavity Turning, Fine Facing

- Pre grooving marks the third groove with partial depth
- Finish cavity turning finalises the combustion bowl geometry
- Fine facing ensures a precise crown surface finish, critical for sealing
- Tools used are
  i. Diamond grooving tool for pre-grooving
  ii. Diamond SCGW/VCMW for cavity turning and fine facing
- Important parameters are as follows:

Machine make:- ACE CNC
Machine number:-P145,151,257
Program No:-O128

Facing Operation:-

To achieve a smooth surface and reduce roughness on the upper part of the piston, a facing operation is conducted. This process utilizes an RPMX diamond tool, which enables the attainment of desired surface finish.

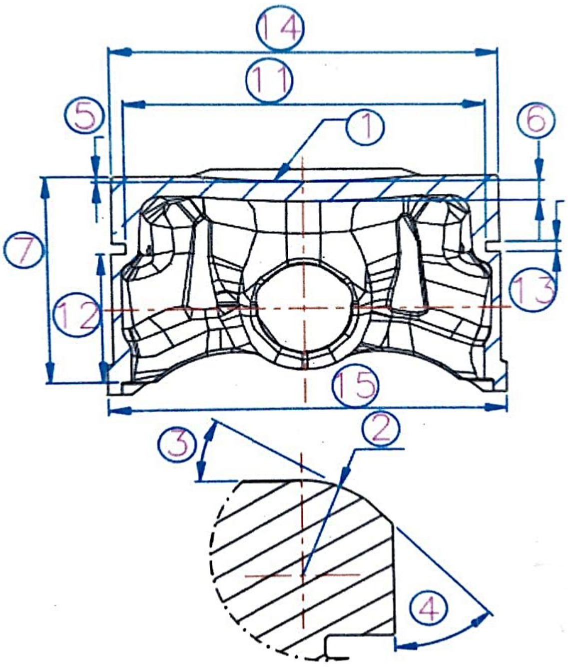
Finish Facing:-

After the completion of the cavity turning process, a VCMW (Very Close Machining Wheel) tool is implemented to provide the final facing and achieve a smooth surface for both the cavity and the piston face. This step guarantees the desired quality and functionality of the piston.

Cavity Turning:-

Cavity turning is a crucial process involved in the manufacturing of large-sized pistons used in heavy- duty vehicles and diesel engines. Its primary objective is to create a cavity on the upper side of the piston, which facilitates complete and enhanced combustion within the piston chamber. Following the facing operation, a turret rotation is initiated, and a PCD (Polycrystalline Diamond) tool is employed to create the required cavity dimensions as specified in the engineering drawing. This step ensures optimal combustion efficiency by providing an appropriate space for fuel-air mixture interaction.

Sub operation	Cutting speed	Rpm	Feed	Life	Type	Radius	Material
Facing	300-450	2000-2500	0.15-0.20	400 max	RPMX	6R	Diamond
Cavity turning	550-700	2000-2500	0.10-0.30	5000 max	PCD	4R	Diamond
Finish Facing	550-650	2500-2800	0.1-0.2	10000max	VCMW/RDNX	0.4R	Diamond
Clamping press	12-18kg/cm						

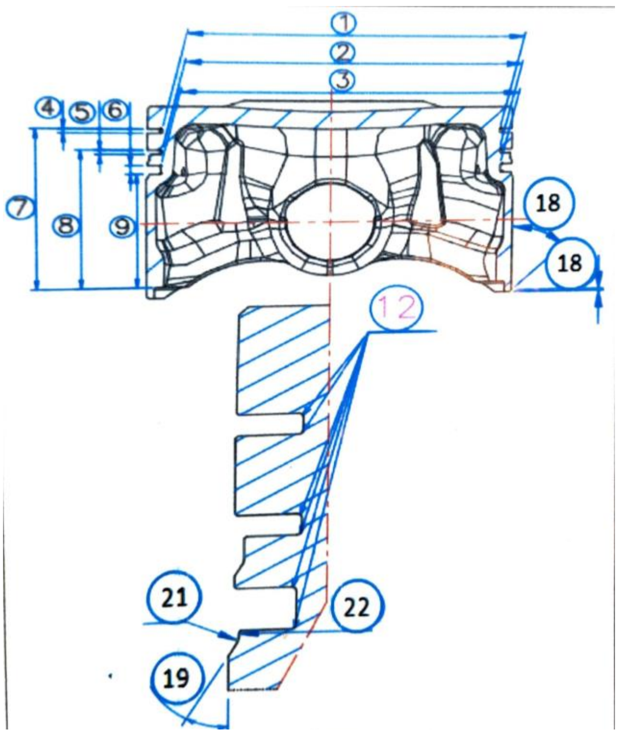


Important parameters are:

1) Cavity diameter
2) Cavity profile radius
3) Cavity profile angle 1
4) Cavity profile angle 2
5) Cavity depth
6) Crown thickness
7) Total height (with respect to seat)
8) Pre groove III diameter
9) Pre groove III height
10) Pre groove III width

Operation 7: Finish grooving

This is a critical step in piston manufacturing that involves creating the ring slots on the piston. These slots serve multiple purposes, including facilitating oil distribution to lubricate the piston and aiding compression within the combustion chamber. Additionally, this process involves the creation of chamfers in the ring slots as required. It is a complex procedure with various important aspects to consider. There are at least three grooves on the sides of the piston. Two of them is where the compression rings go into. The Compression rings ensure that the pressure from the compression stroke of the engine will not escape the cylinder on this tiny gap. But as you can see the compression rings still have a tiny vertical gap. That is to allow oil to pass through and help lubricate the cylinder walls so that the piston can move smoother within the cylinder.



Important parameters are:

1) Groove Diameter I
2) Groove Diameter II
3) Groove Diameter III
4) Groove Width I
5) Groove Width II
6) Groove Width III
7) Groove Height I
8) Groove Height II
9) Groove Height III
10) Groove Root Radius

The third groove is where the oil control ring (or just oil ring) sits. There are oil squirters along the crankcase and these squirters squirt oil into the bottom of the piston to cool it down, also this oil finds it's way into the cylinder wall through the oil drain holes. The oil control ring scrapes the oil down, so there is very little oil that will be left into the cylinder when the piston is going down.

Sub operation	Cutting speed	RPM	Feed	Life	Type	Radius	Material
Plunging CI	100-120	350-450	0.05-0.075	300max	Grooving tooling	0.3	Carbide
Plunging AL	500-800	2000-3000	0.08-0.12	5000max	Grooving tooling	0.3	Diamond
Finish AL	500-800	2000-3000	0.04-0.066	5000max	Grooving tooling	0.3	Diamond
Finish CI	250-800	800-1500	0.04-0.066	1000max	Grooving tooling	0.3	CBN
Land OD turning	500-800	2500-2800	0.1-0.25	10000max	VCMW	0.5	Diamond
Clamping pressure	0.8-1.5 MPa						

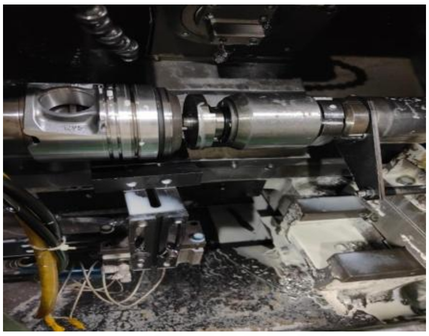
Operation 8: Finish all OD Chamfers

Chamfering of outer diameters (ODs) of ring lands, skirt edges, and crown shoulders is completed to remove burrs and facilitate smoother piston movement

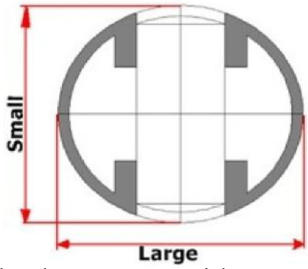
Important parameters:

i. Chamfer angle
ii. Land radius
iii. GGC (Groove Ground Concentricity)

Operation 9: Finish Oval turning



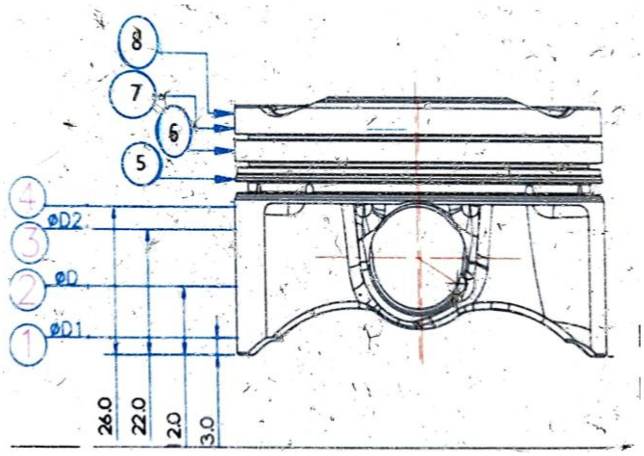
Designers have recognized that having the entire skirt of a piston in contact with the cylinder walls is not only unnecessary but also detrimental to performance due to increased friction, which robs power. Piston ovality, or its egg-shaped profile, determines that the piston body is narrower along the minor axis (where the piston pin is located) and broader along the major axis (the thrust surface). When considering the width of the skirt, the widest part of the piston is in the load-bearing region of the skirt. Therefore, the clearance between the piston and the cylinder wall is measured at the center and towards the bottom of the skirt.



Ovality is employed to accommodate the expansion of the piston caused by heat. It provides a controlled one-dimensional solution to regulate the amount of contact the piston has with the thrust face. Moreover, it offers the expected strength despite the absence of a full round skirt. In fact, skirts with Forged Side Relief (FSR) are even stronger than full round designs, but they necessitate more precise adjustments to the skirt profile to match the wear characteristics of full-round skirts.

CNC turning machines use programmed offsets to achieve this elliptical profile. Land concentricity and top land ovality are verified with dial gauges. At a height of 12mm from the base, the ovality is zero i.e. the piston is perfectly

Sub operation	Cutting speed	RPM	Feed	Life	Type	Radius	Material
Aluminum Turning	N.A	1800-2000	As per finish	5000Max	Turning tool	0.8R	Diamond
Ring turning	N.A	500-1000	As per finish	5000max	Turning tool	1.0R	CBN

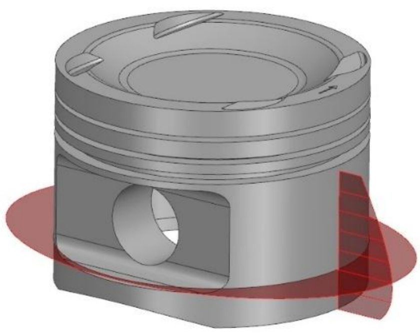


Important parameters are:

1) D1 at 3mm
2) D0 at 12mm
3) D2 at 22mm
4) D3 at 26mm
5) 3rd land diameter
6) 2nd land diameter
7) Top land diameter A
8) Top land diameter B

Operation 10: Linear and Polar Drops

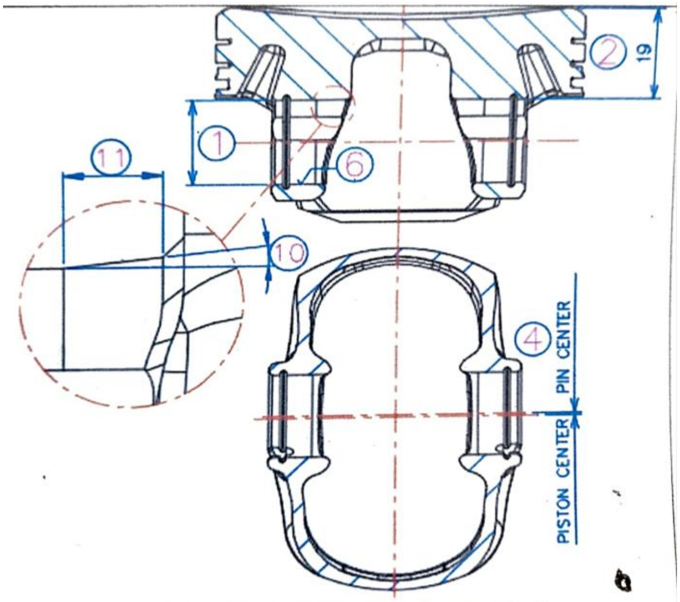
- Linear drop is the decrease in diameter (profile height) measured in a straight line along skirt length. This is usually barrel shaped in high performance pistons.
- Polar drop is the radial variation in diameter i.e. at different angular positions for the same cross section.
- This geometry correction along the axial and circumferential direction is done to compensate for asymmetric expansion under thermal load.



HEIGHT	0°+180°	05°+185°	10°+190°	15°+195°	20°+200°	25°+205°	30°+210°	35°+215°	[illegible]20°
1	0.0630	0.069	0.0877	0.1150	0.1502	0.1924	0.2363	0.2817	[illegible]
2	0.0400	0.046	0.0647	0.0920	0.1272	0.1694	0.2133	0.2587	0.300[illegible]
3	0.0260	0.032	0.0507	0.0780	0.1132	0.1554	0.1993	0.2447	0.2866
4	0.0170	0.023	0.0417	0.0690	0.1042	0.1464	0.1903	0.2357	0.2776
5	0.0105	0.0165	0.0352	0.0625	0.0977	0.1399	0.1838	0.2292	0.2711
6	0.0060	0.012	0.0307	0.0580	0.0932	0.1354	0.1793	0.2247	0.2666
7	0.0040	0.010	0.0287	0.0560	0.0912	0.1334	0.1773	0.2227	0.2646
8	0.0030	0.009	0.0277	0.0550	0.0902	0.1324	0.1763	0.2217	0.2636
9	0.0020	0.008	0.0267	0.0540	0.0892	0.1314	0.1753	0.2207	0.2626
10	0.0010	0.007	0.0257	0.0530	0.0882	0.1304	0.1743	0.2197	0.2616
11	0.0000	0.006	0.0247	0.0520	0.0872	0.1294	0.1733	0.2187	0.2606
12 : D0	0.0000	0.006	0.0247	0.0520	0.0872	0.1294	0.1733	0.2187	0.2606
13	0.0000	0.006	0.0247	0.0520	0.0872	0.1294	0.1733	0.2187	0.2606
14	0.0010	0.007	0.0257	0.0535	0.0886	0.131	0.1751	0.2205	0.2625
15	0.0025	0.0086	0.0272	0.0557	0.0908	0.1334	0.1776	0.223	0.2651
16	0.0045	0.0107	0.03	0.0587	0.0939	0.1365	0.1811	0.2263	0.2686
17	0.0075	0.0138	0.0337	0.0632	0.0986	0.1413	0.1862	0.2313	0.2739
18	0.0160	0.0224	0.043	0.0727	0.1084	0.1512	0.1965	0.2415	0.2843
19	0.0190	0.0255	0.0462	0.0765	0.1122	0.1549	0.2003	0.2452	0.2881
20	0.0270	0.0335	0.0542	0.0845	0.1202	0.1629	0.2083	0.2532	0.2961
21	0.0360	0.0425	0.0632	0.0935	0.1292	0.1719	0.2173	0.2622	0.3051
22	0.0470	0.0534	0.0735	0.1040	0.1397	0.1823	0.2276	0.2726	0.3154
23	0.0590	0.0653	0.0847	0.1150	0.1503	0.1931	0.2381	0.2832	0.3258
24	0.0735	0.0798	0.0987	0.1285	0.1637	0.2065	0.2512	0.2964	0.3388
25	0.0905	0.0967	0.1152	0.1445	0.1792	0.2222	0.2667	0.3119	0.3542
26	0.1130	[illegible]191	0.1377	0.1660	0.2011	0.2435	0.2877	0.3331	0.3752
27	0.1410	0.147	0.1687	0.1930	0.2282	0.2704	0.3143	0.3597	0.4016
28	0.1720	0.178	0.1967	0.2240	0.2592	0.3014	0.3453	0.3907	0.4326
29	0.2080	0.214	0.2327	0.2600	0.2952	0.3374	0.3813	0.4267	0.4686

Operation 11: Fine Boring

This step represents one of the final stages in the manufacturing process of pistons. It involves the removal of any roughness and chips from the pinhole, resulting in a refined and polished surface. This process is carried out using an automatic CNC (Computer Numerical Control) machine, which ensures precise and accurate operations. The CNC machine utilizes advanced automation and machining techniques to achieve the desired final touch on the pinhole, ensuring the highest quality standards in piston manufacturing.



Important parameters are:

1) Pin bore size
2) Compression height
3) Pin bore offset
4) Pin bore finish
5) Bombing angle
6) Bombing starting distance

Sub operation	Cutting speed	RPM	Feed	Life	Type	Radius	Material
Rough boring	N.A	2500-3000	As per Finish	5000Max	Boring tool	10R	Diamond
Fine Boring	N.A	2500-3000	As per Finish	5000Max	Boring tool	10R	Diamond

Operation 12: Valve pocket milling

Valve pockets, which are commonly formed in the top land or face of pistons, are well-known in the manufacturing industry. However, an important area that requires attention is the portion of the relief opening into the piston sidewall. This specific region experiences high thermal concentration due to the close proximity between the piston and the cylinder liner. To address this concern, a cutting tool is employed to shape the valve on the top of the piston. This manufacturing process allows for customization and flexibility, as the valve shape can be altered according to the specific requirements of the consumer. By incorporating this approach, manufacturers can optimize the thermal performance and overall efficiency of the piston-cylinder system.
Once all the machining processes have been completed, the pistons proceed to the CRI inspection stage in the visual inspection chamber. This step is crucial to ensure the quality and reliability of the pistons before they move on to the next stages of Inspection.

Critical Parameters

1. **Groove width**
- Measured using a snap gauge with two sides: **Go** (minimum acceptable width) and **No-Go** (maximum allowable width).
- The **Go** side must fit into the groove; the **No-Go** side must **not**.
- If the Go side doesn't fit, the groove is **too tight**, causing the ring to jam or malfunction.
- If the No-Go side fits, the groove is **too loose**, allowing the ring to move excessively, leading to compression leakage (blow-by), noise, reduced engine power, and possible ring breakage

2. **Groove diameter**
- The clearance between the piston groove diameter and the ring's inner diameter ranges from 1.10 mm to 2.20 mm (varies by piston model).
- Checked using a fixture gauge with a dial gauge.
- If the groove diameter is **too large**, the ring may extend beyond the piston's outer diameter, preventing proper liner entry and increasing blow-by.
- If the groove diameter is **too small**, it causes the ring to sink into the groove, resulting in higher oil and fuel consumption (blow-by), engine noise, reduced power, and risk of ring damage.

3. **Circlip Groove distance**

- This is the distance between the two grooves inside the pin bore where the circlip locks are fitted.
- If the distance is **too small**, both circlips may not fit properly, preventing the gudgeon pin from staying in place.
- If the distance is **too large**, the pin can move back and forth, hitting the circlips and causing noise. Over time, this impact can loosen or dislodge the circlip, leading to engine failure.

4. **Circlip Groove width**

- This refers to the width of the groove that holds the circlip.
- A **Snap Gauge** is used to check this parameter.
- If the groove is **too narrow**, the circlip won't fit.
- If it's **too wide**, the circlip may move within the groove, causing engine noise. Under load, it may even come out, which could damage the engine.

5. **Circlip Groove diameter**

- This is the diameter of the groove where the circlip sits.
- A **larger diameter** makes the circlip loose, which can cause rattling or the circlip falling out.
- A **smaller diameter** makes it hard to fit the circlip. Under pressure, it may still come out, risking engine damage.

6. **Compression height**

- The distance from the center of the piston pin bore to the top of the piston is called the **Compression Height**.
- It is inspected using a dial gauge with a precision of 0.01 mm or 0.001 mm.
- If the Compression Height is **too high**, the piston may strike the engine head. This reduces the clearance between the piston and the head, causing rapid upward force during compression. This increased load stresses the piston pin, connecting rod, and crankshaft, potentially leading to damage or engine failure.
- If the Compression Height is **too low**, the clearance between the piston and engine head increases while fuel quantity remains unchanged. This causes insufficient compression pressure, resulting in slower piston movement, reduced power output, poor acceleration, and inability to handle full engine load effectively.

7. **Pin bore squareness**

- The centerline of the pin bore should be perpendicular to the centerline of the piston. If it is not straight but tilted, then this condition is called Pin Bore Squareness (i.e., lack of squareness).
- If the pin bore has excessive tilt, the piston will tilt inside the cylinder after assembly. This occurs because the connecting rod forces the piston pin to align straight, which in turn straightens the tilted pin bore. As a result, the piston becomes misaligned due to the bore's lack of squareness.
- Therefore, when the piston runs in the engine cylinder, a lack of pin bore squareness causes uneven contact.
- Excessive rubbing increases wear and may lead to piston seizure, where the piston jams inside the cylinder, potentially causing engine failure.

8. **Pin bore diameter**

- The hole made in the piston to fit the gudgeon (piston) pin is called the **Pin Bore Diameter**.
- If the diameter is **too large**, the pin will fit loosely, causing rattling noises and increased engine wear due to the piston jerking during movement.
- If the diameter is **too small**, the pin will be tight or may not fit at all, leading to assembly issues and customer complaints.
- The acceptable tolerance range is divided into two groups: **higher diameter group** and **lower diameter group**. Pistons are color-marked based on which group the pin bore diameter falls into.
- If a piston's two pin bores fall into different groups, the marking is done according to:
  - **Lower diameter group** for **OEM** (original equipment manufacture) **pistons**, as it ensures tighter fit and reduced clearance for better engine performance.
  - **Higher diameter group** for **trade (aftermarket) pistons**, prioritizes easier assembly in a variety of conditions.

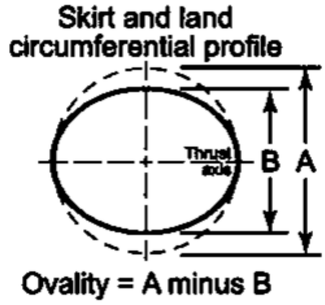
9. **Outside diameter (OD)**

- The outside diameter refers to the maximum diameter of the piston's outer surface. It is a crucial parameter that directly affects fitment and engine performance.
- The piston is not a perfect cylinder. It is both tapered and oval in shape. The diameter is smaller along the pin bore axis (minor axis) and larger at 90° and 270° from the pin bore (major axis).
- During inspection, the pin bore is kept facing forward, and the measurement is taken at the location of maximum diameter.
- This measurement is done using either the Honda Method or the K.S. Method.
- If the outside diameter is too large, the piston may not fit into the liner, or it may seize during engine operation, which can lead to engine damage or even accidents.
- If the outside diameter is too small, there will be excessive clearance between the piston and the liner. This can lead to movement and knocking sounds, cause noise issues, and in severe cases, result in piston tilting and ring damage.

NOTE: Pistons are made **tapered** for two key reasons:

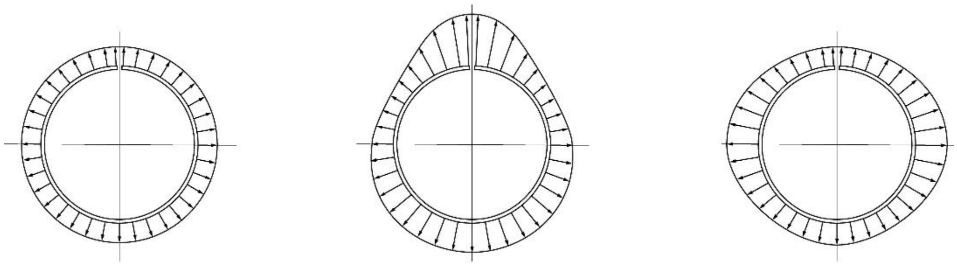
- Material Thickness Effect: The presence of more material near the crown (top) leads to greater heat absorption and expansion during operation.
- Temperature Effect: The top of the piston experiences higher combustion temperatures than the bottom. Greater heat causes more expansion at the top.
- Due to both material mass and temperature differences, the top part of the piston expands more than the bottom. Therefore, the outside diameter of the top portion is made smaller to compensate for this expansion and prevent seizing or engine damage.

10. Ovality



- Ovality is the difference between the smallest and largest diameters of a component.
- In pistons, ovality is intentionally introduced on the outside diameter (OD) because more material exists along the **minor axis** than the **major axis**, mainly due to the presence of the piston pin boss.
- During engine operation, the piston heats up, and the minor axis expands more than the major axis because of the higher material concentration.
- To compensate for this uneven thermal expansion, the diameter along the minor axis is made slightly smaller than that of the major axis.
- If this reduction isn't applied, the minor axis may expand excessively during engine operation, causing the piston to seize inside the cylinder liner, which can lead to engine damage or failure.
- To check ovality, the following calibrated instruments are required:
  - Calibrated fixture
  - Dial gauge
- To set the height for ovality checking, a vernier caliper and piston master should be used.
- Ovality can be Normal, Positive or Negative.

Normal Negative Double Negative



11. G.C.C (Groove Ground Concentricity)

- G.C.C refers to the concentricity between the piston's ring grooves and its outer diameter (OD).
- It occurs when the center used for groove machining differs from the center used for OD machining.
- If the center shifts, the grooves will not remain evenly deep around the piston — on one side, the groove will be too deep, and on the opposite side (180°), it will be too shallow.
- If GGC is present:
  - The piston ring may sit too deep on one side and stick out on the other.
  - This causes uneven contact — instead of the rings contacting the liner evenly, the piston body or misaligned ring scrapes the liner directly.
  - Rings may get jammed, increasing the risk of seizure, blow-by, or serious engine damage.

12. G.P.S (Groove Plane Squareness)

- G.P.S refers to the squareness of the groove plane relative to the piston's centerline.
- Ideally, the groove should be at 90° to the centerline. Any tilt or deviation from this is called G.P.S.
- If G.P.S. is high (i.e., groove is not square), the following issues may occur:

o The piston ring fits unevenly, slanting in the groove.

o **Friction between the ring and the liner increases**, leading to **faster wear** of both components.

o **Improper sealing** occurs between the piston and liner. This results in **compression leakage**, known as **blow-by** and reduces engine performance.

o Lubricating oil may **pass over the ring** into the combustion chamber instead of returning to the sump.

- This causes **high oil consumption**, referred to as **HOC (High Oil Consumption)**.
- The oil is burned with exhaust gases instead of being reused.

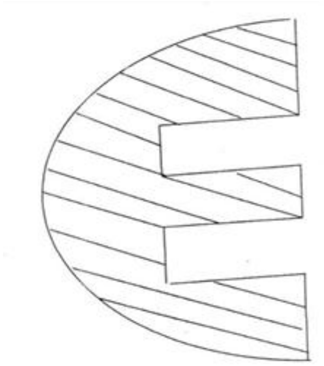
13. Weight

- In engines that use multiple pistons, it is essential that the weight difference between pistons is minimal to ensure uniform engine performance and balance.
- Hence, pistons are weighed and grouped accordingly.

14. B-diameter

- In KS-type pistons, the B diameter refers to the diameter measured 1.5 mm inward from the outer edge of the top ring groove (which is a keystone type groove) on both sides.
- Since the measurement is taken 1.5 mm in from each side, the B diameter is typically 3.0 mm smaller than the piston's outside diameter (OD).
- If the B diameter is too large, the piston ring will not fit properly within the groove. It may protrude beyond the piston's OD, preventing the piston from fitting into the engine. In cases where it still fits, the piston may operate too tightly, which can lead to engine damage.
- If the B diameter is too small, the ring may sit below the OD. This leads to compression gas leakage (blow-by), which reduces engine efficiency and power.

NOTE: The keystone groove design offers functional advantages. Its angled surfaces help prevent carbon buildup, as deposits do not settle easily and are expelled during operation. Additionally, the increased flank length reduces wear by lowering friction between the ring and groove.



15. Groove taper

- Groove taper refers to the inclination or slope of the groove flank
- An upward (positive) taper is used in compressor grooves to ensure optimal sealing performance.
- When the ring is pre-inclined upwards, the pressure from combustion forces it either to stay in place or move into a more upright position.
- If the taper were downward, the applied pressure would push the ring further down, **worsening the seal** and causing **compression leakage**, known as **blow-by**.

16. Groove parallelism

- Groove Parallelism is the degree to which the base of the piston ring groove is parallel to the piston's central axis.
- If the groove is not parallel, the piston ring will not seat uniformly.
- This leads to uneven wear, poor sealing, increased blow-by, or even ring breakage.

17. Form of Bore

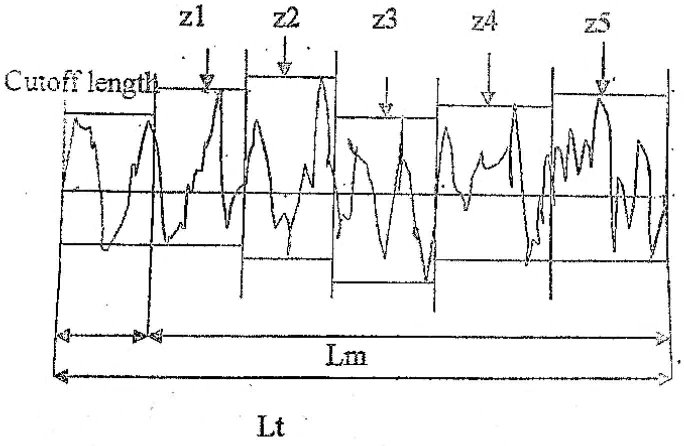
- Form of the bore in high performance pistons is usually barrel shaped i.e. the diameter increases from both ends towards the center.
- This spline-based profile helps the bore to maintain its roundness under combustion pressure.

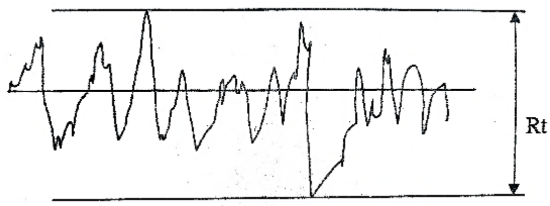
18. Bombing Angle

- The bombing angle is a straight-tapered angle applied to the pin boss.
- Unlike the curved foam bolo profile, bombing is linear and therefore easier to machine than a spline curve.

19. Roughness

- Roughness consists of line irregularities in the surface texture produced by the machining process.
- Roughness profile is the traced profile after filtering with a wave filter of a definite cutoff length.
- The roughness parameter Rz, R_{max}, Rt, and Ra are evaluated from the roughness profile.
- Centre line average (Ra) is arithmetical average value of all distances of the roughness profile "R" from the center line. Ra = $\frac{1}{Lm}\int_0^{Lm}|y|\,dx$
- Average roughness depth (Rz) is the average value of the individual roughness depth in five sequential single measuring length (Le).
  Rz= (Z1+Z2+Z3+Z4+Z5)/5
- Maximum roughness depth (R_{max}) is the deepest individual roughness depth "Z" on the measuring length (Lm)
- Maximum roughness depth (Rt) is the vertical distance between the highest and lowest point of the roughness profile "R" within the measuring length.

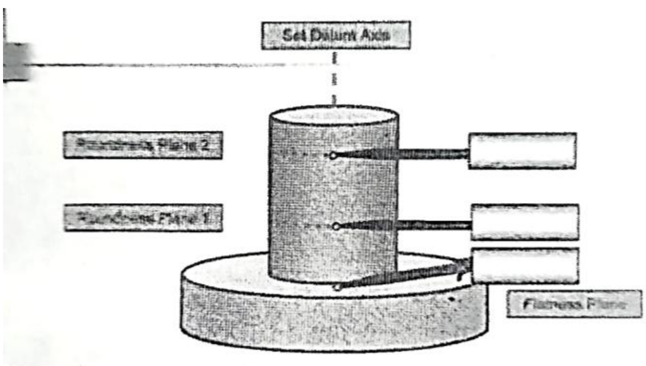


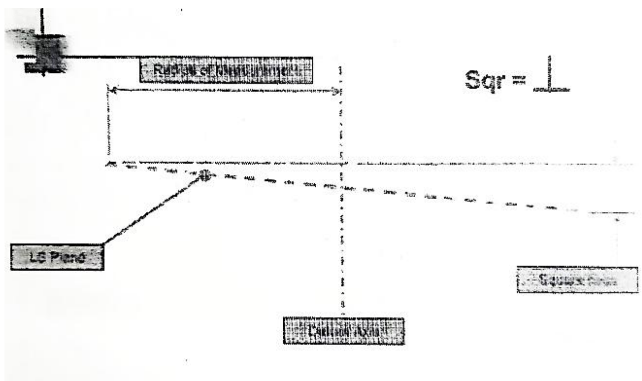


20. Waviness

- Waviness refers to the more widely spaced surface irregularities that occur due to factors like machine vibrations or deflections during processing.
- While roughness accounts for fine tool marks and microscopic irregularities, waviness captures the large-scale surface deviations that may affect sealing, fit and functional performance.

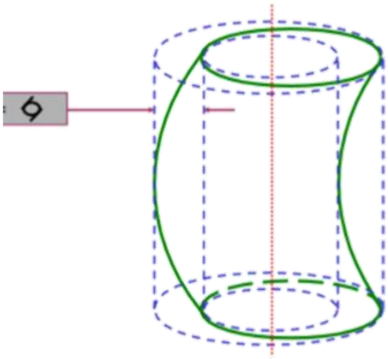
NOTE: Flatness is evaluated by measuring the deviations of a surface from a least squares reference plane. This reference plane represents the "ideal" flat surface that best fits the actual measured surface.
To assess squareness of this flatness plane with respect to a predefined datum axis, a method is used where the datum axis is constructed from two roundness reference planes. This ensures that the flatness is not only within tolerance but also aligned correctly relative to the piston's intended axis.



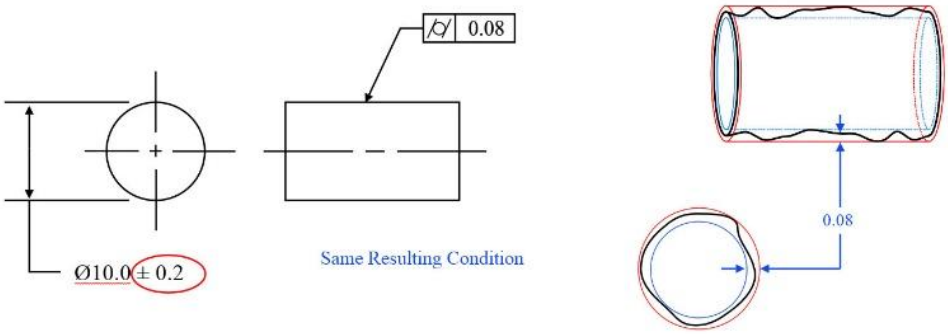


21. Cylindricity (Roundness, Straightness)

- The cylindricity control is a GD&T tolerance from the form control group and guarantees a part's cylindric shape in terms of two key aspects, roundness, and straightness.
- Cylindricity essentially forms a perfect cylindrical boundary around the object that the entire part must lie in.
- The cylindricity tolerance zone is represented by two concentric cylinders.
- It is measured using the CMM (Coordinate Measuring Machine).

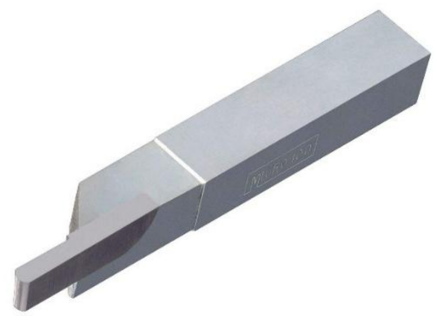


Green represents the tolerance zone. Purple is the surface of the cylinder and has to fit into the zone.



Tool Geometry

The tool shank is usually made of solid carbide K01/K10 while the chip is of a material called Compax (PCD: Polycrystalline Diamond).

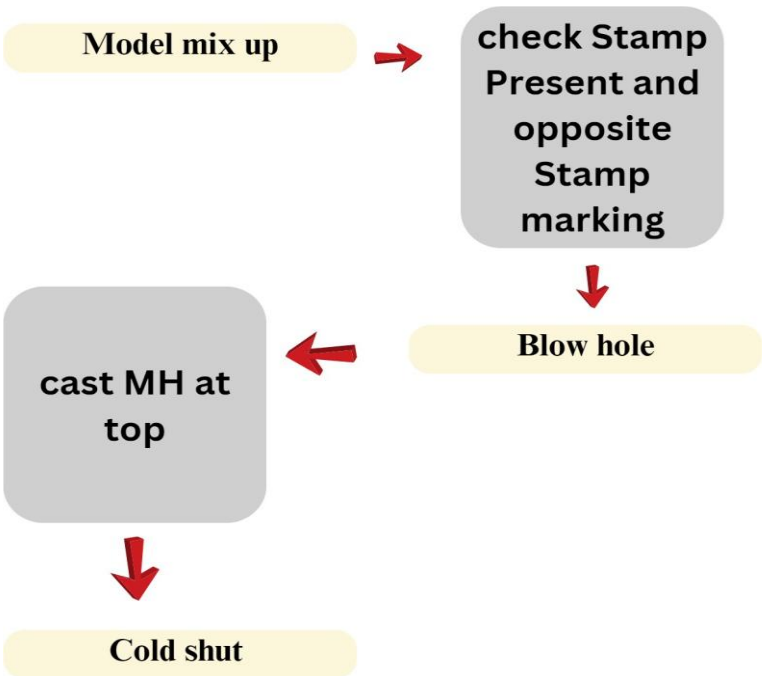
	
1. OD Finishing Tool	2. Grooving Tool

	
3. Fine Boring Tool	4. Broaching Tool

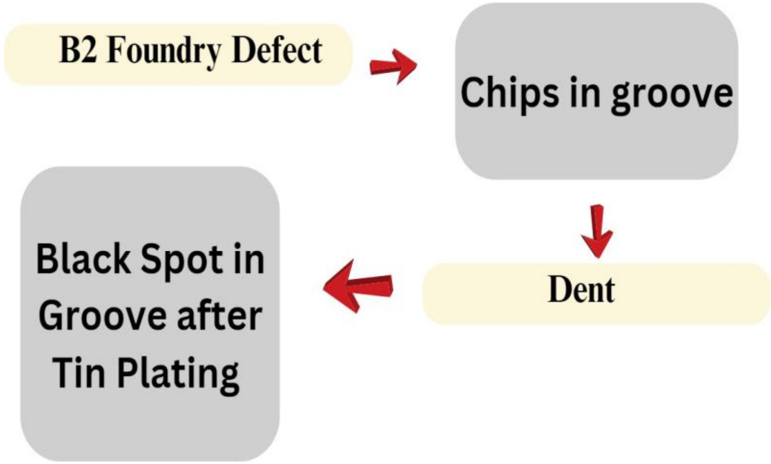
Visual Inspection

The visual inspection chamber serves as a critical stage in the manufacturing process, where trained inspectors meticulously examine the pistons for major defects or any machining defaults that can be detected by the naked eye. During the CRI (Critical to Quality) inspection, each piston is carefully assessed for visual defects, imperfections, cracks, surface irregularities, and dimensional variations. This thorough examination is conducted in an ideal environment, allowing inspectors to identify and address any issues that have the potential to impact the performance or longevity of the final product. By upholding the highest standards of quality control through this meticulous inspection, manufacturers can ensure the delivery of superior pistons that meet or exceed customer expectations. there are basically four Zone that ensures the quality of piston -

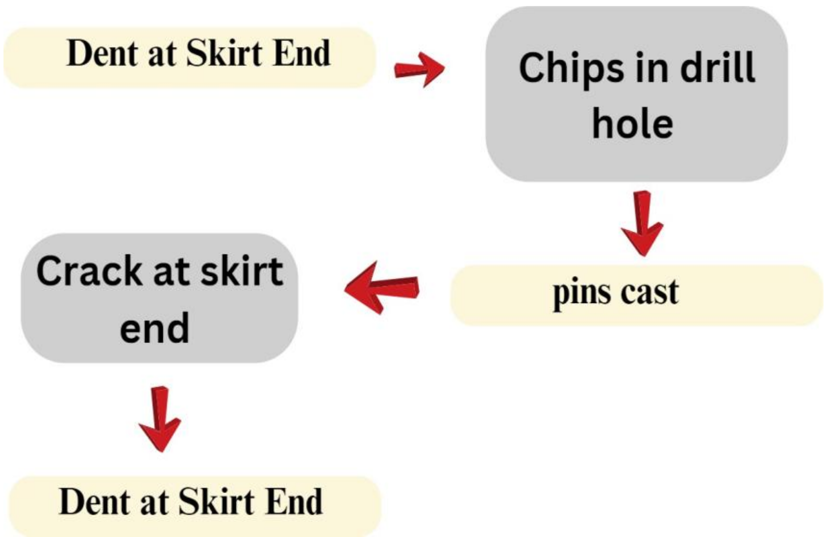
Zone 1 :- In this Zone piston Top is checked



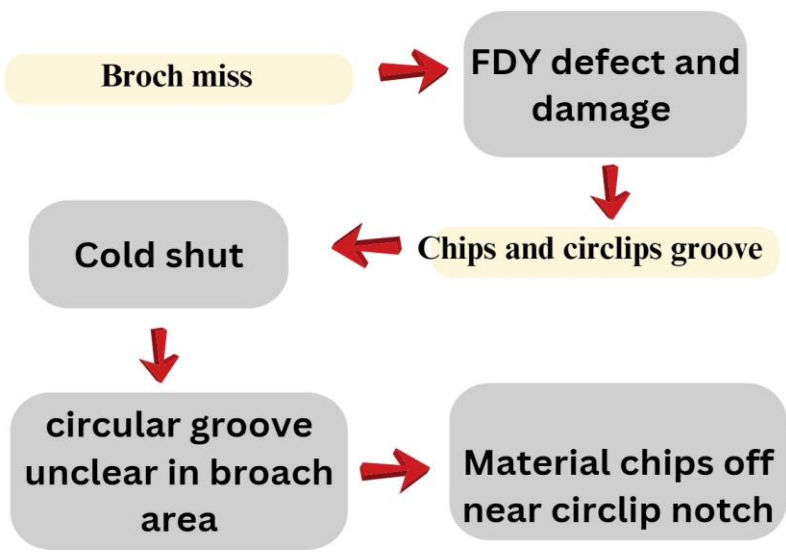
Zone 2: - In this zone, ring groove area is checked in 360 Rotation



Zone 3:- Skirt area (to be checked with 360 Rotation)



Zone 4:- To be checked both side of Pin bore



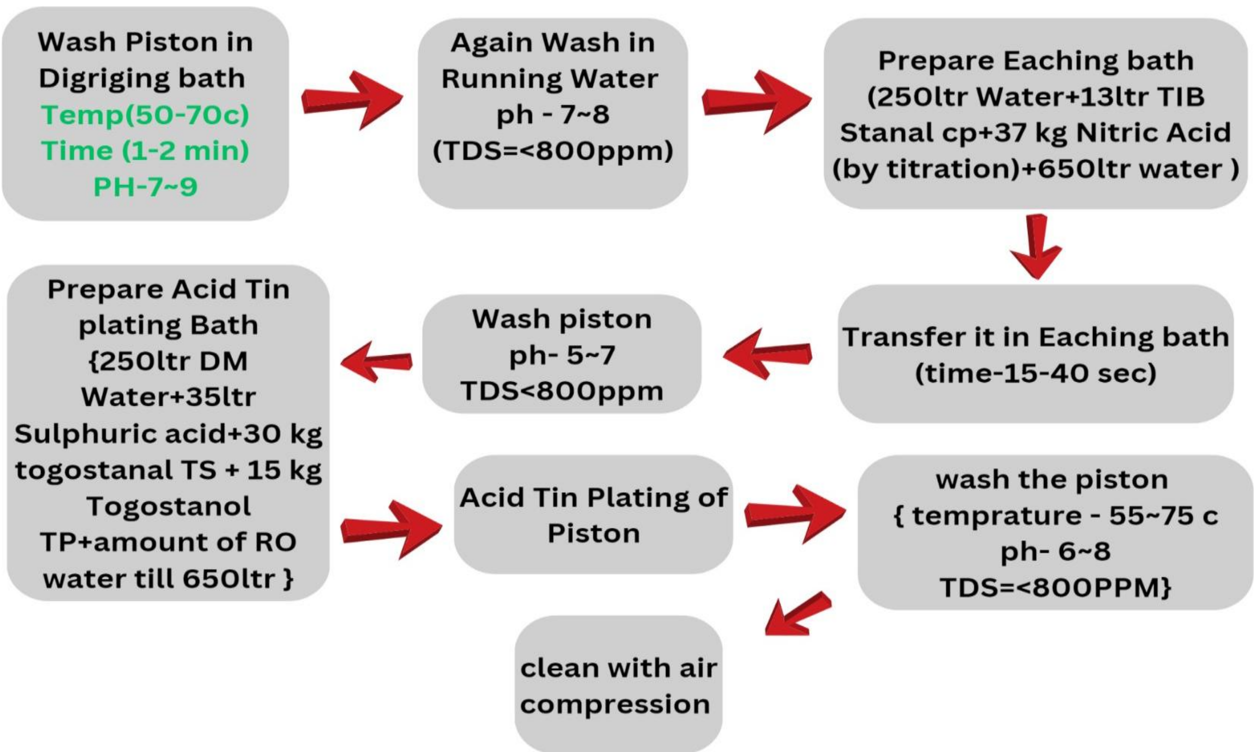
Surface Treatment

Surface treatment plays a vital role in enhancing the hardness and relieving stress on the piston. This process aims to improve the overall durability and performance of the component. Additionally, surface treatment is utilized as a means to facilitate the initial oiling process. One common method employed for surface treatment is plating, which involves applying a thin layer of a specific material onto the piston surface. This plating process not only enhances the hardness of the piston but also provides a smooth and uniform surface, reducing friction and wear. Furthermore, the plating acts as an effective medium for oil retention, ensuring proper lubrication during operation. By implementing surface treatment techniques like plating, manufacturers can significantly enhance the quality and functional characteristics of pistons, resulting in superior performance and extended lifespan.

Acid Tin Plating:-

Acid tin plating, also known as tin electroplating or tin dipping, is sometimes performed on pistons for various reasons:

- Corrosion resistance: Acid tin plating provides an additional layer of protection against corrosion, ensuring the longevity and optimal performance of the piston.
- Anti-seizure properties: Tin plating's good lubricity reduces friction and helps prevent sticking or seizing of the piston within the cylinder bore, enhancing reliability.
- Improved wear resistance: Tin plating forms a protective barrier between the piston and the cylinder wall, reducing friction and minimizing wear, particularly beneficial in high-performance engines.
- Heat dissipation: The thermal conductivity of tin helps with heat dissipation, which is crucial in high-performance or turbocharged engines to prevent engine damage.



Bonderising Operation: -

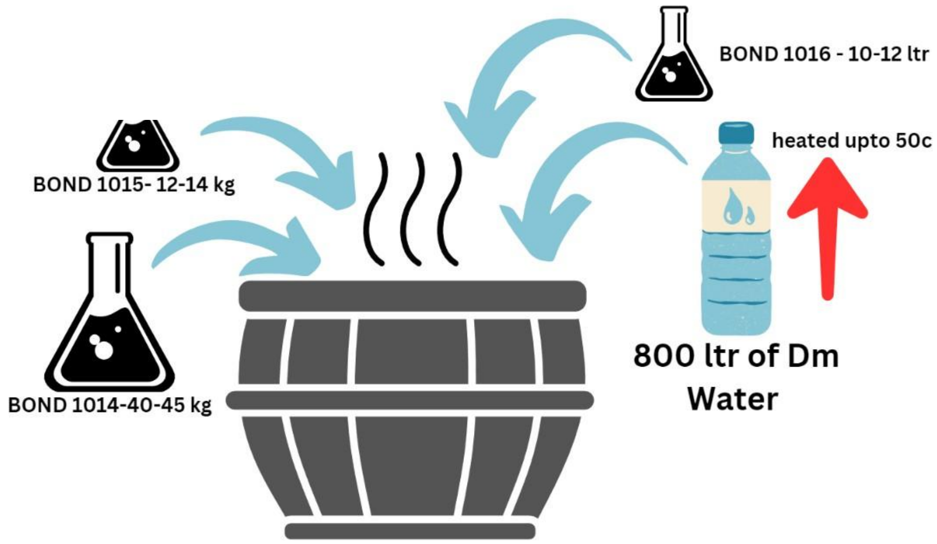
The bond-raising operation, also known as bonding or knurling, is performed on pistons for specific reasons related to engine performance.

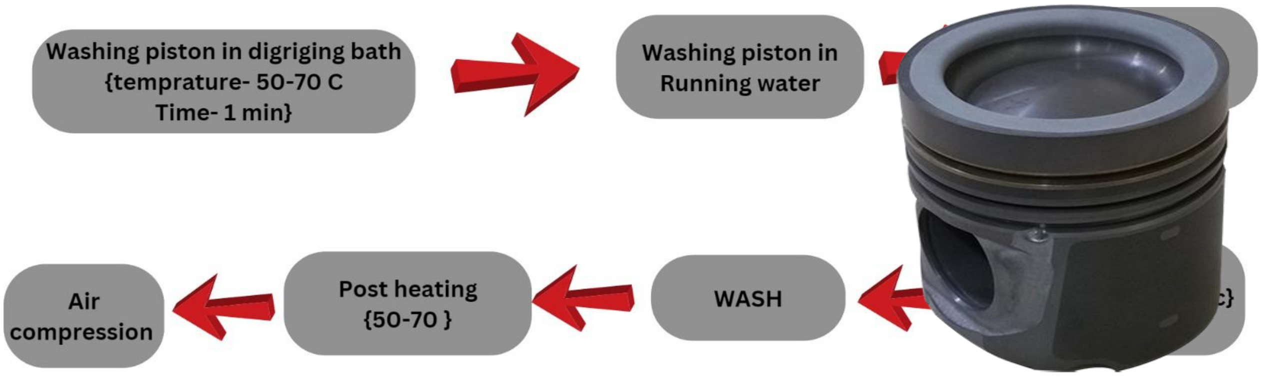
- Improved oil retention: The bond-raising operation creates small ridges or grooves on the piston skirt. These ridges help to retain a thin layer of oil on the piston skirt during engine operation. The retained oil acts as a lubricating film between the piston and cylinder wall, reducing friction and minimizing wear.
- Enhanced heat transfer: The raised ridges created by the bond-raising operation increase the contact area between the piston and the cylinder wall. This increased surface area improves heat transfer from the piston to the cylinder, aiding in cooling the piston and preventing overheating.
- Anti-scuffing properties: The ridges produced by the bond-raising operation provide a textured surface on the piston skirt. This texture helps to break up any potentially harmful films or deposits that may form on the cylinder wall. It also promotes better oil distribution and prevents the piston from scuffing or seizing within the cylinder.
- Noise reduction: The bond-raising
- Operation can help reduce piston slap noise, which is caused by the piston skirt coming into contact with the cylinder wall. The raised ridges absorb vibrations and reduce the amplitude of the piston slap, resulting in quieter engine operation.

when temperature is between 50 to 70 C, production will start.

Bonderising Bath

When temperature is between 80-90 C then production will start.

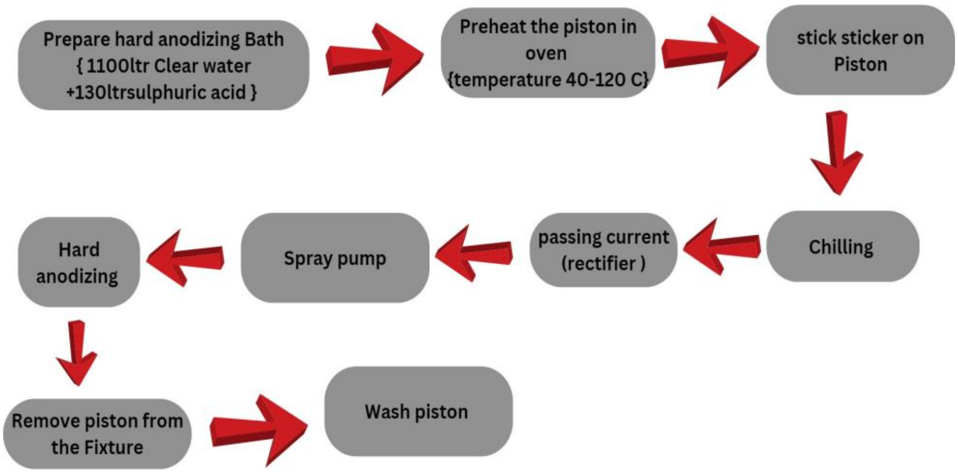




Hard Anodizing:-

Hard anodizing is sometimes performed on pistons for various reasons related to performance and durability:

- Increased wear resistance: Hard anodizing creates a thick and hard oxide layer on the piston surface. This layer improves the piston's wear resistance, protecting it from the abrasive forces and friction that occur during engine operation. It can help extend the lifespan of the piston and maintain its performance over time.
- Reduced friction: The hard anodized surface has a low coefficient of friction, which helps reduce friction between the piston and cylinder wall. This results in improved efficiency and reduced energy loss due to friction, leading to enhanced engine performance.
- Improved heat resistance: Hard anodizing provides increased heat resistance to the piston. The anodized layer acts as a barrier, protecting the piston from the high temperatures generated during engine combustion. This is particularly important in high-performance engines or engines that operate under extreme conditions.
- Corrosion protection: The hard anodized layer acts as a protective barrier against corrosion. It enhances the piston's resistance to chemicals, fuels, and other corrosive elements present in the engine environment. This helps prevent corrosion-related damage and ensures the longevity of the piston.
- Reduced scuffing and galling: Hard anodizing reduces the risk of scuffing and galling, which can occur when the piston comes into contact with the cylinder wall. The hard anodized surface provides a smoother and more resistant surface, minimizing the likelihood of these undesirable effects.



Skirt D10 Coating:-

Coatings are often applied to the skirt of pistons for several reasons related to performance, durability, and engine efficiency. Here are some common reasons for applying coatings on the skirt of a piston:

- Friction reduction: Coatings can reduce friction between the piston skirt and the cylinder wall, improving engine efficiency. Lower friction means less energy is wasted on overcoming resistance, leading to increased power output and fuel efficiency.
- Wear resistance: Coatings can enhance the wear resistance of the piston skirt. The skirt is in direct contact with the cylinder wall and is subjected to constant sliding motion. A wear-resistant coating helps protect the piston from excessive wear, prolonging its lifespan and maintaining performance over time.
- Heat dissipation: Some coatings have thermal barrier properties, helping to manage heat transfer from the piston to the cylinder wall. By reducing heat transfer, these coatings contribute to lower operating temperatures, which can improve engine efficiency and prevent overheating.
- Noise reduction: Coatings can help reduce piston slap noise, which occurs when the piston skirt contacts the cylinder wall during engine operation. Certain coatings can absorb vibrations and dampen the noise, resulting in quieter engine performance.
- Corrosion protection: Coatings can provide a protective barrier against corrosion and chemical degradation. Engines are exposed to various chemicals, fuels, and contaminants that can cause corrosion. Applying a corrosion-resistant coating to the piston skirt helps prevent damage and ensures the longevity of the piston.
- Lubrication improvement: Some coatings have self-lubricating properties or can retain a thin layer of oil, improving the lubrication of the piston skirt. This reduces friction and wear, promoting smooth operation and enhancing the overall performance of the engine.

Standard Room

After the piston undergoes complete machining and preparation, it is transferred to a designated standard room. The purpose of this standard room is to assess and verify certain parameters that cannot be effectively checked during the production line process due to resource limitations and the complex setup of heavy and sensitive machinery.

In the standard room, highly accurate and sensitive machines are employed to meticulously evaluate critical parameters. This ensures that the piston meets stringent quality standards and specifications. The machines utilized in this room are capable of detecting minute deviations and variations that may not be apparent through regular line inspections.

Visual inspection plays a significant role in the standard room, as any defects that might have been overlooked in the production line are carefully examined. The team in the standard room is equipped with the necessary expertise and precision instruments to identify even the slightest imperfections. This rigorous evaluation process guarantees that the final product meets the desired quality requirements.

Shadow Master:-

Profile projector used for quality control and inspection purposes. It utilizes lighting, optics, and projection techniques to project a magnified image of an object's profile onto a screen or surface, allowing operators to compare it against a reference template or CAD model for dimensional accuracy, surface defect detection, shape verification, alignment verification, and batch comparison.

Object Placement: The object, in this case, a piston, is securely positioned on a stage or fixture beneath the projector.

Lighting: The projector employs a focused light source, typically an intense halogen or LED lamp, to illuminate the object. This illumination enhances the visibility of details and surface features.

- Optics: The projector consists of an optical system, including lenses and mirrors, that captures the light reflected or transmitted by the object. The optical system magnifies the object's profile, focusing it onto a projection lens.

- Projection: The projection lens projects the magnified image of the object's profile onto a screen or surface located at a convenient viewing distance for the operator.
- Image Comparison: The operator compares the projected image with a reference template or CAD model representing the desired profile of the piston. This comparison helps identify any variations, deviations, or defects in the piston's shape, dimensions, or surface condition.

it measures the:-

- **Groove Root radius**
- **Key stone angle**
- **Chamfer width**
- **angle depth**

Roughness tester machine

A roughness tester is used in piston manufacturing to measure and evaluate the surface roughness of pistons. This helps ensure quality control, optimize functional performance, analyze friction and wear properties, optimize manufacturing processes, and comply with industry standards. By assessing surface roughness, manufacturers can maintain consistent quality, enhance piston functionality, improve durability, optimize processes, and meet customer requirements.

it measures

- **Skirt finish**
- **Bore finish**
- **Groove finis**

CMM Machine:- CMM machines are essential in piston manufacturing for precise dimensional measurement and quality control. They accurately measure complex geometries, surface profiles, alignment, and positioning of piston features, ensuring adherence to required standards. By providing statistical analysis and comprehensive quality assurance, they help identify deviations and defects, guaranteeing optimal performance of the pistons.
here it measures the **off set in piston .**

MMQ-400-Mohr:- The MMQ 400 Mahar is a specific model of a measuring instrument used in piston manufacturing. It is designed to measure several key parameters related to the ring grooves of pistons, including:

1. Waviness of Ring Grooves: The MMQ 400 Mahar is capable of measuring the waviness of ring grooves. Waviness refers to the deviations in the groove surface from the ideal straight or circular shape. This measurement helps ensure proper seating and functioning of piston rings, promoting effective sealing and reduced oil consumption.

2.Groove Taper: The instrument can also measure the groove taper, which refers to the variation in groove width along its length. Groove taper measurements ensure uniformity and consistent dimensions along the entire length of the ring groove, which is critical for proper ring installation and sealing performance.

3.Linear Drop: Linear drop refers to the measurement of the vertical distance between the highest point of the ring groove and a reference line or plane. This measurement helps assess the clearance between the ring and groove, ensuring proper contact and functioning of the piston rings.

4.Polar Drop (Ovality): The MMQ 400 Mahar can measure the polar drop or ovality of ring grooves. Ovality refers to the variation in the circular shape of the groove. This measurement helps determine the roundness and uniformity of the groove, ensuring optimal ring performance and sealing.

Digital Burette meter:-

The accurate measurement of piston cavity volume is crucial for ensuring precise design and manufacturing of pistons, optimizing their performance in internal combustion engines

1. Preparation:

- The piston was thoroughly cleaned and inspected for any debris or contaminants.
- A thin layer of grease was applied to the top surface of the piston, ensuring a watertight seal.
- A fiber sheet was carefully placed over the greased area to cover the entire top surface of the piston.

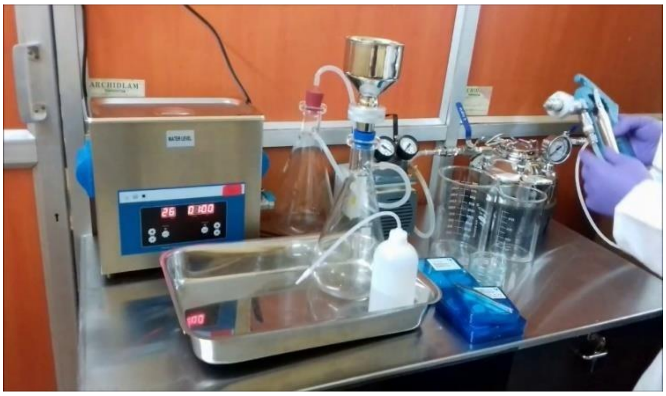
2. Setup:

- The digital burette meter was calibrated and set up according to the manufacturer's instructions.
- The burette was securely positioned on a stable support stand or holder.

3. Measurement:

- The piston was positioned with the greased and covered top surface facing upward.
- A small hole was created in the fiber sheet using a needle or similar instrument to allow the introduction of deionized water.
- Deionized water was poured slowly into the cavity through the hole, while carefully observing the digital burette meter for changing volume readings.
- The pouring was stopped once the cavity was completely filled, and the final volume reading was recorded from the digital burette meter.

Mili Pore:-



Mili Pore machine in measuring dust particles in piston machining processes. The objective was to determine whether any issues exist within the washing bath that could potentially impact the quality of machining. The study involved collecting samples from the piston machining process and subjecting them to analysis using the Mili Pore equipment. The results indicated consistent readings of dust particle concentration, providing valuable insights into the machining quality. Additionally, the evaluation of the washing bath system revealed that it was functioning correctly, with parameters such as temperature, pH levels, and chemical concentrations remaining within the specified range. Based on these findings, it is recommended to periodically monitor and recalibrate the Mili Pore machine for accurate measurements, as well as conduct regular inspections and maintenance of the washing bath system. These measures will help ensure ongoing quality control and prevent any unforeseen deviations.

Contour graph:-

Contour Measurement Contracer is a precision instrument utilized in the manufacturing of pistons to measure the profile of both the outside and inside chamfer angles and radii. Its primary function is to provide accurate measurements of these critical features, enabling manufacturers to assess the conformity of pistons to design specifications. The Contracer generates graphical representations that depict any deviations occurring within the chamfer angles and radii, offering valuable visual insights into the dimensional accuracy and uniformity of the piston profiles. This professional-grade equipment aids in quality control by identifying and documenting any variations or irregularities, allowing manufacturers to make necessary adjustments to ensure optimal performance and reliability of the manufactured pistons of the engines they are used in.

Production optimization techniques employed

Poka Yoke

Poka-yoke is a Japanese term that means "mistake-proofing". A poka-yoke is any mechanism in a lean manufacturing process that helps an equipment operator avoid mistakes. Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur.

Poka-yoke was provided on the following machines:-

1. To check pre-boring operation before boring operation.
2. For prevention of variation between enlargement diameter and pre-bore diameter.
3. For prevention of wrong loading of the piston.
4. To check compression height, pin bore diameter, groove diameter, pin bore squareness and major outside diameter.
5. To check for oil hole drilling.
6. To check for drilling pin boss.
7. To check for missing slots in the pin bore.

In process inspection

Apart from utilizing the Poka yoke individual inspection apparatus is provided to each worker so that he can inspect and correct any irregularities in the machining, also rejection charts and production charts are used to measure and reduce rejections and optimize production.

Packing:-

After the completion of the manufacturing process, the piston proceeds to the packaging stage, where it is carefully placed into designated boxes and organized according to specific requirements. The packaging process ensures that the pistons are appropriately packed, maintaining their integrity and facilitating efficient storage and transportation.

After packing the lot goes to godown which is handled by the sales coordination department.

Conclusion

During my four-week training at Shriram Piston and Rings Limited in Ghaziabad, I had the opportunity to immerse myself in the industrial environment, gaining firsthand exposure to production systems and the disciplined work culture.
Within the piston plant, I focused on studying the Production Operation Sequence (P.O.S.) for various piston models. This involved closely examining the manufacturing process, understanding the sequential steps involved, and analyzing the production flow.

The comprehensive study of piston manufacturing operations at *Shriram Pistons & Rings Ltd.* has provided valuable insights into the intricacies of modern machining, casting, and quality control processes. From raw material processing in the aluminium foundry to operations such as rough turning, broaching, and finish oval turning, each step contributes to the final piston's shape, size, performance, and reliability.

Particular attention was given to critical quality parameters such as groove width, oil hole positioning, pin bore dimensions, and skirt coatings. It became clear that consistent process control, proper tool use, and routine inspection are necessary to maintain these specifications.

Safety measures like poka-yoke and other in-process inspections help avoid errors and ensure smooth production and process standardization. With advancements in surface treatments like hard anodizing and skirt D10 coatings, the plant demonstrates its commitment to continuous improvement and innovation.

This report serves as a technical documentation of current manufacturing practices in piston production and can be a helpful foundation for further process optimisation using quality improvement initiatives such as Six Sigma or Lean manufacturing.

Overall, this training has proven to be a valuable step in my professional development. It gave me a closer look at how manufacturing problems are tackled, how process decisions are made, and where engineers play a role in improving productivity and quality. I believe this learning will not only help me in future projects but also shape the way I approach problems as a mechanical engineer.