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A brief review of the technology in piston machining to goal the product localization in Vietnam

Minh Quang Chau†, Danh Chan Nguyen‡*, Dinh Tuyen Nguyen‡, Viet Duc Bui‡†*

† Faculty of Mechanical Technology, Industrial University of Ho Chi Minh City, Ho Chi Minh City, Vietnam
‡ Institute of Mechanical Engineering, Ho Chi Minh City University of Transport, Ho Chi Minh city, Vietnam
‡† Institute of Engineering, Ho Chi Minh city University of Technology (HUTECH), Ho Chi Minh city, Vietnam

*Corresponding author email: chanck06@gmail.com; bv.duc@hutech.edu.vn

ABSTRACT

The recent rapid growth of the Vietnamese automobile market is convincing proof that the Government has been giving the industry a close interest in formulating policies to build and develop the industry. In particular, the automobile production and assembly industry are increasingly focused on developing, thereby confirming the competitiveness of domestic cars with imported cars. However, up to now, supporting industries for the automobile manufacturing industry in Vietnam are still very rudimentary. To help the automobile industry, increase the localization rate for cars manufactured in Vietnam, this article focuses on the assessment of manufacturing technologies and materials used in the manufacturing process for pistons of automobile engines, from which to find the most suitable technological solution and material for the manufacture of this part in Vietnam. Many casting technologies can be used to produce pistons for automotive engines such as die-casting and centrifugal casting. The choice of the appropriate casting method depends on the manufacturer's decision. The trend of choosing aluminum alloy materials for piston production still dominates although steel and new materials have confirmed their role.

KEYWORDS

machining technology, automobile manufacturing industry, casting technologies, piston materials

INTRODUCTION

Along with the formation and development of the world automobile industry, the automobile industry in Vietnam was formed very early [1]. However, through many fluctuations periods in the history of the country, this industry has also gone through many ups and downs in the process of formation and development. Vietnam is a densely populated country with a developing economy and an increasingly improved life, so the demand for cars is increasing more and more, enough for auto businesses to invest in large-scale production. However, at present, the capacity of the domestic market is not yet developed compared to its potential, due to the lack of market conditions in the Vietnamese automobile industry as well as other factors to develop as countries in the region. By the end of 2020, Vietnam has only more than 350 automobile-related manufacturing enterprises, with a total designed assembly capacity of about 680,000 vehicles/year. Out of 350 manufacturing enterprises related to automobiles, more than 40 are manufacturing and assembling cars; 45 enterprises producing chassis, bodywork, vehicle body; 214 companies producing auto parts and accessories ... with domestic production and assembly output, meeting about 70% of domestic demand for cars with less than 9 seats [2].

According to the plan to develop the auto industry of Vietnam, by 2020, the rate of production value for cars up to 9 seats is 30-40% and about 40-45% by 2025; similarly, cars with 10 seats or more will reach 35-45% and 50-60% by 2025; For trucks, this ratio must reach 30-40% and 45-55% by 2025 [3]. But after nearly 20 years of development, the localization rate of cars produced in Vietnam is still very low, most of them have not met the set target and much lower than the average rate of other countries in the region. Specifically, trucks under 7 tons achieve an average localization rate of over 20%; passenger cars with 10 seats or more, special-use car rates of 45- 55%. As for individual cars with up to 9 seats, the average localization rate will reach 7-10% (excluding Toyota's Innova, which is 37%). Also, localized products with very low technology content such as tires of cars, seats, mirrors, glasses, electrical wires, batteries, plastic products ... and have not mastered the core technologies such as the engine, control system, and transmission [4].

Although domestic automobile production and assembly activities have achieved certain results, they have not yet met the criteria of the real automobile manufacturing industry, mostly at the level of simple assembly. There has been no cooperation - association and specialization between production - assembly and spare parts and component manufacturing enterprises. And a system of large-scale suppliers of raw materials and components has not yet been formed. To make a car requires from 30,000 to 40,000 different parts and components [5]. Therefore, the automobile industry needs the cooperation of many other industries such as mechanical engineering, electronics, chemical industry ... But the linkage between manufacturing industries is still lax. And there is no tight combination, so the effect is not high. Up to now, only a few domestic suppliers have been able to participate in the supply chain of automobile manufacturers and assemblers in Vietnam. Compared with Thailand, which has nearly 700 tier 1 suppliers, Vietnam has less than 100 suppliers. Thailand has about 1,700 tier 2 and 3 suppliers, while Vietnam has less than 150 suppliers [6].

Casting is the most important type of embryo technology in the mechanical engineering industry. In Vietnam, before 1985, this technology in many factories was relatively outdated, also used coal-fired blast furnaces to cook cast iron, molds were made on a fixed sand base, byproducts of cast products are usually very high (from 20% - 30%) [7]. However, after 1985, thanks to the renovation, the economy gradually shifted to a market economy, all economies thrived, including mechanical engineering. To meet the increasing requirements of casting quality, casting technology has undergone a strong innovation in technology and equipment. Up to now, most of the large and small mechanical manufacturing factories have been equipped with electric arc furnaces and medium frequency furnaces to cook iron and steel. The existing arc furnaces, with a cooking capacity of 0.5 tons/batch - 30 tons/batch, means that until now, Vietnam's casting ability can cast details with a weight of more than 20 tons. The casting factories have applied the technology of parallel cooking two furnaces, so it is possible to cast high-quality steel or cast-iron parts with a weight of up to 2 tons.

Even when cooking non-ferrous metals (copper alloys, aluminum alloys), most mechanical factories also use electric frequency ovens or electric furnaces. Along with the renovation of smelting equipment, molding technology also has important innovations, by abandoning fixed sand-based molding technology, most of the mechanical fabrication factories have used fresh mold technology. In which, each time molding, the preparation of new materials is done meticulously, making molds on separate mold boxes [8]. Many factories apply sand molds to glass water. Moreover, some factories have successfully applied Furan molding technology to cast iron. Thanks to the successful application of advanced molding technologies, the quality of the casting has improved significantly, the casting waste due to the gas basket is only about 5% - 10% (for complicated details). To check the composition as well as to adjust the composition of the casting during the smelting process, many mechanical manufacturing enterprises have been equipped with emission spectroscopy [9]. It allows for quick analysis of the cast iron samples outside the furnace, thereby making timely adjustments during cooking. As such, foundries in Vietnam are already capable of casting all the desired fine steel grades.

Metal castings alloys are vital components widely used in the automotive, aerospace, and general engineering industries. Cast metals parts account for more than fifty percent of an automobile engine. In aluminum casting, the typical alloying elements are magnesium, manganese, copper, silicon, and zinc. Aluminum alloys containing major elemental additives of Mg and Si have become a potential substitute for steel panels in automobile industries. A study in [10] reported that aluminum has surpassed iron as the second most used automotive material worldwide (behind steel). A total of about 110 kg of the aluminum vehicle in 1996 is predicted to rise to 250 or 340 kg, with or without taking body panel or structure applications into account, by 2015. Furthermore, in engines, the piston is a very important part. The piston is responsible for receiving the force of the gas during the combustion process to rotate the crankshaft and then receiving the inertial force of the crankshaft accumulated in the flywheel to move up and down in the cylinder [11]. Pistons are in direct contact with the combustion gas at high temperatures and forces, so the piston materials need to withstand abrasion, great strength and lightness to reduce the moment of inertia, and anti-lock in the cylinder when the engine is working at high temperature. Pistons are usually made of various materials such as cast iron, steel, aluminum, or even ceramic. However, aluminum alloys are most often used.

Aluminum alloy has the advantages of lightness, good thermal conductivity, easy casting, friction coefficient with small cast-iron cylinders, but the coefficient of expansion is large, so it must make a large gap, lead to cause air leakage [12]. In terms of detail fabrication technology, currently used is the die casting method with some characteristics and limitations as follows: High pressure casting products usually have a thickness of from 0.8 mm to 10 mm, but in practice, 2 mm to 6 mm thick will give the best casting results. However, in the high-pressure casting method, the liquid metal fills the cavity through the runner at high velocity, resulting in dispersion flow or turbulent flow in the mold and this is the cause of the oxides, pitting makes it difficult for heat treatment afterwards [13]. The research of aluminum alloy casting technology solutions for automobile pistons to minimize the above limitations is very necessary. Therefore, the research and manufacture of aluminum alloy as the piston is especially important because it contributes to the localization of Vietnamese automobile products.

The development of the automotive industry strongly depends on two main issues: increased fuel-efficiency to accomplish the ever more stringent regulations on gas emission control and improved automobile performance. To achieve such goals, the use of advanced materials to improve the quality of car components and significant weight reduction is crucial, such as, for the motor pistons. Pistons require different properties in different areas of their body, such as high thermal fatigue resistance in the top, high wear resistance in the pin-bore area, and low weight in the skirt [14]. On our days, they are not pistons with composition gradient [15]. The pistons are usually produced with homogeneous composition, in one alloy, existing in some cases incorporations of another material, to improve the mechanical characteristics in a certain area (for instance in the grooves for the segments)[16]. The pistons are typically produced by gravity casting, in a metallic mold and afterward machined.

However, in special cases, pistons are manufactured by forging to increase their mechanical properties. Relatively to centrifugal casting, this technique has been mainly used for obtaining cylindrical parts [17]. There are essentially two basic types of centrifugal casting machines: the horizontal types, which rotate about the horizontal axis, and the vertical type, which rotates about a vertical axis. This article explains emerging casting technologies as well as promising materials for piston production for the automotive industry in Vietnam. The application of metal and material technologies to the goal of localization of products in the automobile manufacturing and assembly industry in Vietnam has also been partially elucidated in this work.

TYPICAL CASTING TECHNOLOGIES

The metal casting process [18] begins by creating a mold, which is the 'reverse' shape of the part we need. The mold is made from a refractory material, for example, sand. The metal is heated in an oven until it melts, and the molten metal is poured into the mold cavity. The liquid takes the shape of the cavity, which is the shape of the part. It is cooled until it solidifies. Finally, the solidified metal part is removed from the mold. Many metal components in designs we use every day are made by casting. The reasons for this include: (a) Casting can produce very complex geometry parts with internal cavities and hollow sections. (b) It can be used to make small (few hundred grams) to very large size parts (thousands of kilograms) (c) It is economical, with very little wastage: the extra metal in each casting is re-melted and re-used (d) Cast metal is isotropic – it has the same physical/mechanical properties along any direction

Permanent mold casting

Permanent mold casting is a metal casting process that employs reusable molds ("permanent molds"), usually made from metal. The most common process uses gravity to fill the mold, however, gas pressure or a vacuum is also used. A variation on the typical gravity casting process, called slush casting, produces hollow castings. Common casting metals are aluminum, magnesium, and copper alloys. Other materials include tin, zinc, and lead alloys, and iron and steel are also cast in graphite molds [19]. Typical products are components such as gears, splines, wheels, gear housings, pipe fittings, fuel injection housings, and automotive engine pistons [20]. Figure 1 illustrates a permanent molding process to produce automotive pistons. To manufacture automotive components using a permanent mold manufacturing process the first step is to create the mold. The sections of the mold are most likely machined from two separate metal blocks. These parts are manufactured precisely. They are created so that they fit together and may be opened and closed easily and accurately. The gating system as well as the part geometry is machined into the casting mold.

A significant amount of resources needs to be utilized in the production of the mold, making the setup more expensive for permanent mold manufacturing runs [21]. However, once created, a permanent mold may be used tens of thousands of times before its mold life is up. Due to the continuous repetition of high forces and temperatures, all molds will eventually decay to the point where they can no longer effectively manufacture quality metal castings. The number of castings produced by that mold before it had to be replaced is termed mold life. Many factors affect mold life such as the molds operating temperature, mold material, and casting metal. Before pouring the metal casting, the internal surfaces of the permanent mold are sprayed with refractory materials. This coating serves as a thermal gradient, helping to control the heat flow and acting as a lubricant for easier removal of the cast part. Besides, applying the refractory coat as a regular part of the manufacturing process will increase the mold life of the valuable mold. The two parts of the mold must be closed and held together with force, using some sort of mechanical means [22].

Most likely, the mold will be heated before the pouring of the metal casting. A possible temperature that a permanent metal casting mold may be heated to before pouring could be around (175^{o}C). The heating of the mold will facilitate the smoother flow of the liquid metal through the mold's gating system and casting cavity. Pouring in a heated mold will also reduce the thermal shock encountered by the mold due to the high-temperature gradient between the molten metal and the mold. This will act to increase mold life. Once securely closed and heated, the permanent mold is ready for the pouring of the cast part. After pouring, the metal casting solidifies within the mold. In manufacturing practice, the metal cast part is usually removed before much cooling occurs, to prevent the solid metal casting from contracting too much in the mold. This is done to prevent cracking the casting since the permanent mold does not collapse. The removal of the part is accomplished by way of ejector pins built into the mold [23].

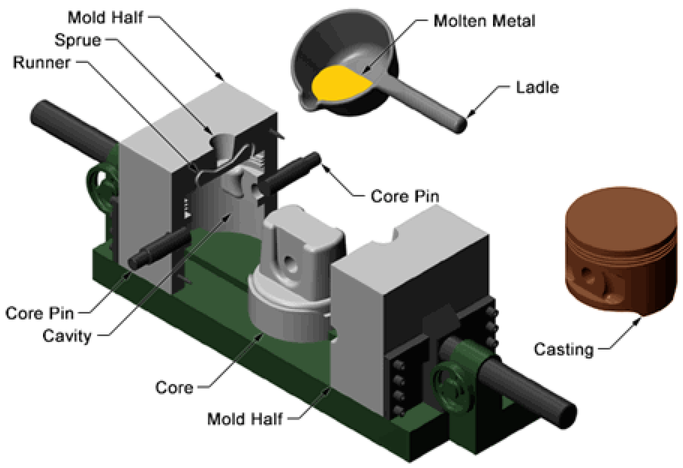


Figure 1. Application of permanent mold casting technology to produce automobile pistons [24]

Table 1. Advantages and disadvantages of metal moulding

Advantages	**Disadvantages**
- Fast crystallization speed, small metal particles on high mechanical casting. - Mold has high durability, can be used many times. - Due to the shiny mold surface, the casting surface quality is high. - The molding process in metal molds increases productivity, reduces toxicity.	- The rapid cooling rate cannot cast alloys with poor melt properties and high melting point (mainly non-ferrous metals are cast). - Because the mold does not settle on the casting, it is easy to appear microscopic cracks (especially alloys with large shrinkage). - Must create complex exhaust systems (especially large details). - The mold is difficult to process, so it is not possible to cast complex castings. When it is necessary to manufacture, the mold cost is high.

Die casting

Die casting [25] is the process of casting metal and liquid alloys that crystallize in a metal mold. Metal, liquid alloys are poured into molds under high pressure (60 ÷ 100). The resulting casting has a high metal density and good mechanical properties. Die casting usually has the following 2 methods: die casting in a hot pressing chamber and die casting in a cool pressing chamber. The European Aluminum Association discusses how cylinder heads are made using gravity die casting. They use this process as it allows the engineers to achieve a high solidification rate in the flame deck region, thus resulting in a very fine microstructure with low porosity. Sand cores were used to realize a sophisticated water jacket cooling system of complex geometry. They also discuss how the Rotacast process which is a type of gravity die casting provides higher productivity due to a considerably lesser number of runners and feeders [7]. We also know about the use of low-pressure die casting to manufacture the cylinder head. The major advantage of this process is almost no process scrap. However, this process decreases the productivity of manufacturing as the cycle time is relatively high. Usually, die-cast components can have walls of 0.75 mm with a smooth surface finish of about 2.2 micrometers, making them useful for thin-walled automotive components [26].

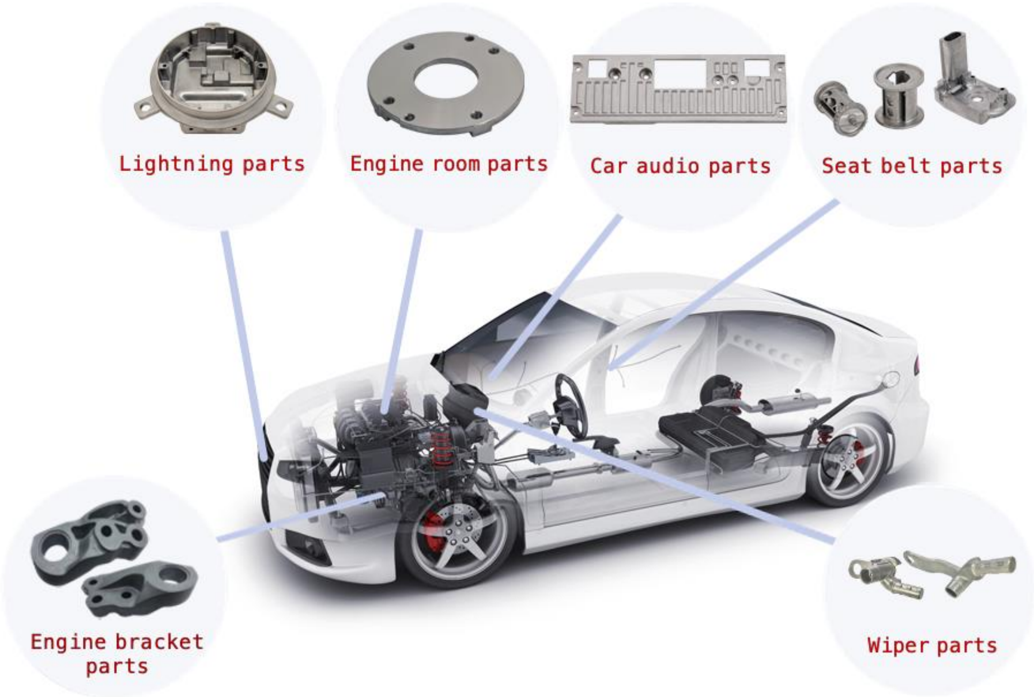
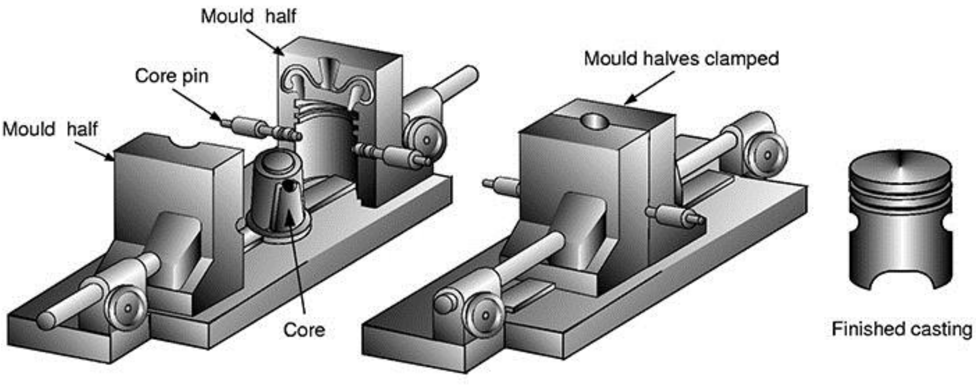


Figure 2. Application of die casting to produce auto parts [27]

Die casting is mostly used because many parts need to be manufactured in a short amount of time (hundreds to thousands per day) with high accuracy. Parts like valve covers, wheels, transmission housings, engine block, wheel spacer, carburetor, impellers and fan clutch, alternator housing, airbag gas generator housing, etc. are all modes through the aluminum die casting method. Automobile parts require uniformity and high surface finish which can be accomplished by using casting methods that work in a controlled environment- pressure dies casting. Die casting was originally developed specifically for automotive applications [28]. The idea is to produce parts that are light, easy to handle, and cheap. Thus, die casting is widely applied to zinc and aluminum which are lighter than cast iron. Figure 2 shows the aluminum die-cast parts of a car. PEGASUS has been supplying quality aluminum die-cast auto parts to the automobile industry with our stable production system since we started this business in 2007 [27].

At present, we are supplying 60 kinds of die-cast products with our unique mold design and casting technology in addition to the processing technology we have been cultivating in the industrial sewing machine industry [29]. Aluminum or Al-Si alloys are used for Die casting. During this process, molten metal is injected at high pressure into a die (made of metal) which is a permanent mold comprising of two parts of the desired shape attached [30].

Once the metal cools, these segments are detached, and the last part is obtained. Since the die is a permanent mold, it can be used multiple times for casting the same component with the same dimensional accuracy and surface finish, thus producing uniformity in the cast parts [31]. However, since the component is cast in metal in contrast to sand in sand casting, certain factors like cooling and solidification time, dissolved gas removal, etc. also come into play. Appropriate modifications must be done to the die to alleviate these challenges which make the designing of the die difficult. An appropriate draft angle ensures that the cast part is removed easily [32].



Open die
Die ready for pouring

Figure 3. Equipment and process of die casting for fabricating aluminum alloy pistons [33]

The aluminum and steel pressure casting method is applied when it is necessary to produce metal materials with complex shapes, after pouring liquid metal into a pressure die, the flow will be hardened under the effect of high pressure or low pressure. Low pressure casting by vacuum aspiration in the mold cavity increases the hardening time of the metal. High-pressure casting is the use of pressure from a plunger force to compress [34]. For high-pressure liquid metal solidification, the procedure is as follows: When pouring liquid alloy into the mold, the plunger performs the job of pressing the liquid alloy down, the liquid alloy will under pressure go to the detailed parts of the mold. The design of the mold has two mechanisms: static structure and dynamic structure, when the material is cast, the dynamic mechanism will support the removal of the mold. The stationary mechanism will assist in removing the excess alloy from the piston-cylinder mouth. The pressure casting cycle then recirculates and continues. Figure 3 depicts the die casting equipment and process for fabricating aluminum-alloy pistons.

Centrifugal casting

Centrifugal casting [35] is the process of casting metal, liquid alloys crystallize in a metal mold and the mold is rotated around the axis. The casting process by centrifugal force acts on the liquid metal. Vertical centrifugal casting [36] is a centrifugal casting method in which the axis of the mold rotates vertically. Molten metal is poured into a high-speed rotating mold (300–3000 rpm depending on diameter) until solidification takes place. The axis of rotation is usually horizontal but maybe vertical for short workpieces. Most metals suitable for static casting are suitable for centrifugal casting: all steels, iron, copper, aluminum, and nickel alloys [37]. Also, glass, thermoplastics, composites, and ceramics (metal molds sprayed with a refractory material) can be molded by this method. Horizontal centrifugal casting machines are generally used to make pipe, tube, bushing, cylinder sleeves (liners), and cylindrical or tubular casting that are simple in shape. The range of application of vertical centrifugal casting machines is considerably wider: gear blanks, pulley sheaves, wheels, impellers, electric motor rotors, valve bodies, plugs, yokes, brackets.

Casting that is not cylindrical, or even symmetrical can be made using vertical centrifugal casting. Centrifugally cast parts have a high degree of metallurgical cleanliness and homogeneous microstructures, and they do not exhibit the anisotropy of mechanical properties evident in rolled/welded or forged parts [38]. Vertical centrifugal casting is a vertical centrifugal casting. Since the mold rotates vertically, each liquid metal molecule is subjected to a centrifugal force and in force, so the free surface of the liquid metal will be a parapolice line. When the height is greater, the difference in the inner radius becomes bigger. Thus, this vertical centrifugal casting method is only for casting short objects. Based on the analysis of the characteristics of the above casting processes, it is easy to see that the vertical centrifugal casting method is the most suitable for the manufacture of pistons [39].

The centrifugal casting process provides a high degree of metallurgical cleanliness and homogenous microstructures. A test was done by the mechanical engineering department at the Minho University, Portugal where the material used for castings was an aluminum alloy AS12UN with the following composition: Fe-0.75%, Si- (11.50–13.00)%, Zn-0.20%, Mg(0.75–1.30)%, Ni-(0.80–1.30)%, Pb-0.10, Sn-0.05%, Ti-0.20% [40]. Three tensile specimens were cut out from the casting to compare the mechanical properties of the different places of the casting with each other. Cylindrical components of up to 8m in diameter and 17 m in length with a wall thickness in the range of 2.5-125mm can be cast by centrifugal casting. K.Venatesvaran [41] discussed the use of Silumin (Al-Si alloys) in centrifugal castings. The silicone content in this alloy ranges between 3-50%. This material is preferred due to its lightweight, high castability, high corrosion resistance, and high machinability. The reason why Silumin is preferred over cast iron for centrifugal casting of pistons is because of its weight (3 times lighter than CI).

It also possesses a higher thermal conductivity, allowing it to dissipate heat very easily as compared to cast iron. Aqeel Ahmed, M. S. Wahab [42] stated that out of the numerous casting methods used to manufacture pistons, each process has its pros and cons and each process has its impact on the mechanical and physical properties as well as on the microstructure of the piston. They analyzed pistons manufactured by centrifugal casting and observed that the hardness from the piston skirt to the piston head increased by 23.7HRB. They compared the properties of a piston made by centrifugal casting to a piston made from gravity permanent mold casting It was observed that the piston made by centrifugal casting had a coefficient of linear expansion as 15.3*10-6 K-1 which is about 23% lower than gravity permanent mold casting. The improvement in wear analysis of the piston made from centrifugal casting was found to be 70.4% more than the piston made from gravity permanent mold casting. Figure 4 depicts a design of a centrifugal casting machine for the fabrication of pistons by Seabra et al. [43]. An automotive piston was produced and rated for mechanical properties after it was produced by the molding machine designed above.

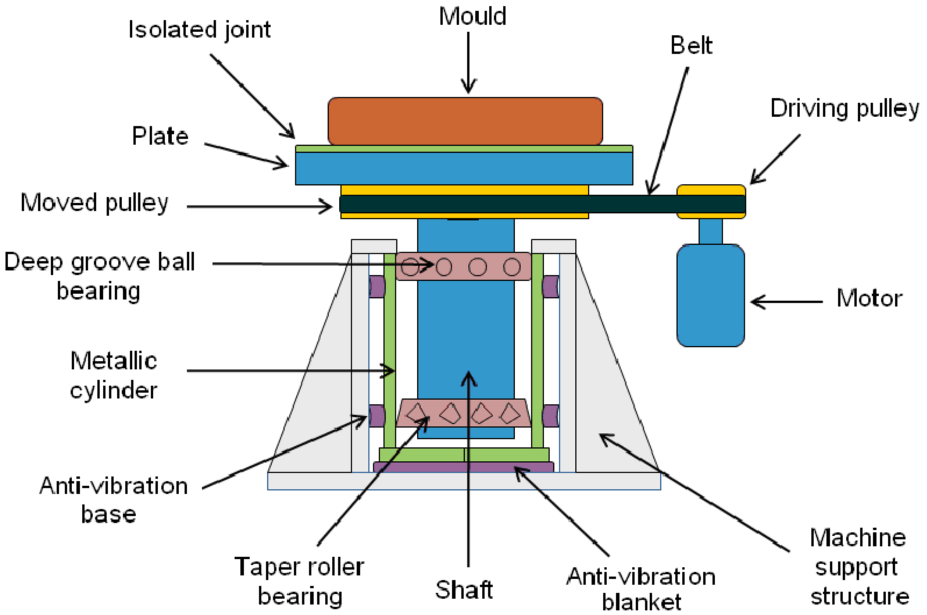


Figure 4. Diagram of the principle of vertical centrifugal casting [43]

TYPICAL MATERIALS FOR PISTONS MANUFACTURING

Due to working under high pressure and temperature, and subject to great friction, piston materials must meet the following requirements: - Small specific gravity - High strength - Small coefficient of friction - Resistance to abrasion and high corrosion resistance - Low coefficient of thermal expansion - Easy to process (cast, cut) - Easy to find [44]. Materials conforming to the above requirements are cast iron, steel, and aluminum alloy. To prevent thermal expansion, a piston lined with a belt is made of Invar alloy (an alloy of iron and nickel) in the part with the top-notch or pinhole.

Cast iron

Cast iron played a central role in the industrial development of the nineteenth century. Being strong in compression, the material was well suited for the casting of columns supporting heavy industrial floor loads in the burgeoning factories and warehouses of the early Industrial Revolution. Cast iron beam bridges were also used widely by the early railways [45]. Usually, grey, ductile, and spherical cast iron is used to make pistons [46]. Grey cast iron has high mechanical strength, high thermal stability, low coefficient of thermal expansion, and relatively good casting and cutting technology, inexpensive. However, grey cast iron has some disadvantages: its density is high, at high temperatures (725ºC) it is easy to crack. Due to the above disadvantages, grey cast iron is rarely used to make pistons for high-speed and high-load engines. Pearlite ductile iron has a pearlite structure like grey cast iron but has higher strength because graphite is concentrated. Ductile iron is used in two-stroke engines with large loads. Cast iron has high strength, high heat resistance, and high wear resistance [47].

Cast iron is an alloy with a high carbon content (at least 1.7% and usually 3.0–3.7%), making it relatively resistant to corrosion. In addition to carbon, cast iron contains varying amounts of silicon, sulfur, manganese, and phosphorus [14]. Metallurgical constituents of cast iron that affect its brittleness, toughness, and strength include ferrite, cementite, pearlite, and graphite carbon. The characteristics of various types of cast iron are determined by their composition and the techniques used in melting, casting, and heat treatment [48]. Cast iron is too hard and brittle to be shaped by hammering, rolling, or pressing. However, because it is rigid and resistant to buckling, it can withstand great compression loads. Cast iron is relatively weak in tension, however, and fails under tensile loading with little warning. In the interior of buildings, sections of banisters are often found to be broken or cracked because of 'mechanical' accidental damage. In the case of outdoor structures, ironwork is also exposed to the elements, with the risk of cracking through frost damage [47].

Steel

Steel has a large density but is highly durable, so it is possible to fabricate thin-walled pistons. However, steel materials are rarely used because of the high cost [49]. The steel pistons will debut in the V6 diesel engine of the Mercedes-Benz E 350 BlueTEC. With the new pistons in place, the car will deliver the same engine output as would be achieved with aluminum pistons (190 kW/258 hp) yet will only use around 5.0 liters of fuel per 100 kilometers (47 mpg) – that's an improvement of about three percent [50]. The use of steel pistons improves efficiency, as steel has a lower level of thermal conductivity when compared with aluminum, meaning higher temperatures are reached within the combustion chamber [51]. This, in turn, leads to increased ignition quality, while the combustion duration is reduced. The overall result is lower fuel consumption and pollutant emissions. An additional advantage of using steel is that it allows the piston to be smaller in size, while also offering greater resistance to mechanical stresses. The use of steel has also allowed engineers to reduce the gap between the cylinder wall and the piston – resulting in the reduction of untreated emissions.

Steel pistons are already found in certain commercial vehicle engines, where they are combined with heavy cast-iron crankcases. Meanwhile, aluminum pistons are normally found in passenger car diesel engines. But the steel pistons developed by Mercedes-Benz will reportedly harmonize perfectly with a car's much lighter aluminum engine housing [52][53]. In these applications, steel pistons are favored because they best handle the severity of the combustion environment and the associated challenges it presents to optimum performance and long-term durability. Steel pistons are significantly stronger than aluminum pistons, and they offer potential combustion and thermodynamic advantages that favor fuel consumption and reduced emissions levels. Improved ring land wear characteristics and the ability to cool the piston through design features are two of the major advantages attributed to steel pistons.

Aluminum alloy

In place of cast iron, Al-Si alloys are more frequently used because these alloys have a high strength-weight ratio and high thermal conductivity. Another advantage of using alloys is that the composition can be varied depending on the demand of the operating conditions on the material properties. However, hypoeutectic Al-Si alloys may soften (hampering the surface characteristics) at very high temperatures even though the performance of the engine increases at a said temperature [32]. Thus, this challenge calls for the strengthening of the alloy. In a start-stop cycle, an engine might be warmed up to 243-523 K in cold winter. Thus, in the case of the cylinder head, if we consider three different loads- the assembly load, combustion load (combustion pressures as high as 200 bar), and thermal load will be the maximum due to non-uniform thermal expansion and contraction [54]. Recently, sustainability and recycling of resources are of paramount importance with increasing public awareness on environmental issues, energy, and depleting natural resources. Aluminum has been recycled since its first commercial production and today recycled aluminum accounts for one-third of global aluminum consumption [55].

Cast aluminum alloys are widely used in the manufacture of pistons [56]. Aluminum pistons have the following advantages: Small specific gravity; Good heat transfer; Small coefficient of friction; Easy to process and cut [57]. However, aluminum pistons have disadvantages: high coefficient of thermal expansion, less wear resistance than cast iron. Commonly used aluminum alloys are Al-Cu and Al-Si. The most commonly used material is A-10B with the following main components: Mg: 0.2 ~ 0.5%; Cu 4 ~ 8%; Si: 4 ~ 6%; Left Al. Many places now use cast aluminum alloys with low thermal expansion coefficient, small specific gravity, and better heat and wear resistance than A-10B. The composition of this alloy is as follows: Si: 11 ~ 13%; Ni: 0.8 ~ 1.3%; Mg: 0.8 ~ 1.3%; Ti: 0.05 ~ 0.2%; Mn: 0.3 ~ 0.6%; Zn: £ 0.5%; Fe: £ 0.8%; Sn: £ 0.02%; Pb: £ 0.7%; Al:% remaining; Cu: 1.5 ~ 3% [58]. Thus, in comparison to steel and cast iron, aluminum alloys, although there are still certain disadvantages, it is considered as the most suitable material for the pistons manufacturing of all kinds of common car engine [59].

CONCLUSIONS

To increase the localization rate for the automobile industry in Vietnam, this work conducted a brief assessment of the fabrication technologies as well as the materials used in the piston manufacturing process. of all types of automobile engines to find the most suitable manufacturing technology and materials for automobile manufacturers in Vietnam. The results of the grass assessment can draw the following conclusions: There are various technologies used in the production of pistons in an automobile engine. However, the casting method is the most common solution. Currently, there are many casting methods applied in the manufacturing process such as sand casting, metal casting, pressure casting, and centrifugal casting ... Among these methods, the method of centrifugal casting is suitable. for the process of manufacturing pistons for all types of automobile engines produced in Vietnam. To make pistons, there are many materials used such as cast iron, steel, aluminum alloy, ceramics. In which, types of aluminum alloys have many outstanding advantages and can be considered as materials. most suitable for the manufacturing process of pistons on all types of automobile engines manufactured in Vietnam, to increase the localization rate of the automobile manufacturing industry in Vietnam. Based on the requirement of the part to be cast, specialized processes can be used the material and process parameters of which have been elucidated in this paper.

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