

CYLINDER BLOCK STRUCTURE

RELATED APPLICATIONS

This application is based on Japanese Patent Application No. 2011-013475 filed with the Japan Patent Office on January 25, 2011.

BACKGROUND

1. Technical Field

The present invention relates to a cylinder block structure, and particularly relates to a structure that facilitates discharge of blow-by gas in an engine with a plurality of cylinders.

2. Related Art

In an internal combustion engine, which generates torque by an up-and-down motion of a piston inside a cylinder, it is preferable to recirculate blow-by gas to an intake air side, except for a two-cycle engine. The blow-by gas is unburned gas that remains inside a crank chamber. The blow-by gas includes, for example, hydrocarbon and causes engine oil to deteriorate inside the crank chamber. On the other hand, if the blow-by gas is simply discharged, influence on environment is left as a problem. It is necessary to ensure a passage to pump the blow-by gas out of the crank chamber.

FIG. 3 illustrates a passage for blow-by gas disclosed in Japanese Utility Model Application Publication No. JP-A-62-175205. This publication discloses an engine that includes an oil returning hole and a blow-by gas rising hole in a cylinder block. The oil returning hole returns oil, which is discharged from a valve mechanism and received at a cylinder head top surface, to a crankcase. The blow-by gas rising hole guides blow-by gas inside the crankcase to a rocker cover. The engine has an oil

returning structure that has a blow-by gas rising hole 112 and an oil returning hole 111. The blow-by gas rising hole 112 has an opening portion that actively receives airflow generated inside the crankcase. The oil returning hole 111 has an opening portion that prevents airflow from flowing into the crankcase.

FIG. 3 illustrates a protrusion 114 that actively guides blow-by gas 117 to the blow-by gas rising hole 112 to discharge the blow-by gas inside a crank chamber. The protrusion 114 has a similar shape to a baffle member 113 that prevents blow-by gas from flowing into the oil returning hole 111 due to rotation of a counter weight and a connecting rod. The protrusion 114 has a different function from the baffle member 113. Specifically, the protrusion 114 does not reflux blow-by gas 116, which flows in an arrow direction due to rotation of the counter weight and the connecting rod, to the crank chamber along a skirt inside the crank chamber again. The protrusion 114 guides the blow-by gas 116 to the blow-by gas rising hole 112.

In Japanese Utility Model Application Publication No. JP-A-62-175205, the blow-by gas rising hole 112 is formed inside a sidewall of a cylinder. This makes the cylinder portion larger in size and makes it difficult to cool the cylinder portion.

Although Japanese Patent Application Publication No. JP-A-2010-084560 does not directly describe the blow-by gas, this discloses an invention that includes a partition wall between cylinders with a communication hole as a structure that reduces pumping loss due to air compression inside the crank chamber. The air inside the crank chamber is assumed to contain the blow-by gas. Thus, Japanese Patent Application Publication No. JP-A-2010-084560 discloses an exemplary method for ventilation of blow-by gas.

Japanese Patent Application Publication No. JP-A-2010-084560 discloses the following invention. The invention includes a communication hole on the partition

wall that allows the blow-by gas to flow between cylinders arranged in parallel. The invention includes a counter weight that makes a timing to cover the communication hole and a timing to flow the blow-by gas agree with each other.

Japanese Utility Model Application Publication No. JP-A-62-175205 discloses an engine that includes a passage for the blow-by gas inside the wall at the side face of the cylinder block. This enlarges the engine.

The protrusion 114 (see FIG. 3) disclosed in this publication has a difficulty in formation by casting such as aluminum die cast. In this respect, the structure for flowing the blow-by gas disclosed in Japanese Patent Application Publication No. JP-A-2010-084560 is appropriate for downsizing of the engine. However, simply disposing the venthole on the partition wall between cylinders, which is described in Japanese Patent Application Publication No. JP-A-2010-084560, does not ensure an efficient discharge of the blow-by gas for the following reasons.

Rotational motion of the member such as a counter weight, a crank arm, and a connecting rod causes the blow-by gas to flow inside the crank chamber. In Japanese Patent Application Publication No. JP-A-2010-084560, the venthole, which is disposed on the partition wall between the cylinders, is arranged parallel to the flow of the blow-by gas inside the crank chamber. Accordingly, the blow-by gas does not efficiently flow into the venthole.

Thus, arranging a communication hole between the cylinders requires a method for allowing the blow-by gas to flow into the communication hole more actively as described in Japanese Patent Application Publication No. JP-A-2010-084560. The method must not degrade formability of the cylinder block. If a cylinder block cannot be formed with high yield, an engine cannot be produced with high yield.

SUMMARY

The present invention provides a cylinder block structure for a multi-cylinder internal combustion engine. The cylinder block structure includes a partition wall at a skirt between a plurality of cylinders and a communication hole. The communication hole is communicated between the cylinders at an upper side of the skirt of the partition wall. The cylinder block structure includes a protrusion on a lateral inner wall surface of the skirt. The protrusion is formed by inwardly recessing an outer surface of the cylinder block.

The present invention forms a protrusion by inwardly recessing a cylinder block outer surface on a lateral inner wall surface of a skirt on a partition wall between cylinders inside the cylinder block. This forms a narrow portion between a crank locus, which is a rotation locus of a counter weight, and the inner wall surface of the skirt. Thus, the blow-by gas at an upper stream side increases in pressure when the blow-by gas passes through the gap. This forcibly makes the blow-by gas to flow into a communication hole formed parallel to the flow.

The protrusion may be arranged at one side of the partition wall. This flows the blow-by gas with the protrusion at one side of the partition wall into the other side of the partition wall while preventing the blow-by gas from returning from the other side of the partition wall. This forms smooth flow of the blow-by gas.

The protrusion formed on the lateral inner wall surface of the skirt is a protrusion formed by inwardly recessing the outer surface of the cylinder block. This facilitates pulling out of a mold at casting even if the protrusion is formed. Further, the cylinder block has a recess on the outer surface, thus allowing a mold to cool the recess with the casting mold. This ensures effective cooling of the mold even when a thick portion is provided in the vicinity of the skirt of the cylinder block, and prevents a

problem such as sink and cracking in production of casting, thus forming a cylinder block with high yield.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a cross-sectional view of a cylinder block according to an embodiment of the present invention;

FIG. 2 is a perspective view of the cylinder block including a portion indicated by the line A-A in FIG. 1; and

FIG. 3 is a cross-sectional view of an exemplary conventional engine that has protrusions at a skirt.

DETAILED DESCRIPTION OF THE EMBODIMENTS

In the following detailed description, for purpose of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

FIG. 1 is a cross-sectional view of a cylinder block 1 according to an embodiment of the present invention. More particularly, FIG. 1 is a cross-sectional view where a partition wall between cylinders is cut away along a direction perpendicular to a crankshaft 20. FIG. 2 is a perspective view of the cylinder block 1 including a portion indicated by the line A-A in FIG. 1.

As illustrated in FIG. 1, the cylinder block 1 according to the embodiment includes a cylinder 2 and a skirt 3. Throughout this description, the cylinder block 1 has directions defined as follows. The crankshaft 20 has a front-back direction. The

side where the cylinder 2 is arranged is defined as the upper side. The opposite side of the upper side is defined as the lower side. The direction perpendicular to the crankshaft 20 and a vertical direction is defined as the lateral direction. The cylinder block 1 has a side portion that is defined as a portion in the lateral direction. The cylinder block 1 includes a plurality of cylinders that are arranged parallel to one another (see FIG. 2). The cylinders in V-shaped arrangement or horizontally opposed arrangement has a difficulty in disposing a communication hole between the cylinders.

The respective cylinders are separated by a partition wall 4 in the skirt 3. In FIG. 1, the partition wall 4 is not shown since the partition wall 4 covers a whole cross-sectional surface, and thus only the reference numeral 4 is illustrated. The crankshaft 20 and other members are coupled to the partition wall 4 at a through hole 5. A cylinder head is coupled to the upper side of the cylinder block 1. An oil pan and a lower block are coupled to the lower side of the cylinder block 1. These are not shown.

A piston 21 moves in a vertical direction inside the cylinder 2. The piston 21 is coupled to the crankshaft 20 by a connecting rod 22. Thus, linear motion of the piston 21 is converted into rotational motion of the crankshaft 20.

It is preferred that at least one counter weight 23 be arranged at one connecting rod 22. This reduces vibration caused at conversion of linear motion into rotational motion. The counter weight 23 is a weight that is arranged at the opposite side of a crank pin 24 of a crank arm (not shown) in order to cancel vibration caused by the crank arm and the connecting rod 22. Alternatively a crank web that is a combination of the crank arm and the counter weight 23 may be used. An outermost periphery of a rotation locus of the counter weight 23 or the crank arm (which is hereinafter referred to as "a counter weight 23 and other members") is referred to as a crank locus 6.

The skirt 3 has a shape that is continuous with the cylinder 2 at the upper side and has a width that becomes wider as it goes downward in order to accommodate the crank locus 6. It is preferred that the skirt 3 have the maximum width at the lower end. This facilitates pulling out of mold at casting.

The lateral inner wall surface 7 of the skirt 3 has a clearance 8 with a predetermined width to avoid interference with the crank locus 6. The cylinder block 1 has a protrusion 9 that is formed by inwardly recessing an outer surface 1a of the cylinder block 1 on the lateral inner wall surface 7 of the skirt 3. That is, a recess 1d is formed on the outer surface 1a of the cylinder block 1. The recess 1d is formed to protrude inward, thus forming the protrusion 9. The protrusion 9 is formed to avoid interference with the crank locus 6. Accordingly, at the lateral inner wall surface 7 of the skirt 3, a clearance 8n between a part of the protrusion 9 and the crank locus 6 forms the narrowest gap.

In "the protrusion 9 formed by inwardly recessing the outer surface 1a of the cylinder block 1," the inner protrusion 9 does not necessarily have the same shape as a shape of the outer recess 1d. That is, an amount of protrusion of the inner protrusion 9 and an amount of recess of the outer recess 1d may be different. It is because the inner protrusion 9 and the outer recess 1d have different functions as described later. Accordingly, the casting mold for the cylinder block 1 may not have the protrusion 9 inside. The casting mold for the cylinder block 1 is not only for forming the recess 1d inward from the outer surface 1a. The casting mold for the cylinder block 1 may be a mold for forming the protrusion 9 inside and the outer surface may be ground thereafter. The casting mold for the cylinder block 1 may be a mold for forming the outer recess 1d and the inner protrusion 9 may be formed thereafter.

Forming the inner protrusion 9 by depressing the outer surface 1a is preferred

since this can form the inner protrusion 9 while keeping the thickness of the skirt 3 of the cylinder block 1.

It is not necessary to form the protrusion 9 uniformly in a front-back direction of the cylinder. Rather, it is preferable to form the protrusion 9 on the partition wall 4 at the side of the cylinder into which the blow-by gas flows. As illustrated in FIG. 2, assume that there are three cylinders (30a, 30b, and 30c). The blow-by gas flows through communication holes 4h that are disposed on the partition walls 4 from a cylinder 30a to a cylinder 30c. The cylinder 30c has a discharge opening for blow-by gas at its upper or lower portion. It is not necessary to form the protrusion 9 uniformly in the front-back direction. That is, the protrusion 9 of the cylinder 30a only needs to be disposed in the vicinity of the partition wall 4 at a proximity of the cylinder 30b in which the blow-by gas flows.

Accordingly, it is not necessary to form the protrusion 9 uniformly in the front-back direction of the cylinder block 1 for the following reason. The protrusion 9 facilitates discharge of the blow-by gas through the communication hole 4h arranged near the protrusion 9 as described later. Thus, if the protrusion 9 were formed on the partition wall 4 at the side of the cylinder from which the blow-by gas flows out, the protrusion 9 would return the blow-by gas that flows out back to the cylinder in the upstream of flow direction.

As illustrated in FIG. 1, the communication hole 4h is arranged on the partition wall 4 between the cylinders. The communication hole 4h may be arranged in the cylinder 2, in the skirt 3, or over both of those. However, the communication hole 4h needs to be formed in a position away from the center of the cylinder 2 to avoid gas leakage from a combustion chamber (a space that is formed by a piston, a cylinder, and a cylinder head) when the piston 21 moves to the lowest point inside the cylinder 2. It

is because the leakage of combustion gas from the combustion chamber causes degraded engine output.

The communication hole 4h needs to be formed at a position that is farther from the crankshaft 20 than a position where the whole area of the communication hole 4h is overlapped with the crank locus 6. If the whole area of the communication hole 4h were overlapped with the crank locus 6, the blow-by gas would be difficult to flow out.

Thus, positions of the communication hole 4h and the protrusion 9, which are disposed on the lateral inner wall surface 7 of the skirt 3, cannot be determined at only one point. However, the communication hole 4h is formed at the upper side of the skirt 3. The protrusion 9 is formed at the same height as the communication hole 4h or at the lower end side of the skirt 3 below the communication hole 4h where the protrusion 9 is not wholly covered with the crank locus 6. "Height" means a height with the lower end 3u of the skirt 3 being the reference.

It is preferable that the lateral inner wall surface 7 of the skirt 3 from the lower end 3u of the skirt 3 to the inner protrusion 9 have an arc-like shape along the crank locus 6 or an arc-like shape with a curvature larger than the arc-like shape along the crank locus 6. If the curvature becomes smaller toward the lower end 3u of the skirt 3, this makes it difficult to pull out of a mold. This makes the width of the cylinder block 1 excessively wide, making it difficult to downsize the engine.

It is preferable that a portion from the inner protrusion 9 of the skirt 3 to the upper side (before the cylinder) be formed as a standing wall in an almost straight shape. Forming as a standing wall provides higher rigidity than that of an arc-like curve. This can provide a reduced thickness portion 10 that may have a small thickness. Forming the reduced thickness portion 10 ensures a lightweight engine and improves fuel

consumption.

Next, advantageous effects of the cylinder block 1 will be described. As described above, the piston 21 vertically moves in the cylinder 2 by compression and explosion of fuel. The vertical linear motion is converted into rotational motion of the crankshaft 20 through the connecting rod 22. The crankshaft 20 has the counter weight 23 and other members, thus rotating in a constant direction. The blow-by gas 12 then flows along the lateral inner wall surface 7 of the skirt 3 in accordance with rotation of the counter weight 23 and other members.

When the counter weight 23 and other members pass through a portion that faces the protrusion 9 of the lateral inner wall surface 7, the clearance 8n between the counter weight 23 and the inner wall of the skirt 3 becomes narrow. Accordingly, the pressure increases in the upper stream side 8b that is the clearance between the counter weight 23 and the inner wall of the skirt 3 at the upstream of the clearance 8n. It is because the blow-by gas 12 that flows together with the counter weight 23 has difficulty passing through due to the narrowed clearance 8.

Thus, the blow-by gas 12y with increased pressure passes through the communication hole 4h, and sent into the next cylinder. As described above, the blow-by gas flows into the next cylinder through the communication hole 4h formed on the partition wall 4 between the cylinders. Thus, in order to facilitate the flow of the blow-by gas into the next cylinder, the protrusion 9 is preferably formed in the vicinity of the communication hole 4h into which the blow-by gas flows (see FIG. 2).

If the protrusions 9 are formed on both side faces of the skirt 3 regardless of a rotation direction of the counter weight 23, this reduces a region to which the blow-by gas escapes. This encourages the blow-by gas to pass through the communication hole 4h. Accordingly, it is preferable that the protrusion 9 be arranged at the both side

faces.

In contrast, it is preferable that the protrusion 9 not be arranged in the vicinity of the communication hole 4h to which the blow-by gas flows from the next cylinder. This returns the blow-by gas 12y that flows in back to the former cylinder. This will be described with reference to FIG. 2. As described above, the protrusion 9 is arranged at the cylinder 30a in the vicinity of the partition wall 4 next to the cylinder 30b to which the blow-by gas flows. On the other hand, in the cylinder 30b to which the blow-by gas flows from the cylinder 30a, the protrusion 9 is not arranged at the partition wall 4 side next to the cylinder 30a. This does not return the blow-by gas back to the cylinder 30a.

The cylinders are arranged in parallel. This collects the blow-by gas in the cylinder arranged at one end. This cylinder additionally has a discharge opening for blow-by gas so as to recirculate the blow-by gas to an intake air side. This ensures downsizing and lightweight of the engine itself without providing means for taking out the blow-by gas at respective cylinders.

Next, advantageous effects of the outline of the cylinder block 1 according to the embodiment of the present invention will be described. FIG. 2 is a perspective view illustrating a portion indicated by the line A-A in FIG. 1. The recess 1d, which corresponds to the protrusion 9 formed on the lateral inner wall surface 7 of the skirt 3, is formed on the outer surface 1a of the cylinder block 1. The recess 1d forms the clearance 14 between the respective cylinders in the cylinder 2. The clearance 14 is formed with a protrusion in the mold of the cylinder block 1. This means that, in the mold, a portion forming the protrusion provides a recess for cooling from the outer surface of the mold.

That is, although the mold often forms a thick portion between the cylinders,

the thick portion or a portion in the vicinity of the thick portion can be cooled. A casting, which is casted with a casting mold, such as the cylinder block 1 is produced by teeming molten metal into the casting mold. When the casting is cooled down in the casting mold, it is ideal that the temperature at each portion of the casting uniformly decreases. However, the thick portion is cooled more slowly than a thin portion. If the casting have a large difference in cooling temperature, damage such as sink and cracking occurs in the casting.

Accordingly, cooling the thick portion or the portion in the vicinity of the thick portion reduces damage occurring at cooling, thus forming a cylinder block with high yield.

As described above, the cylinder block 1 has the partition wall 4 between the cylinders. The partition wall 4 with the communication hole 4h has the protrusion 9 in the vicinity of the communication hole 4h such that the clearance 8 between the crank locus 6 and the protrusion 9 becomes narrow. Accordingly, the pressure of the blow-by gas inside the cylinder block 1 increases at the upper stream side 8b every time when the counter weight 23 passes through a position that faces the protrusion 9. The blow-by gas then flows from the communication hole 4h to the next cylinder, thus ensuring effective discharging of the blow-by gas.

The protrusion 9 is formed by the recess 1d arranged on the outer surface 1a of the cylinder block 1. This allows the structure to easily cool the casting from outside of the casting mold when the cylinder block 1 is casted. Particularly, the recess 1d can be formed between the cylinders where a portion tends to be thick. This can produce the cylinder block 1 without any sink and cracking with high yield.

The present invention can be preferably applied to formation of a cylinder block of an engine.

The foregoing detailed description has been presented for the purposes of illustration and description. Many modifications and variations are possible in light of the above teaching. It is not intended to be exhaustive or to limit the subject matter described herein to the precise form disclosed. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims appended hereto.

CLAIMS

1. A cylinder block structure for a multi-cylinder internal combustion engine, the cylinder block structure comprising:
 - a partition wall at a skirt between a plurality of cylinders; and
 - a communication hole that is communicated between the cylinders at an upper side of the skirt of the partition wall, characterized in that
 - the cylinder block structure has a protrusion on a lateral inner wall surface of the skirt, the protrusion being formed by inwardly recessing an outer surface of the cylinder block.