Research on the Marine Crankshafe Machining Inspection Process

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Abstract. The crankshaft is an important part of the engine. Its material is made of carbon structural steel and ductile iron. It has two important parts: the main journal and the crankshaft. The crankshaft is one of the main components of the piston engine, which is used to convert the reciprocating motion of the piston into a rotary motion. According to the number of engine cylinders, the crankshaft is generally divided into single-cylinder, two-cylinder, four-cylinder, six-cylinder and eight-cylinder crankshafts. The crankshaft used in marine diesel engines has a large load and the rotational speed is not very high. Therefore, it is much larger in size and weight than ordinary crankshafts. It is very difficult to manufacture and inspect. Take the 8S90ME-C marine crankshaft as an example, after machining it. The overall inspection plan is summarized.

Crankshaft Incoming Inspection

Before the blank enters the factory, it is required to provide the certificate of forging. The certificate must include the chemical composition, mechanical properties, furnace batch number, performance heat treatment and stress relief curve. The above documents are signed by the surveyor of the classification society; the workpiece is delivered for 2 weeks. A certificate of classification society is provided. The furnace card number and the classification society logo of the workpiece are marked on the workpiece body at the specified position. Axis parts are additionally required to provide size reports and classification society UT inspection reports. The inspection standard is MAN patent company material standard S34MnV, non-destructive testing standards are 0743099-1, 0743165-0, EN602U, EN602R, EN602S.

The connection sprocket inspection needs to provide the ship inspection certificate, joint bolt size report and sprocket size report when the sprocket and the corresponding coupling bolt enter the factory. The hoisting rod is made of 45# steel. It is required to provide heat treatment and quenching proof. It can be used for UT and MT flaw detection. The inspection standard JB/T-5000.15 packaging frame should check whether the weld is complete, no open welding is allowed, and the angle of the crank surface is not allowed. An examination. Anti-rust oil must have a certificate of conformity.

Crankshaft Process Inspection

Single Part inspection control (Checkpoint Wait, Users and classification societies are required to participate in the inspection of each piece size, UT, MT).

According to the requirements of the technical agreement, before the single piece is processed, it must be inspected by the user and the classification society to check the size of each part and the UT and MT inspection.

Crank. Incoming UT flaw detection, according to MAN patent company semi-combined forged crankshaft flaw detection specifications to carry out incoming inspection, from the upper and lower sides of the crank, the inner surface and the curved road diameter for testing, if the defects are found, the blank supplier is notified in time to exchange. (Control specification 0743099-1 EN602U EN602R) Before the workpiece is machined, each machine operator checks whether the workpiece number and part number of the workpiece match the furnace card number and part number of the

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process inspection document.

After the turning and turning of the car, the curved neck will be used as the basis for the subsequent Machining. The tolerance should be strictly controlled, and the self-inspection size should be marked on the curved neck and filled in the self-inspection record. The inner size of the crank is to be self-tested before the R root Machining and recorded on the transfer shift. After the R is finished, the internal size of the crank is detected again and recorded in the self-test record; R is checked with the corresponding template.

Turning and milling machine machining, check the retention before hot hole machining, and ensure the cooling of the coolant during machining. After the hot-filled hole is processed, the workpiece needs to be placed for 24 hours before the hot-filled hole is inspected. Self-test hot hole size (according to the size of the table size), arm thickness size, total thickness size is filled in; self-test upper and lower parallelism and hot hole verticality. Special inspections check the hot hole size, arm thickness size and total thickness size. UT and MT flaw detection are controlled according to MAN patent company semi-combined forged crankshaft materials and quality specifications (0743099-1, 0743165-0, EN602U, EN602R, EN602S).

Intermediate Shaft. Incoming UT flaw detection according to MAN patent company semi-combined forged crankshaft material and quality specification requirements (0743165-0, EN602U, EN602R) before the workpiece Machining, the operator checks the workpiece furnace card number, part number and process inspection file furnace card number, part number Match. For semi-finishing, the self-test support belt has a roughness Ra1.6, a shaft end face (0.05 mm) and a vertical side of the hot-loading process table (0.02 mm) and the journal. During finishing, self-checking the outer diameter and length dimension of the neck of the hot-fit shaft, the dimension between the end faces of the two hot-packing stations, and the total length of the intermediate shaft, and recording the test results on the self-inspection record sheet.

After the workpiece is finished, check the dimensions of each part. If the intermediate shaft is semi-finished for more than 24 hours, the workpiece can be directly inspected after the workpiece is processed. Otherwise, it needs to be inspected directly after finishing. After being placed for 24 hours, check the size), the length of the neck of the hot-fit shaft, and the dimension between the end faces of the two hot-mounting stations. The visual inspection center supports the roughness and end face process blocking amount. MT flaw detection is 100% external surface inspection according to MAN patent company semi-combined forged crankshaft material and quality specifications. (0743165-0, EN602U, EN602R, EN602S)

Flange Shaft (**Including Front and Rear Section Flange Shaft**). Incoming UT inspection is controlled according to MAN patent company semi-combined forged crankshaft materials and quality specifications (0743165-0, EN602U, EN602R). Before the workpiece is processed, the operator checks whether the workpiece number and part number of the workpiece match the furnace card number and the part number of the process inspection document. During semi-finishing, the self-test support belt has a roughness Ra1.6, a shaft end face (0.05 mm) and a vertical side of the hot-loading process table (0.02 mm) and the journal. During the finishing process, the length of the neck of the hot-fit shaft is measured, and the length of the journal end face to the end face of the oil seal flange is recorded on the self-inspection record sheet.

After the workpiece is finished, check the dimensions of each part. (If the hot-spinning semi-finishing is placed for more than 24 hours and then finished, the special inspection can be directly checked after the workpiece is processed; otherwise, it needs to be placed after finishing. After the hour, check the size), the length of the neck of the hot-fit shaft, and the size of the end faces of the two hot-loading stations. The visual inspection center supports the roughness and end face process blocking amount. MT flaw detection: 100% external surface inspection according to MAN patent company semi-combined forged crankshaft material and quality specifications. (0743165-0, EN602U, EN602R, EN602S)

Thrust Shaft. Incoming UT flaw detection: according to MAN patent company semi-combined forged crankshaft material and quality specification requirements control (0743165-0, EN602U, EN602R) before the workpiece Machining, the operator checks the workpiece furnace card number,

part number and process inspection file furnace card number, piece The number matches. During semi-finishing, the self-test support belt has a roughness Ra1.6, a shaft end face (0.05 mm) and a vertical side of the hot-loading process table (0.02 mm) and the journal. During finishing, self-test hot-spindle neck length dimension, journal end face to oil seal flange end face size. Recorded on the self-test record sheet.

After the workpiece is finished, check the dimensions of each part. (If the hot-spinning semi-finishing is placed for more than 24 hours and then finished, the special inspection can be directly checked after the workpiece is processed; otherwise, it needs to be placed after finishing. After the hour, check the size), the length of the hot neck and the length of the neck, and the dimensions between the end faces of the two hot mounts. The visual inspection center supports the roughness and end face process blocking amount. MT flaw detection: 100% external surface inspection according to MAN patent company semi-combined forged crankshaft material and quality specifications. (0743165-0, EN602U, EN602R, EN602S)

Single-stage Crankshaft Inspection Control on Crankshaft

Error Detection. The first test of the crankshaft as a whole inspection is the crank turn detection. Firstly, the end surface of the tailstock flange is used to detect the outer circle of the tailstock. The detection table is set to "0" at the lowest point, and the crankshaft is adjusted so that the tailstock jump is within 0.02 mm. Then adjust the gear opening value, and set the wireless measurement sensor in the gear to “0” point when the crank neck is at the top dead center. Adjust the value of the crank opening to ensure that the deviation of the sensor value on the detection panel relative to the “0” value is within ±0.02 mm. After the value of the opening and closing of the file is adjusted, the value of the opening and closing of the curved neck at 0°, 90°, 180°, and 270° is recorded.

The cranking opening is the benchmark for the overall detection of the crankshaft, and the subsequent testing is performed after adjustment. Since the crankshaft is docked and then re-measured on the leveling platform, the offset difference on the machine tool is measured as internal control data and is not reflected in the final crankshaft inspection report for the reference of the crankshaft leveling on the ground.

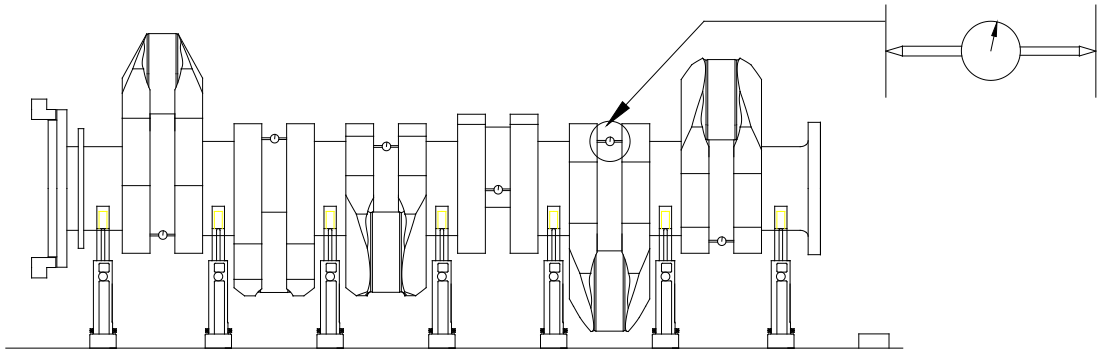


Fig.1 Detection diagram

Length Detection. The front crankshaft length detection reference is the outer end face of the front joint flange, and the rear crankshaft length detection reference is the thrust block F face. The main tool arm is equipped with a dial indicator to clean the thrust flange reference surface and the standard block contact surface. The standard block is attached to the reference surface (the front end of the front flange). The dial gauge is pressed on the standard block and the reference surface. , set to the Z axis relative to the "0" point. The main arm moves to detect the large side of the "A" end of the crank, and presses it to 3 mm at a distance of 100 mm from the surface of the main journal, and rotates for 1 week to find the high and low points. The length dimensions are: high point length value = panel Z axis reading - dial indicator high point deviation value; low point length value = panel Z axis reading - dial indicator low point deviation value. The length dimension of the reference plane to the "A" end of each crank is detected and recorded separately.

Angle and Half Stroke Detection. The main arm supports the table, moves the table up and

down to find the highest point of the shaft diameter, and the pressure gauge 3mm sets the X axis to “0” point. Move the stroke distance of the X axis, turn the crank pin, find the highest point, and set the angle C axis to “0” point. During the test, the dial indicator is moved back and forth on the surface of the neck to be tested, and the crankshaft is rotated up and down to find the maximum point of the curve. This point is the highest point of the curved neck, the observed percentage and the machine panel display. The half-stroke size is the value of the X-axis panel; the angle is the value of the panel C-axis.

The angular position of the front and rear crankshaft coupling flanges is detected. The front crankshaft angle is based on CT01 and the rear crankshaft is based on CT07.

Flange Flatness and Jitter Detection. Bounce detection, the main tool arm count dial gauge, 3mm in the beating surface pressure gauge to be detected, the crankshaft rotation observation percentage represents the number change value.

Flatness: 2m flat ruled blue oil, thickness 0.1mm (detected by thickness gauge wheel), use flat ruler to drag on the surface to be tested, remove the flat ruler to observe the contact condition of blue oil, the color must not have intermittent condition, both sides of color Should be deeper, the center color is better hallow is qualified.

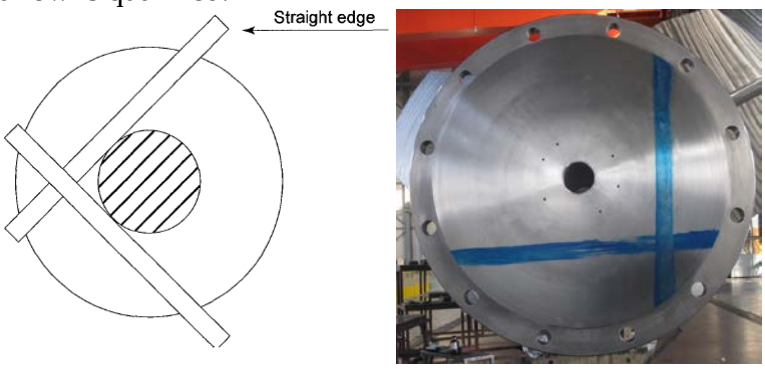


Fig.2 Flatness Inspection Diagram

Spindle Neck and Crank Pin Level Detection. The instrument used for the test is a saddle level. When measuring, measure 8 angles and record the data. The angle is defined as follows:
Intermediate axis indexing: based on CT01 curved neck, that is, CT01 curved neck is 0° at top dead center, Figure F is a view, and the crankshaft counterclockwise rotation angle is 0°, 45°, 90°, 135 °, 180°, 225°, 270°, 315°.

The curvature of the neck is based on the measured neck and neck, that is, the measured neck is set to 0° at the top dead center. Figure F is the view, and the crankshaft is rotated counterclockwise to divide the angle into 0°, 45°. 90°, 135°, 180°, 225°, 270°, 315°.

Note: When detecting the crankshaft level, the journal level is detected at the three points of each angle “F”, “M” and “A” during machining and self-test; when the crankshaft is handed over to the user and the classification society, the user and the classification society are considered. Depending on the requirements, each angle can be checked for three points or only "M".

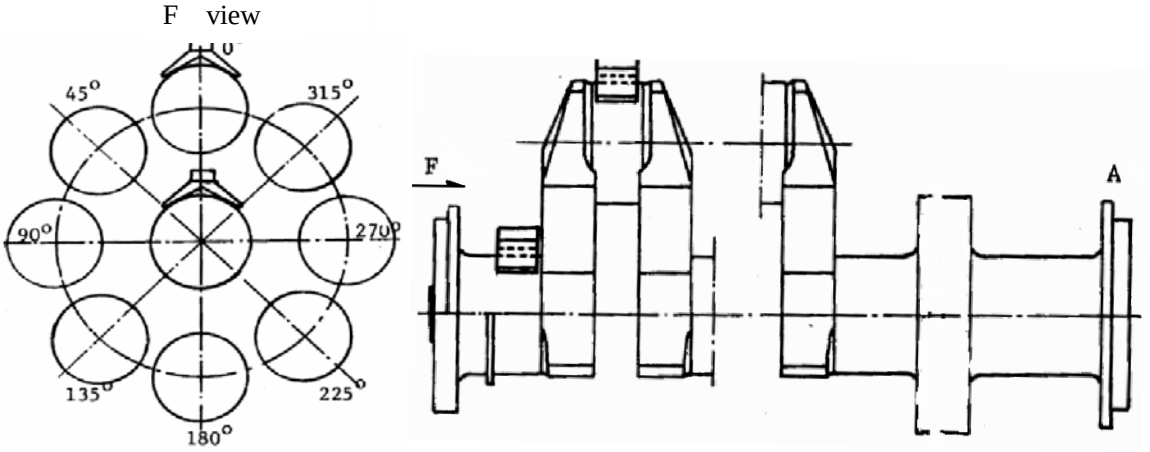


Fig.3 Sketch map of flatness measurement

Since the crankshaft is docked and re-measured on the leveling platform, the level measurement on the machine is measured as internal control data and is not reflected in the final crankshaft inspection report for the reference of the crankshaft leveling on the ground.

Spindle Neck Bounce Detection. When the spindle neck is detected, the two parts of the non-machining test A and F of the measured spindle neck are flush with the center of the journal. When facing the large disk, the crankshaft rotates counterclockwise to detect the spindle neck jump, ensuring that the jump is not exceeded within one week. The self-test record fills in 8 angular position jumps. The specific index is the same as the spindle neck level detection. The maximum difference is the runout of the axis.

Journal Size Detection. Check the size of the main journal and the crank neck as shown below. Each journal detects four positions of “F”, “M” and “A”. Each position is divided into “A”, “B”, “C” and “D”. Direction, each axis is divided into 12 points for measurement.

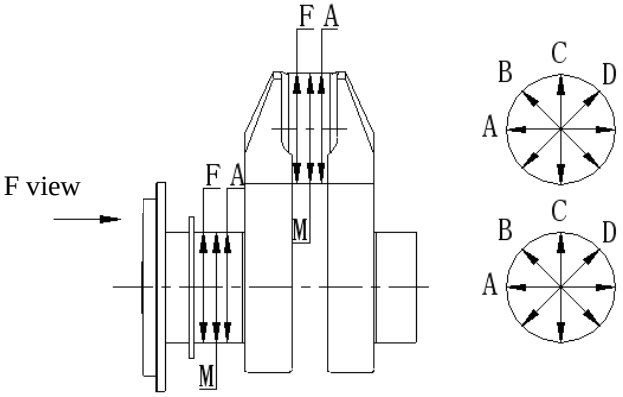


Fig.4 Sketch of axle neck size detection

Roughness Detection. All spindle neck and crank neck roughness should be controlled within Ra0.8 during the machining stage. Detect the two outer end faces of the thrust shaft and the flange shaft and the roughness of the two end faces of the thrust flange according to the requirements of the drawings, and then allow the machine tool to be finished, and ensure that the end face has no joint marks; detect the smooth transition of the R root and the flange joint position (sample) Inspection, the specific number is shown in the tooling list); the flange roughness between the flanges of the flanges is tested to meet the drawing requirements; the remaining flange end faces and the outer circle roughness are detected.

Crankshaft in the Flange Machining of Each Flange Hole Detection

After the crankshaft completes the drilling process, it is necessary to check the number, size, and index circle of each hole to match the drawing. The results are recorded on the inspection record sheet. Final inspection on the leveling platform after the crankshaft is docked. After the completion of the crankshaft docking, the final inspection of each parameter is required. The specific inspection items and inspection methods are as follows:

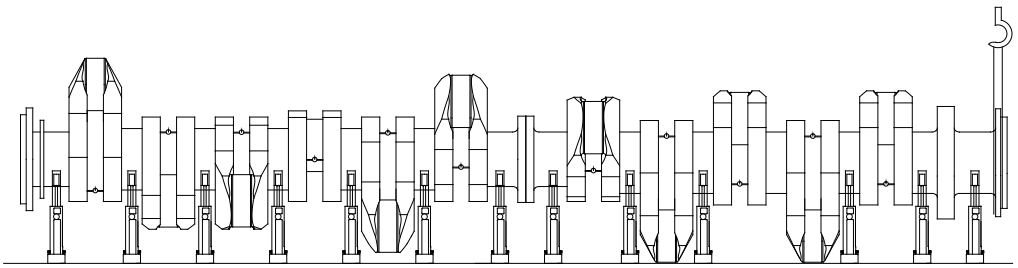
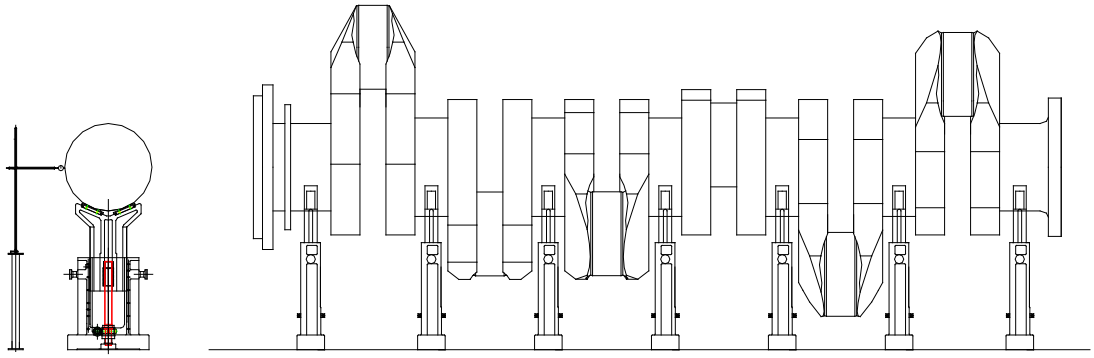


Fig.5. Crankshaft Connection completion

Open Value Detection. When the crankshaft is inspected as a whole, the value of each crank is first detected. Adjust each shaft diameter bracket so that the crank opening value is within ±0.03mm.

Recording data: When the corners of each corner are at the top dead center, set the number of each of the corners to “0”, and read the value of the opening and closing of each of the curved necks at 90°, 180°, and 270°. Recorded in the inspection record. The cranking opening is the benchmark for the overall detection of the crankshaft. After the adjustment, the subsequent inspection can be carried out.



Pic.6. Schematic diagram of spindle neck runout detection

Spindle Neck Bounce Detection. When the spindle neck is detected, the two dial gauges at both ends of A and F of the tested spindle neck are flush with the center of the journal. The percentage of the revolution of the crankshaft is expressed in a week to ensure that the jump is not exceeded within one week. The self-test record fills in 8 angular position jumps. The specific index is the same as the spindle neck level detection. The maximum difference is the runout of the axis.

Spindle Neck and Crank Pin Level Detection. The instrument used for the test is a saddle level. When measuring, measure 8 angles and record the data. The angle is defined as shown in Figure 3: based on the CT01 curved neck, that is, the CT01 curved neck is 0° at the top dead center, Figure F is the view, and the crankshaft counterclockwise rotation angle is 0°, 45°, 90 °, 135°, 180°, 225°, 270°, 315°.

The curvature of the neck is based on the measured neck and neck, that is, the measured neck is set to 0° at the top dead center. Figure F is the view, and the crankshaft is rotated counterclockwise to divide the angle into 0°, 45°. 90°, 135°, 180°, 225°, 270°, 315°.

Note: When detecting the crankshaft level, the journal level is detected at the three points of each angle “F”, “M” and “A” during machining and self-test; when the crankshaft is handed over to the user and the classification society, the user and the classification society are considered. Depending on the requirements, each angle can be checked for three points or only "M".

Detecting the Journal Size of each Spindle Neck Crank Pin. Check the size of the main journal and the crank neck as shown below. Each journal detects four positions of “F”, “M” and “A”. Each position is divided into “A”, “B”, “C” and “D”. Direction, each axis is divided into 12 points for measurement.

Grinding Tile Detection and Roughness Testing. Grinding tile inspection and roughness testing, internal self-test is first coloring inspection and then roughness inspection. Ship inspection and user inspection are first roughness inspection and then color inspection.

Conclusion

After this method is controlled, the marine crankshaft has been upgraded by more than 95%. The quality control of the crankshaft machining process is well controlled, and the probability of occurrence of waste is greatly reduced. Because the crankshaft material of the ship is relatively large, this reduces the scrapped Cost, as PDCA continues to cycle, quality will be further improved.

References

[1] Peng Lihua. New Discussion on Manufacturing Technology of Internal Combustion Engine Crankshaft [J]. Metal Forming Process, 2004(2): 11-22.

[2] Zheng Huisai. Research on new technology and tooling for large-scale marine crankshaft cranking [D]. Qinhuangdao: Yanshan University, 2012.

[3]Zhu Mingqi. Laying the foundation of the world's largest shipbuilding country with scientific and technological innovation—8K90MC-C large-caliber marine diesel engine crankshaft off-line [J].Shanghai, 2008(9):30-31.

[4]Yu Yunwei, Zhang Jian. Development of crankshaft manufacturing technology for low-speed and high-power diesel engines in China [J]. Shanghai Shipbuilding, 2009(4):38-41.

[5] Li Jizhen. The key to the manufacture of crankshaft is in blank [A].2008 Proceedings of China Shipbuilding Industry Association Casting and Forging Branch [C].2008:129-130.