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Analysis and Research on the manufacturing process and structure optimization of engine camshaft

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Abstract: *Enginecamshaft is the biggest weight with key functioncomponents in valve mechanism,.In this paper, the structure and arrangement of the cam shaft are described, and the manufacturing method of the traditional integral cam shaft and the assembly type cam shaft in the modern times are described in detail,At last, the paper discusses the structure optimization analysis of Camshaft Based on CAE software platform.*
Keywords: *Camshaft,Configuration integral type,Assembly type,CAE,Structure optimization*

I. INTRODUCTION

Camshaft is the key components of the valve mechanism of the piston engine, drive by the crankshaft via a timing gear, works at the speed of 1 / 2 of the rotation speed of the crankshaft rotates, and works at a high speed, Precise control of the inlet and exhaust valve in accordance with the provisions of the order and phase to open, close, and ensure that the valve has enough lift. When camshaft works, it needs a high speed rotation, which bears a great torque, which requires a higher strength of the camshaft; Due to the surface of the cam and the rocker arm or tappet between have very high periodic contact stress and the faster relative sliding velocity, which requires the cam shaft has enough toughness and stiffness, the cam surface has good wear resistance and impact resistance. valve mechanism is an important part of the engine, it determines whether the economic performance of an engine is superior, the work is reliable, noise and vibration is in the lower range, and so on. Therefore, the design of the cam shaft is very important in the design of the valve mechanism and even in the whole engine.

II. STRUCTURE OF CAMSHAFT

2.1 Cam shaft structure

The cam shaft is provided with an inlet and an exhaust cam of each cylinder, and some are also provided with a shaft neck which can reduce the deformation of the shaft body. One end of the camshaft is a bearing support point, and the other end is connected with the timing gear of the drive. The side of the intake and exhaust cam is egg shaped, the design aims to make the inlet and exhaust valve open and close at the time of the designer, that is, the accurate distribution of gas phase; To ensure that the cylinder full of air intake and exhaust, in particular, is to enable the valve with a good air distribution performance, adequate intake, exhaust completely; It also needs to consider the durability of the engine and the smooth running of the operation, making the gas distribution agencies work smoothly, vibration and noise is small; At the same time, the cam also needs to have a good lubrication system, the cam and stud the contact stress is not too large..

2.2 Arrangement Form Of The Cam Shaft

The arrangement of the cam shaft is divided into three types: Underneath, mid and upper.

(a) (b) (c)

Fig.1 Arrangement form of the cam shaft

(a)Underneath (b)mid (c)upper

In the past, most engine camshaft arrangement is arranged under type, the cam shaft at the bottom, through the cam drive tappet and tappet push push rod to top rocker, by utilizing the lever principle, control valve opening and closing. The advantage of this arrangement is that the distance between the cam and the crankshaft is small. It can be used only for a pair of gears, so the structure is simple and easy to be maintained. But because of their more parts, transmission chain is longer, the mechanism stiffness greatly decreased, when the engine to run at a high speed, and even destroy the valve movement, thus, exhaust valve can not be in accordance with the scheduled time to open and close.

With the continuous advancement of technology, people on the engine power requirements continue to improve, cam shaft speed is also rising, setting camshaft arrangement was gradually replaced by superimposed. At this point, the cam shaft is arranged on the cylinder cover, and the cam is driven by the rocker arm, the rocker arm to drive the valve, and even some of the valve is directly driven by the cam. This arrangement form because of the distance between the cam and the valve is very short, so the reciprocating motion of the body is less than the other two kinds of arrangement form, the running of the stability is also very high, more suitable for high-speed rotation of the engine. But because the camshaft is far away from the center line of the crankshaft, the timing transmission mechanism is more complicated, and the cylinder head cover is more troublesome. At present, there are two kinds of overhead camshaft::SOHC and DOHC. As the name suggests, SOHC use one camshaft at the top at the same time control, exhaust valve, DOHC used by two camshafts to control the intake valve and exhaust valve respectively. With the continuous improvement of the engine speed and the increase of number of valve, dual overhead camshaft prospects for the development of far superior to single overhead camshaft. Figure 2 for a certain brand of four cylinder engine cam shaft configuration, this product adopts the double overhead cam shaft, each cam shaft 8 a cam, a camshaft control eight intake valve opening and closing, a camshaft control of the exhaust valve opened and closed.

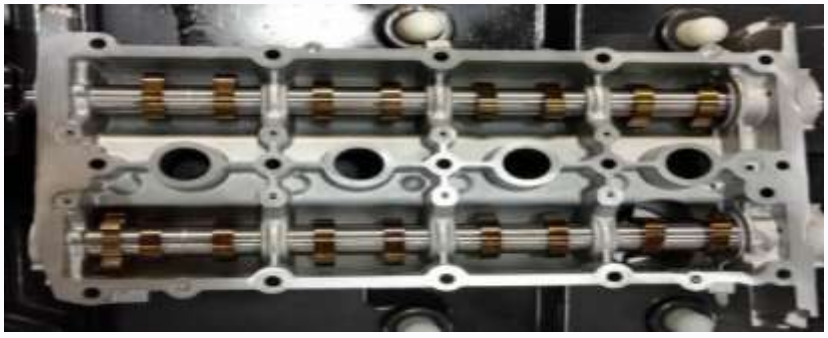


Fig.2 Arrangement form of the cam shaft ofa brandFour cylinder engine

III. MANUFACTURING PROCESS OF CAMSHAFT

3.1 one-piece camshaft

With the birth of the camshaft, the development of the cam shaft design has never been interrupted, the camshaft is a constant acceleration and deceleration of the device, reduce the quality is conducive to reducing energy consumption, reduce emissions of pollution. At first, the cam shaft is one-piece, people use various methods to reduce the quality.

Fig.3one-piece camshaft

Due to the rise of the casting technology , it is very common to find that camshaft make by the special cast iron, nodular or chilled cast iron camshaft malleable cast iron by chill casting production . Chilled cast iron cam axle is the plastic cam shaft model is placed in the sand and casting camshaft blank, cold treated by this process of castings for local cooling, prompted the rapid solidification. Such a cam surface of the HRC hardness of 45, so that the cam has excellent wear resistance. In order to reduce the quality of the camshaft, the hollow casting camshaft is produced, and a glass tube is put into the casting to take out after the casting is completed, so that the cost is reduced, and the quality of the cam is reduced.

With the increasing speed of the engine, the surface of the cam needs to bear the increasing stress of the Hertz. Using chill casting method for producing special cast iron cam shaft and nodular cast iron cam shaft can withstand the maximum stress for 1000 MPa, soon can not meet the need. Forged steel cam shaft can bear 2000 ~ 2500MPa of the extrusion stress, the need to bear the larger extrusion stress, can be used forging type camshaft, but its cost is higher.

In the new development of the belt roller with the moving parts of the cylinder pressure is very high gasoline and diesel machine, cam by Hertz extrusion stress has been a breakthrough in the chill casting and sintering of the cam shaft so far to reach the limit. At present, the market, the new engine camshaft manufacturing process is cast steel camshaft. The camshaft was initially lost foam mould casting casting process, by making use of the technological process can be cast with the external contour of the less processing workload and a belt through or just through one end of the cylindrical hole of the cam shaft to reduce the weight . The first use of this process made of 100Cr6 cast steel cam shaft wall thickness of 5 ~ 6mm, the hardness is 230HB.

3.2 Assembled Camshaft

The assembled Camshaft, the shaft body and the supporting shaft, respectively, and the material is optimized and matched, and the split body is precisely processed, and then is assembled in a certain way. Cam is generally used carbon steel or powder sintering material, the shaft is the use of hollow seamless steel pipe. Compared with the previous one-piece camshaft, the cam shaft can have a better choice of material combination, which can play the advantages of each part, and can reduce the overall quality and manufacturing

cost of the camshaft. This cam shaft began in 1982, and now in many car companies, can be found in such an assembly type cam shaft.

The key technology of the assembly cam shaft is the connection between the cam and the shaft. . With the continuous improvement of engine power, torque and rotational speed of, cam shaft under the impact load and dynamic torque is also increasing, cam shaft and the connecting strength has become evaluation of assembly type cam shaft is the most important technical indicators.

Fig.4 Assembled Camshaft

3.2.1 Hot jacket method

The hot jacket method is the use of thermal expansion and contraction of the cam shaft assembly and principle. Under normal temperature, the cam and the shaft tube have the interference size, and the external cam is heated in high temperature, the internal axle tube is cooled at low temperature, and the specific machine tool is controlled by the NC, and the two are assembled in a short time. First, all the cams are arranged in a certain order, and the shaft pipe is inserted into all the cam holes, and the interference connection between the cam and the shaft body is realized.

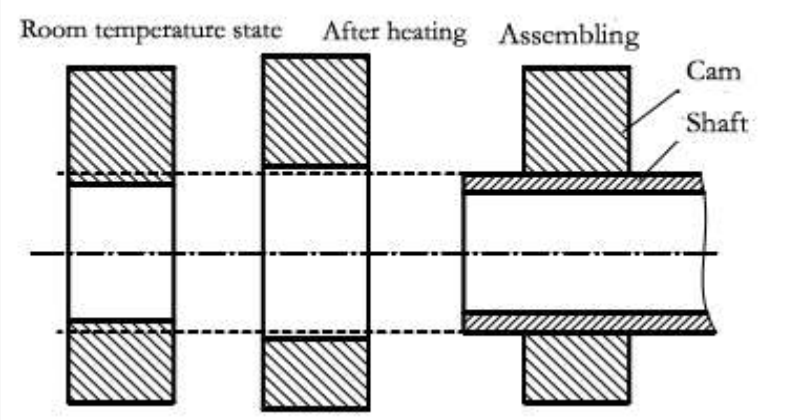


Fig.5 Sketch Map of Hot jacket method

3.2.2welding process

Some manufacturers in order to strengthen heat set of legal system into the camshaft cam shaft and the connecting strength, in cam shaft and the connection by soldering or brazing along the cam and a shaft body of the joints melting welding materials, cam shaft pipes and welded together.

3.2.3sintering method

The shaft body is inserted into the cam of the powder metallurgy forming, and then is heated in a sintering furnace. In the liquid phase, the sintering material will shrink, so that the contact surface of the cam and the material particles in the liquid diffusion, making the cam more dense, and more closely connected to the shaft body.

3.2.4Internal high pressure forming method

The internal high pressure forming method is also called the hydraulic tube expanding method. This method first cam shaft and pipe installation together, and welding method is different from the first clearance with the use of a special device to be located, and then injected into the tube of high pressure liquid, ends with the axial plugging head sealing die, the tube pressure increases, making shaft tube plastic deformation, until the axle tube and cam are closely connected. In order to ensure that the plastic deformation occurs at the connection point, one method is to increase the limit device in other places, and the other is to make the cam and the shaft connection more easily plastic deformation.

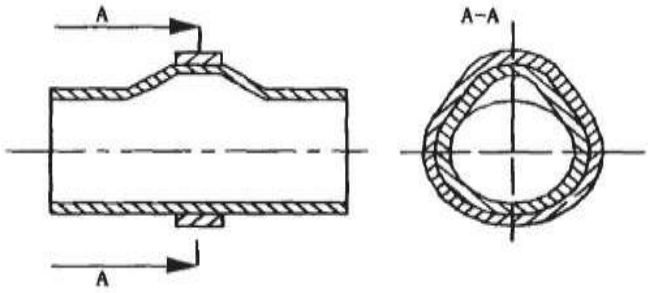


Fig.6 Sketch Map of sintering method

3.2.5Mechanical expanding tube method

The mechanical expanding tube method is similar to the basic principle of the internal high pressure forming method, both of which are closely connected with the plastic deformation of the connecting point of the shaft and the cam. First, the cam is matched with the shaft body, and the special device is used for positioning, and then, the shaft body is pushed or pulled through a cone or a ball pull rod with a surplus amount. The shaft is driven by the pull rod to generate plastic deformation, and the cam has elastic deformation, so that the shaft pipe is connected with the cam to complete the assembly.

3.2.6Pressure combination method for pipe rolling

Pipe roll flower set pressure combination method is a new way of assembly, firstly, the shaft body with cam with the surplus size, at the connecting place of the shaft and the cam, cam processed corresponding shallow grooves, shallow groove with an axial, radial and with a specific device will pipe shaft pressed into cam, the shaft body and the outer diameter of the cam between the inner diameter of interference, after extrusion, between the lines produce plastic deformation, making both with very strong.

Fig.7 Sketch Map of Pressure combination method for pipe rolling

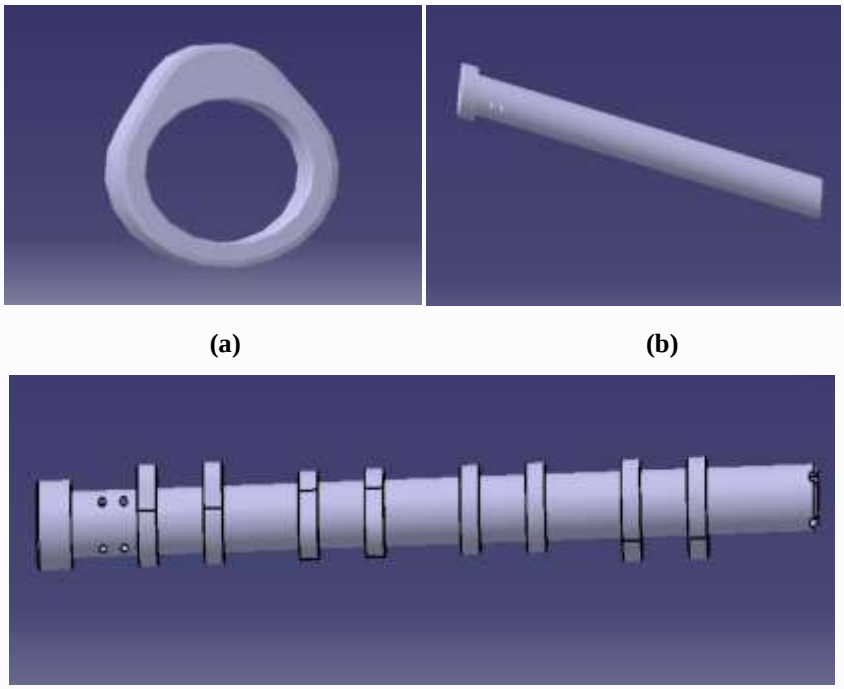
IV. THE OPTIMIZATION ANALYSIS OF CAMSHAFT

The optimization analysis of the modern cam shaft is developing in high efficiency, high speed, high precision and low cost. The traditional optimization analysis method can not meet the analysis requirements of the complex structure. With the rapid development of the computer industry, the CAE software industry has also been an unprecedented development, by using CAE software, to performance as well as the operation reliability and safety of product engineering and analysis, so that even if the complexity of the problem, without too much simplification, can get up to speed quickly, the high precision solution.

The optimization analysis of the cam shaft generally contains 4 steps:

(1) establish three-dimensional model

First ,we need to use of Pro / E, CATIA, UG, SolidWorks CAD modeling software of valve mechanism to simplify and three-dimensional modeling, parts must include the key parts of the cam shaft, a rocker arm, a tappet and a valve, a valve spring, and the the software calculated these parts of the mass, center of mass, moment of inertia, preparing the necessary parameters for the following dynamic analysis. As shown in Figure 8, the use of CATIA to establish a three-dimensional model of the camshaft.



(a) **(b)**

(c)

Fig.8 Using CATIA to model the cam shaft

(a) cam (b) shaft (c) camshaft

(2) Dynamic analysis of the model

Using ADAMS, AVL/TYCON and other software on the above modeling of the gas distribution mechanism for dynamic analysis, in order to obtain the force on the cam shaft. Before most of the set type cam shaft low engine speed, calculation of cam stress condition of the kinematic analysis, each component as a rigid body is calculated, with increasing engine speed, vibration of the valve mechanism, deformation have become increasingly prominent, traditional calculation method has been unable to actuarial calculation practical problems. In this part, the multi-body dynamics is used to analyze the parts as flexible body, and the deformation of each part and the coupling effect between the various cylinders are attached. As shown in Figure 9, the need to establish a graph of the structure of the structure model plus the camshaft.

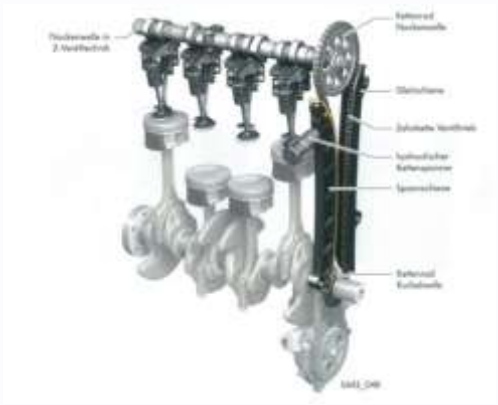


Fig.9 Multi-body dynamics analysis model

(3) Using the finite element software to analyze the deformation, stress and fatigue of the cam shaft.

The stress data of each part of the cam shaft is obtained, and input to the ANSYS, PATRAN/NASTRAN, ABAQUS and other finite element software in the form of load and constraint, The stress and deformation, the stress distribution and the safety factor are obtained, and the structure of the camshaft is satisfied with the design requirements.

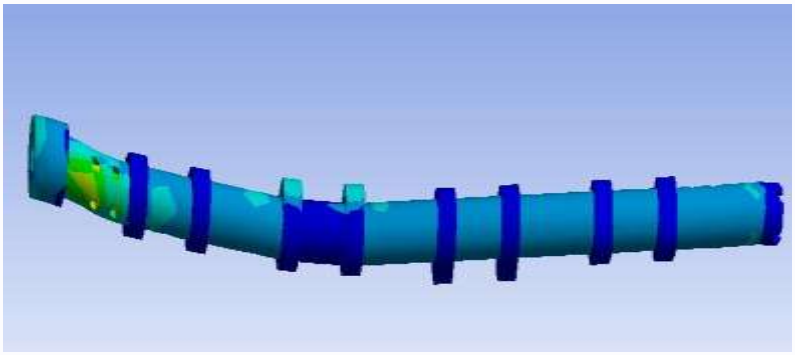


Fig.10ansys analysis of the stress distribution of the cam shaft

(4) Using optimization software to optimize the structure of the cam shaft

We need to input the above dynamic analysis results and the finite element analysis data to the Optistruct and other structural optimization software, the input needs to optimize the specific parameters, the calculation, you can get the optimization of the product,Then check, verify the optimized product is qualified, repeated such operations, you can get the optimal solution of the cam optimization.

Optimum analysis method for cam shaft generally is the case, these optimization methods can better match a variety of materials, to achieve both economic, and meet the requirements of application, the cam shaft shape distribution is more, its quality reaches the lightest. Generally through this optimization method, can make the quality of the camshaft reduced by 35% ~ 20%, greatly reducing the cost of cam manufacturing. By this analogy, the optimization analysis of other mechanical mechanism is similar.

V. CONCLUSIONS

Today, people are increasingly demanding on the car, put forward a high power, low fuel consumption, low emissions, lightweight, high durability requirements, the design of the cam shaft is more and more light. Enterprises to seek balance between cost and meet the various indicators, and constantly innovate. The traditional integrated cam shaft still has its advantages of high service life and high bearing load. With the development of CAE, the optimization of the cam shaft will be more simple, quick and accurate.

REFERENCE

[1]. RenyiQian. A summary of the cam shaft manufacturing process [J]. Shanghai automobile, 2005 (03): 26-30.
[2]. Jian Qiao ,Shuqing Kou, Shenhua Yang, WenmingJin. Technology and application of hollow assembled camshaft connection technology [J].vehicle engine, 2007 (1): 1:4.
[3]. Chi Zhang,Shenhua Yang. Study on mechanism and connection strength of assembly cam shaft rolling Journal of plastic engineering, 2005,12 (1) 89-92.
[4]. XiaoqunGun.Parametric design of cam shaft under V5 CATIA environment [J].Modern design technology, 2004 (12): 103-104.
[5]. Tianyuan Ma, FA Zong Li, Yanning Deng, RufuHu.Study on fatigue fracture of diesel engine camshaft [J].mechanical design and manufacture, 2013 (1): 140-145.
[6]. Shaojun Sun, Junhong Zhang, Xiaoming Chen. Based on the computer aided engineering (CAE) technology of the cam shaft stress analysis [J].modern vehicle power, 2005 (4): 14-17.