The Experimental Research of Non-abrasive Cryogenic Polishing on Camshaft

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Abstract. The paper systematically researches a new method for non-abrasive cryogenic polishing on camshaft, which includes laboratory furniture, ice wheel making and modifying, experimental device vibration analysis, polishing experiment on camshaft surface in different conditions and measurement of the polished surface. Results show that the process of non-abrasive cryogenic polishing on camshaft can effectively reduce the surface roughness of workpieces.

1. Introduction
Non-abrasive cryogenic polishing has been demonstrated an effective polishing method[1]. Non-abrasive cryogenic polishing is a method of grinding and polishing the surface of the workpiece without any abrasive water in the condition that the temperature is not higher than zero degrees Celsius[2]. In the process of polishing, the ice wheel does not need to be trimmed, and the preparation is simple, so as to avoid the effect of thermal deformation on the machining errors caused by the workpiece. The processing cost is low and pollution-free, suit the direction of green manufacturing development[3].

2. Experimental Devices
The experiment was carried out on the CA6140 lathe of the cryogenic processing laboratory. Replace the original tool holder with homemade tooling, as shown in Fig 1. The 3d model of the experimental devices is shown in Fig. 2.
In this device, cylinder 5 pushes the skateboard 2 forward movement, guide rail 16, rod 12 connected with skateboard 2, rod 12 pulls the spring 13, pressure sensor 7, shift boarding 14, motor 9, and ice wheel 8 are pulled forward by the other end of spring. By stretching the spring, ensure the constant pressure contact between the ice wheel and camshaft. In the process of polishing, the ice wheel is constantly melting, the cylinder pushes on the board, ensuring constant pressure polishing.

According to the shape of the ice wheel, and the convenient ice wheel is removed from the mould, the mould is made of disc shape and has a certain inclination. In Fig 3. The ice wheel is frozen on the hub, ice wheel is connected to the motor shaft through the hub.

3. Experimental Device Vibration Analysis
In the experiment process, the experimental device is constant vibration, can affect the machining accuracy, to avoid the resonance of the natural frequency and the vibration frequency during the experiment, measured the vibration frequency of the experimental device, and carried out model analysis.

Measurement system is shown in Fig 4. The sensor is fixed in the lathe, laser emitter aimed at the motor, When the motor turns smoothly, started to collect the experimental data, and then taken to Fourier transform to get the spectral graph.
3.1. Experimental devices modal analysis

In Fig 5, created 3D model of the experimental devices, include ice wheel, motor, pressure, sliding block and shifting board. Import 3D model to ANSYS Workbench, made free mode analysis, the divided grid as shown in Fig 6.

The first four modes of the experimental devices are shown in Fig 7 to 10, the nature frequency is shown in Tab 1.
3.2. Vibration measurement experiment
At the condition of polishing pressure is 15N and different motor speed, got the time domain and frequency domain diagrams, shown in Fig 11~14.

| Order number | First order | Second order | Third order | Fourth order |
|--------------|-------------|--------------|-------------|--------------|
| Frequency (Hz) | 51          | 137          | 265         | 342          |
The influence of ice wheel speed on vibration amplitude and vibration frequency is shown in Fig 15,16. From the figures, as the speed rising, the amplitude of vibration decreases, vibrations are getting higher.

![Fig 15 Influence of rotational speed on frequency](image1.png)  ![Fig 16 Influence of rotational speed on amplitude](image2.png)

From the mode analysis in A and experiment in B, it conclude that the vibration frequency of experimental station differs greatly from its natural frequency, so there will be no resonance.

4. **Experimental Analysis**

4.1. **effect of polishing time**

Experiment conditions: polishing pressure is 15N, the speed of ice wheel at 60rpm, 120rpm, 180rpm, 240rpm. The results are shown in Fig 17~20.

![Fig 17 Experimental results at 60rpm](image3.png)  ![Fig 18 Experimental results at 120rpm](image4.png)

![Fig 19 Experimental results at 180rpm](image5.png)  ![Fig 20 Experimental results at 240rpm](image6.png)
From Figs, it concluded that in different speed, the roughness of each point can be reduced, and when the polishing time was 90min, got the best roughness. Less than 90min, although camshaft roughness decreased obviously, on account of polishing time deficiency, it was not minimized. When more than 90min, the roughness has a tendency to increase.

4.2. effect of ice wheel rotate speed
Experiment conditions: polishing time at 90min, pressure is 15N, 20N, 30N. The experiment results are seen in Fig 21~24.

From Figs, it can conclude that after polished at different rotate speed, the roughness had a significantly decrease, when the ice wheel rotate speed is 180rpm, can get the best result, roughness is lowest and distributed uniformly. When ice wheel at a slower rotate speed, the roughness was not satisfactory, and when rotate speed faster than 180rpm, vibration reinforcement, ice wheel will easily broken, and the roughness will increased, too.

4.3. effect of the polishing pressure
Experiment conditions: polishing time is 90min, rotate speed at 180rpm. The result is shown in Fig 24.

From Fig 26, different pressure can decrease camshaft roughness, the best roughness value can be got at 15N. Rising pressure will cause ice wheel broken, influence the roughness.

5. Conclusions
Analysis of the above experimental data, optimum experimental parameters are these: polishing time 90min, ice wheel rotate speed 180rpm, pressure 15N. In these conditions, the roughness had effective reduction, and distributed uniformly. Referring to the polishing results, the non-abrasive cryogenic polishing can reduce the roughness value obviously. It supplies a new polishing process on camshaft.
References

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