3D PRINTABLE PORTABLE TESTING STAND FOR CAMSHAFTS AND THEIR CAM PROFILE

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ABSTRACT: This article is referring to a modular testing stand aimed at independent tuners or automotive enthusiasts. The testing stand is the minimum required equipment to check if there is any wear on the surface of the cams, but also to map the profile of an unknown cam in order to further optimize it in CAD. The stand is 3D printable in order to be cheap to manufacture and buy.

KEYWORDS: performance, shaft, cam, testing, optimization

1. Introduction

Camshafts are the second most important element of an engine assembly. This is a shaft made of a metallic material, obtained by various manufacturing methods (cast, billet and forged manufacturing) and which has cams with a profile that's sharp at one end. The camshaft can be compared to the human heart, as it serves the same purpose, the circulation of "fuel" in the system of which it is a part. The role of the camshaft is to actuate the intake and exhaust valves, that is to transform its rotational movement into a translational movement of the valve to achieve the engine cycles. The valves are opened by pressing directly on the cam follower which attached to the valve, or by interacting with an intermediate mechanism called a rocker arm. When the lobe reaches the maximum height of its profile, the valve will be in the fully open position, and when the valve is closed, the cam follower will be on the base circle of the cam profile.

The importance of the paper lies in analyzing the existing testing methods for a camshaft and developing a new testing stand that is cost-effective in terms of production and acquisition.

2. Current State

Currently, the most widely used test equipment is electronic, which is connected to a computer, and which is using a specialized measurement software.

These test stands use an electronic micrometer that sends a digital signal which is then translated by a computer into valve lift graphs and also their entire valve profile, along with the deviations from it caused by wear.

For the rotational movement of the shaft as well as the vertical and horizontal translational movement of the comparator, three electric motors are required, as well as two rails on which the comparator must slide on its two axes. Electric motors also need a controller to actuate them.

This equipment comes at a high cost, as it is necessary to purchase the electric motors, rails, controller and digital comparator, as well as the license for the software that can read the data from the testing assembly.

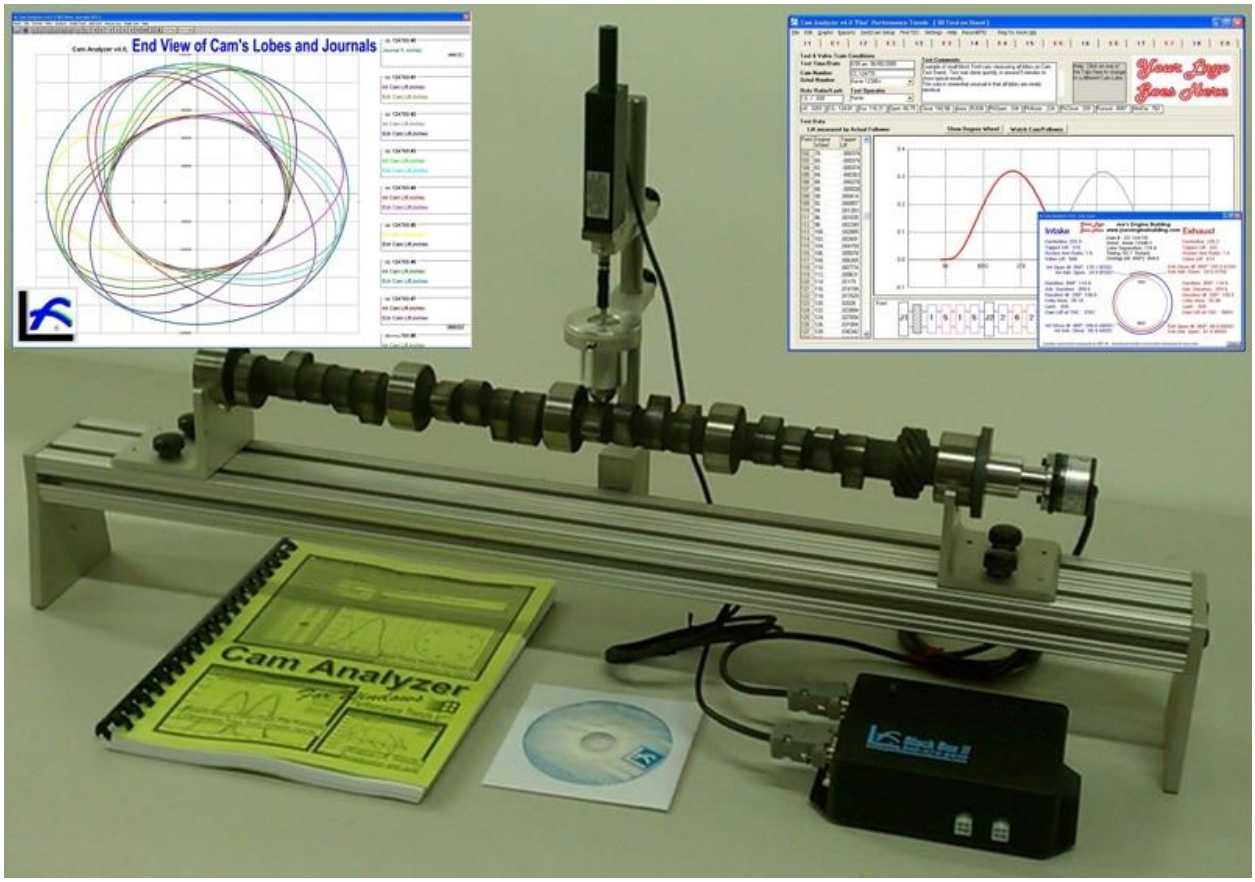

Fig. 1. Cam Analizer (software + hardware) [1]

In Fig. 1. a test stand for a camshaft containing the elements mentioned previously, as well as the installation disc and the user manual of the Cam Analyzer software, can be observed.

This test stand can check both the cams and the camshaft bearing seats.

3. Contributions

As part of this work, a portable test stand assembly was developed, which aims to reduce the purchase price without removing functionality.

In addition to the manual, mechanical comparator, which must be purchased separately, the components of the assembly can be 3D printed with any budget FDM (Fused Deposition Modelling) 3D printer to further reduce the purchasing cost.

Table 1. shows some models of 3D printers that can be used to manufacture the components of the test stand. The sources used can be found in the bibliography at [3 ... 6].

Table 1. 3D Printers

Manufacturer	Name	Functional and economic characteristics		
		Printing dimensions [mm]	Compatible materials	Price [EUR]
DISWAY	01	220*220*250	PLA, ABS, TPU	226
Kuongshun	K10	220*220*260	ABS, PLA, Wood-Polymer, PVA, HIPS, PETG	188
Creality	Ender 3	220*220*250	ABS, PLA, TPU	179
Geeetech	A10 Pro	220*220*260	ABS, PLA	160

The designed test stand consists of several components, as follows:

- **Mounting rail modules**

The mounting rails of the test stand assembly are small in size and can be chained together according to the length of the camshaft that's being tested (Fig. 2.).

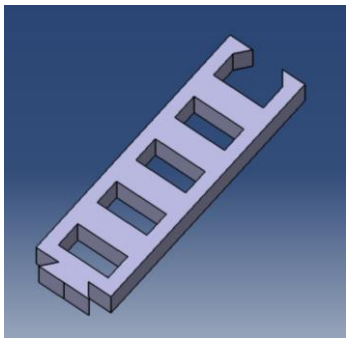

Fig. 2. Mounting rail

- Fasteners of the comparator
    - Mounting support of the comparator

The purpose of this support is to cancel translational movements on the X and Z axes and rotational movements around the X and Z axes of the comparator (Fig. 3.).

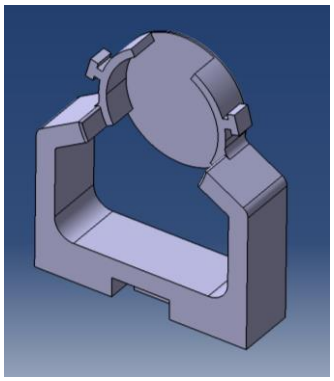

Fig. 3. Mounting support of the comparator

- Closing cover of the comparator’s mounting support

The locking cap is also used to take up the remaining degrees of freedom of the comparator, which are the translation movement on the Y-axis and the rotational movement around the Y-axis (Fig.4.).

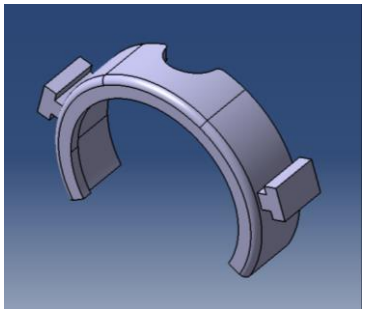

Fig. 4. Closing cover of the comparator’s mounting support

- Cover closing clip

The clip secures the two sections of the mounting support (Fig. 5).

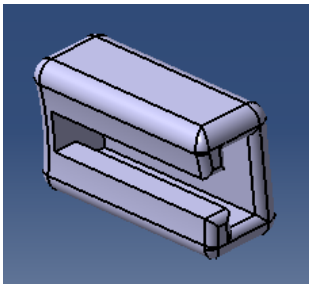

Fig. 5. Clip

- Spacer for raising the comparator's height

This element is used to bring the comparator to the appropriate height (Fig.6.), when it is desired to inspect the camshaft seating bearings.

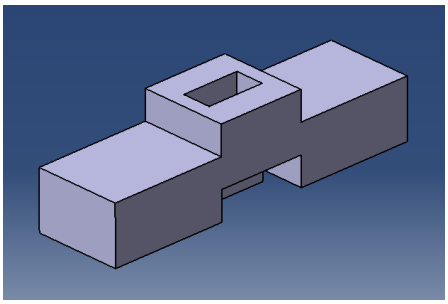

Fig. 6. Spacer

- Camshaft fasteners
  - Camshaft support

The support brackets have four screws in their componence to cancel the translational movements on the X and Z axes and the rotational movements around the X and Z axes of the camshaft (Fig. 7.).

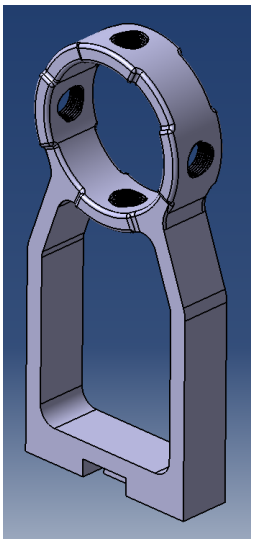

Fig. 7. Camshaft support

- Support screw

Supports use four screws to secure the camshaft (Fig. 8.).

Fig. 8. Screw

- End support with camshaft rotation indicator needle

In addition to canceling the Y+ axis translation movement, this element is intended to help visualise the degree of rotation of the camshaft. This element is height-adjustable by the means of a screw integrated in the construction (Fig. 9.).

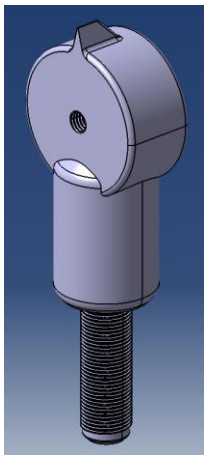

Fig. 9. Support with indicator needle

- End support without camshaft rotation indicator needle

This element is used to cancel the translation movement on the Y- axis, using the centering screw (Fig. 10.).

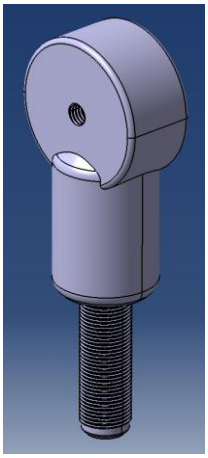

Fig. 10. Support without indicator needle

- Base of camshaft end supports

Into these elements are screwed the two end supports with and without indicator needle (Fig. 11).

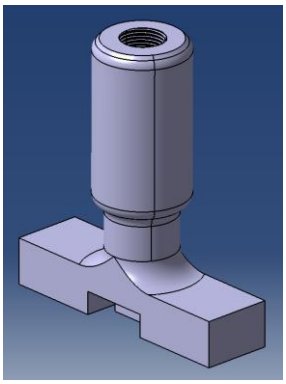

Fig. 11. Base of camshaft end supports

- Centering screw

When mounted in each end bracket, its purpose is to cancel the translational movement on the Y-axis, but not the rotational movement about the Y-axis (Fig. 12.).

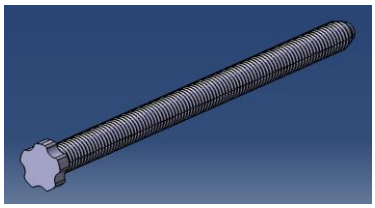

Fig. 12. Centering screw

- Graded bushing

The graded bushing is attached to the camshaft using four screws, and is intended, together with the end support with the indicator pin, to show the rotation of the camshaft in degrees. On one side it shows markings from degree to degree and 10 to 10 degrees, and on the other side it shows markings from 5 to 5 degrees and 15 to 15 degrees. (Fig. 13.).

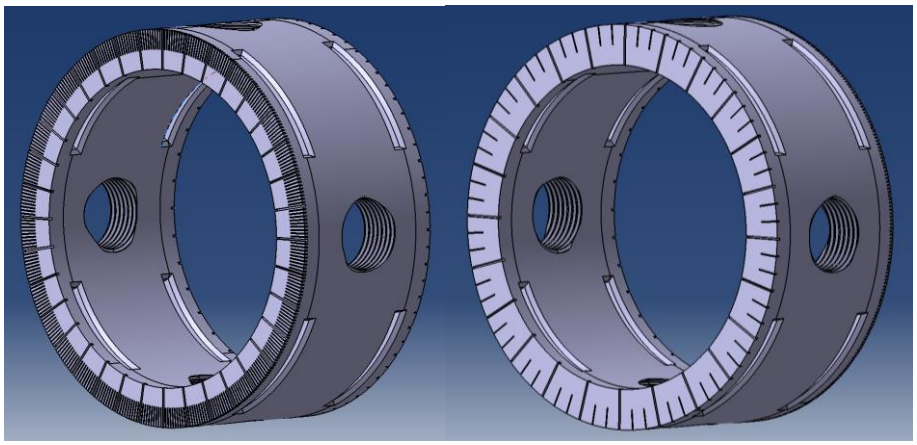

Fig. 13. Graded bushing

- Comparator

After studying several comparator models, the determined size used by the camshaft test stand would be the 58mm in diameter (Fig. 14.).

Fig. 14. Comparator [6]

- Camshaft

The camshaft is the element to be analyzed using this test stand (Fig. 15.).

Fig. 15. Camshaft [7]

6. Conclusions

Through this test stand, camshafts will be able to be checked in terms of cam wear and seating surfaces wear. It will also be possible to map the unknown profile of a camshaft in order to optimize it in a CAD software for performance applications.

The manufacturing cost of such a system is low, as it only requires the purchase of a comparator and the actual 3D printing of the components.

Measurement accuracy is high, but human reading error can occur during measurements, which is completely eliminated by using a fully automatic system.

The assembly can be further developed by adding translation rails for the comparator in the horizontal and vertical directions, but this will increase the complexity of the system and hence the production cost. A digital comparator or even an electronic one could be used to record the values more easily and remove the parallax error which can occur when using a mechanical comparator.

8. Bibliography

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