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Study on the Efficiency of Different Methods of Teaching the Minimum Size Cam Principles

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Abstract: The paper will be concerned with establishing the most efficient way of teaching the principles of minimum size cam for mechanical engineering students. Three methods are presented and the test will reveal the most efficient one, in terms of understanding the general principles and the details related to the subject.Three groups of students are involved in this study. For each group, a different method was presented and the grades at the final test demonstrate which method was more effective for teaching the principles and for receiving the information by the tested subjects. The graphical method consists of drawing the cam profile by points taking into account the maximum admissible pressure angle. The second method for the minimum size cam is the analytical one, which consists of determining the eccentricity and radius of the cam basic circle using mathematical equations. The third method consists of an estimated method for translational followers based on simplifying assumptions.

Keywords: Teaching methods, Minimum size cam, Principles

Introduction

Sometimes it is important to check how students understand certain notions. A difficult problem faced by students is related to the understanding of how the minimum size cam is determined. This concept is sometimes difficult to understand, given that ultimately the problem to be solved is to determine an optimum, and optimization problems are rarely available. The goal is to determine the dimensions of a cam (initial space and eccentricity) so that the pressure angle does not exceed a maximum admissible value (Mereuta E., 2007, 2015, Handra-Luca, V., 1983). As it is known, an infinite number of cam profiles can be obtained for the same work cycle, with the same motion law of the follower. The higher the initial space and the eccentricity are, the lower the pressure angle is. This causes a large size cam and a high consumption of material (Cossalter, V., 1996).

Method

To evaluate how students understand the principles of the minimum size cam three methods are presented (Dobos, F., I., 1985). The students were assessed on the basis of the accumulated knowledge. The results obtained were analyzed and so the best method of teaching the principles of the minimum size cam was chosen.

The Graphical Method

The method involves graphical constructions based on the principle of reversing the motion, planar geometry theorems and kinematic interpretation of the pressure angle (Mereuta E., 2007, 2015, Handra-Luca, V., 1983, Dudita, Fl., 1981).

The cam-follower mechanism is drawn in different positions and the condition of not exceeding the pressure angle determines the area in which the rotation center of the cam is situated and then the initial space and the eccentricity can be determined (fig.1).

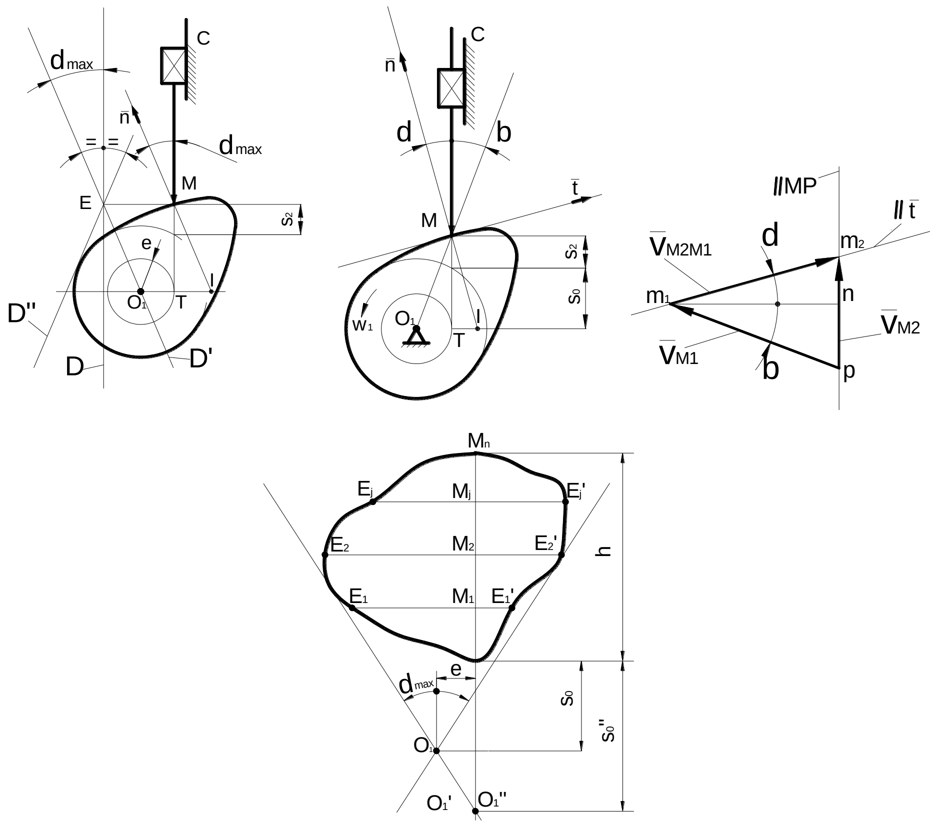

Fig.1. Minimum size cam – graphical method

$$\frac{O_1 I}{\left|\bar{v}_{M2}\right|} = \frac{O_1 M}{\left|\bar{v}_{M1}\right|} \text{ or } \frac{L_{O1I}}{v_{M2}} = \frac{L_{O1M}}{v_{M1}} \tag{1}$$

$$v_{M2} = \omega_1 \cdot \left(\frac{ds_2}{d\varphi_1}\right) \text{ and } v_{M1} = \omega_1 \cdot L_{O1M} \tag{2}$$

$$L_{O1M} = \frac{ds_2}{d\varphi_1} \tag{3}$$

$$M_j E_j = \frac{\frac{ds_2}{d\varphi_1}}{S_i} \text{ for } \varphi_1 = \varphi_{1j} \tag{4}$$

$$M_j E_j = \frac{v_2(\varphi_{1j})}{S_i \cdot w_1} \tag{5}$$

Analytical Method

The analytical method is based on the analytical expression of the pressure angle according to the velocity of the follower, the initial space, the follower displacement and the eccentricity ((Mereuta E., 2007, 2015, Handra-Luca, V., 1983, Dudita, Fl., 1981).

Imposing an admissible value for the pressure angle, a mathematical expression for the radius of the cam can be obtained. This expression is an objective function that is minimized (Dancea, I., 1976).
For each position of the mechanism, the value of the follower eccentricity is determined and the maximum value is chosen (fig.1).

$$\delta = \delta_{\max} \tag{6}$$

$$s_0 = \frac{\left(\frac{ds_2}{d\varphi_1} - e - s_2 \cdot tg\delta_{\max}\right)}{tg\delta_{\max}} \tag{7}$$

$$r_0^2 = s_0^2 + e^2 \tag{8}$$

$$r_0^2 = \frac{\left(\frac{ds_2}{d\varphi_1} - e - s_2 \cdot tg\varphi_{\max}\right)^2}{tg^2\varphi_{\max}} + e^2 \tag{9}$$

$$e = \frac{\left(\frac{ds_2}{d\varphi_1} - s_2 \cdot tg\delta_{\max}\right)}{\cos^2\varphi_{\max}} \tag{10}$$

Approximate Method

This method involves analyzing the lifting stage of the follower. The following simplifying assumptions at the middle of the stage are considered:

a) The follower displacement is a half stroke;
b) The pressure angle reaches its maximum value;
c) The follower velocity reaches its maximum value.

These assumptions are acceptable in practice and do not introduce high errors. Based on this method the mean radius of the cam is obtained and then the initial space is determined (fig.2). The method is identical for the lowering stage of the follower (Mereuta E., 2007, 2015, Handra-Luca, V., 1983, Dudita, Fl., 1981).
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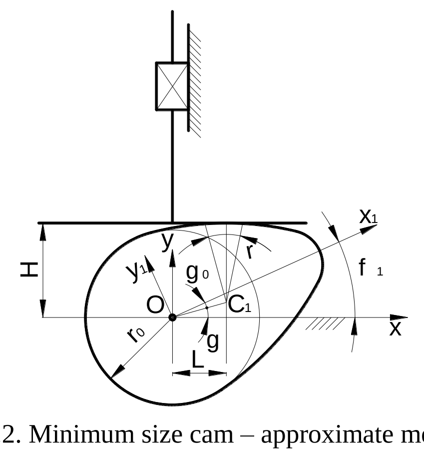

Fig.2. Minimum size cam – approximate method

$$\gamma = \varphi_1 - \varphi_2 \quad (11)$$

$$\frac{d\gamma}{d\varphi_1} = 1 \quad (12)$$

$$L = r_{C1} \cdot \cos\gamma \quad (13)$$

$$H = r_{C1} \cdot \sin\gamma + \rho = r_0 + s_2(\varphi_1) \quad (14)$$

$$\frac{ds_2}{d\varphi_1} = r_{C1} \cdot \cos\gamma \quad (15)$$

$$\frac{d^2 s_2}{d\varphi_1^2} = -r_{C1} \cdot \sin\gamma \quad (16)$$

$$r_0 = \rho - s_2(\varphi_1) - \frac{d^2 s_2}{d\varphi_1^2} \quad (17)$$

$$\rho \geq \frac{F \cdot E_1 \cdot E_2}{\pi \cdot b \cdot (E_1 + E_2) \cdot p_a^2} \quad (18)$$

Results and Discussion

The results obtained were analyzed and thus it was found that the graphical method provides quite good results, most students applying easily the graphical tools. This result can be attributed to the skills that students have in using drawing software, without really understanding what the minimum size cam is (fig.3). It is found that 73.07% of the students get good and very good grades, while 11.53% did not get pass grades.

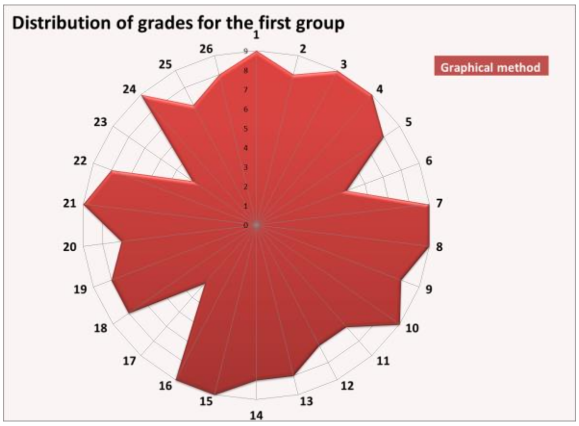

Figure 3. The distribution of grades for the first group acording to the graphical method test

The second method was the analitical one. According to the results, we are now able to conclude that this method was difficult for students. They weren’t able to fulfill the tasks, they didn’t understand the principles and they have difficulties in following an analitical calculus. For this method, it is found that only 22.72% of the students get good and very good marks, 13.63% did not get pass grades, and 18.18% obtained the minimum grade for passing (fig.4).

This is due to the poor preparation of the students and the complexity of a higher mathematical reasoning.

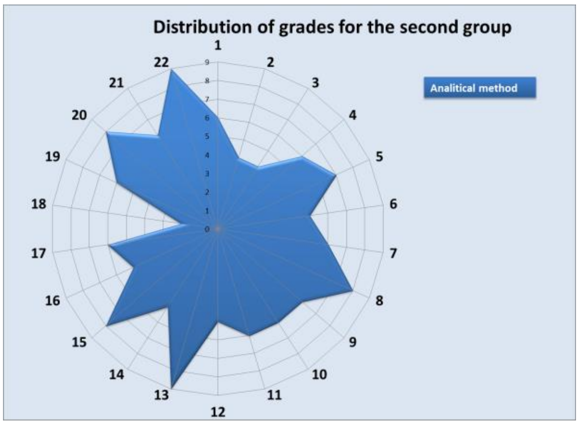

Figure 4. The distribution of grades for the second group acording to the analitical method test

The third method of determining the minimum size cam was using simplistic assumptions and a combination of graphical and analytical methods. Although, theoretically, the results of the students should have been better, it was found that 38.09% of the students obtained the minimum pass mark, and 9.52% did not pass (fig.5). Only 14.28% have scored good and very good grades in this test.

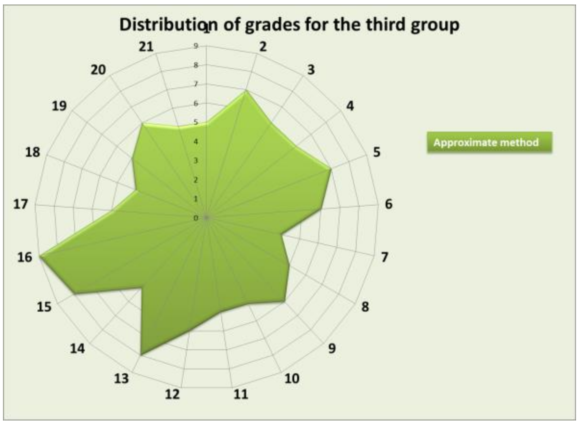

Figure 5. The distribution of grades for the third group acording to the approximate method test

Conclusion

The graphical method was the most efficient, the group's average being of 7.80 on a scale of 1 to 10. It is noticeable that no student has got the maximum grade. The results showed that students have learned the graphical methods, but cannot extrapolate knowledge in the area of interpretation of results. The principles of the method have not been fully understood.

The analytical method led to somewhat weaker results, the average of the group being 6.04 on a scale from 1 to 10. No maximum grades were obtained. The optimization method and the calculations have created problems for the students, and the principles of the minimum size cam were not understood. The approximate method led to the weakest results, the group average being only 5.85 on a scale of 1 to 10 (fig.6).

Although the method uses simplified assumptions and greatly reduces workload, students have focused on building graphics and calculations, completely omitting the end-point of the method. The test revealed great loopholes in understanding the principles of designing the minimum size cam.

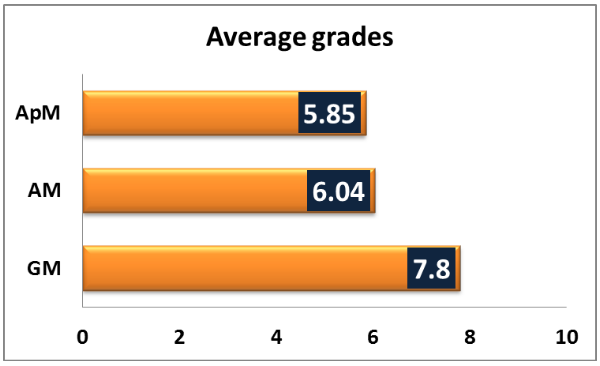

Figure 6. The average grades, recorded for all of the methods: approximate method (ApM), analytical method (AM) and graphical method (GM)

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