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RECOVERY OF A REAL CAM BY USING THE JARVIS MARCH

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Abstract: In this paper the authors performed a comparison between the real shape of a cam and its convex cover. The goal is to highlight the advantages of using the Jarvis march in the synthesis of cams. The authors analyzed an intake cam used by the K7 engine manufactured by Renault Company, both from the constructive and variation of the dynamical parameters points of view.
Keywords: cam, Jarvis march, precision, K7 engine

INTRODUCTION

It is well known that the using the calculation programs that implement the Jarvis march offers the advantage of the possibility of the realization of a very precise and convex profile of the cam. The precision is practically limited to the precision of the computer. For instance, a precision of 0.1^0 is very usual in this case, comparing to the precision of 1^0 in the case of the classical methods.

Using such programs that implement the Jarvis march, the authors have as final goal to obtain a profile of the cam which modifies the functioning cycle of a typical K7 engine from Otto to an Atkinson type one. The Atkinson cycle is characterized by diminished polluting emissions and improved BSFC.

It was highlighted in some papers that the use of the Miller cycle for a Diesel leads to the decreasing of the polluting emissions and the increasing of the efficiency. Wang [1] applied the Miller for a Diesel engine, while Gonca [2–4] proved, by mathematical models, the increasing of the thermal efficiency with the aid of a cam obtained by mathematical calculation, which was implemented on a Diesel engine.

Li [5] studied the effective specific consumption of an Otto engine with direct injection obtaining, by using the Miller cycle, a decreasing of the BSFC by approximate 4.7 % for great loads and angular velocities.

In this paper, the authors recovered the cam of a K7 type engine by using the Jarvis march. They analyzed the camshaft of the engine from the point of view of the admission cam.

The distribution mechanism was simplified considering that the valve rocker is one with equal arms, directly acting upon the valve. In addition the surface of the valve rocker that is actuated by the cam is considered to be a plan one, so we discuss about a flat tappet.

EXPERIMENTAL DATA

The considered engine was a K7 type one manufactured by Dacia–Renault Company.

The experimental setup is described in Figure 1. On the camshaft we installed the device for the measurement of the variation of radius of the cam.

Figure 1: Determination of the dimensions of the cam

The rotational angle of the camshaft is determinate using a device to measure the angular displacement. In this way the dimension of the cam was measured using an angular step of 5^0, the value of this variation being read on a dial extensometer with a precision of $0.01\,mm$; the obtained data was used as input data in the calculation program that implements the Jarvis march. The obtained values are presented in Table 1. Separately we measured the radius of the base circle of the cam obtaining a value equal to $14.5\,mm$.

Table 1: Numerical values for the dimension of the cam

Angle of rotation of the camshaft	Valve's displacement	Angle of rotation of the camshaft	Valve's displacement
0	0	185	0
5	0.01	190	0
10	0.06	195	0
15	0.13	200	0
20	0.19	205	0
25	0.27	210	0
30	0.39	215	0
35	0.59	220	0
40	0.88	225	0
45	1.3	230	0
50	1.95	235	0
55	3.01	240	0
60	3.89	245	0
65	4.61	250	0
70	5.05	255	0
75	5.25	260	0
80	5.19	265	0
85	4.91	270	0
90	4.38	275	0
95	3.68	280	0
100	2.79	285	0
105	1.95	290	0
110	1.28	295	0
115	0.9	300	0
120	0.61	305	0
125	0.4	310	0
130	0.28	315	0
135	0.2	320	0
140	0.15	325	0
145	0.11	330	0
150	0.04	335	0
155	0.01	340	0
160	0	345	0
165	0	350	0
170	0	355	0
175	0	360	0
180	0		

In our assumptions presented in the first paragraph, the displacement of the valve lift is equal to the variation of the cam radius. This variation is graphically presented in Figure 2.

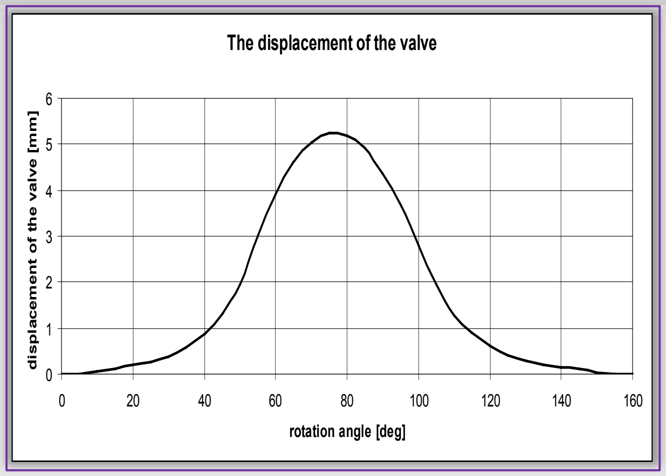

Figure 2: Variation of the displacement of the valve as function of the rotation angle of the camshaft

THE JARVIS MARCH

The Jarvis march is an algorithm that offers the convex cover of a finite set of planar points. The convex cover is obtained as a polygon having the apices among the original points.

If the original set of points form a convex set, then the convex cover consists in the set itself, the order of points being or not the same as in the original set.

Usually, the convex cover consists only in a part of the original set, the order of the points in the convex cover being not the same as in the original set.

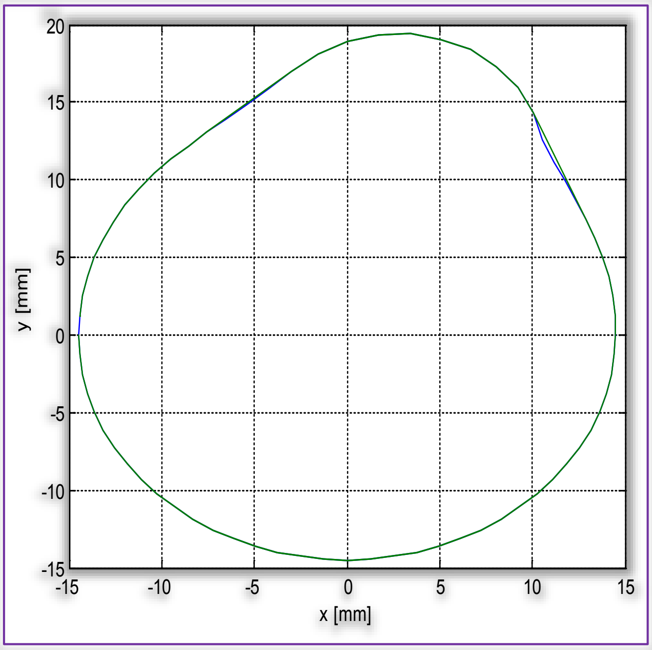

Figure 3: The original set of points and its convex cover for the cam

In our case we have 72 points which offer the profile of the original cam with a step of 5^0. The original polygon which passes through these 72 points is drawn with blue line in Figure 3. The convex cover of this set of points is drawn with green line in the same figure. Only 64 points out of the original 72 are used. This non-conformity has as main causes by the great angular step (we have to consider a smaller one), and our assumption of a flat tappet of the distribution mechanism.

The reader can easily see that the differences between the real cam and the cam obtained by using the Jarvis march are small ones, so we may state the quasi coincidence of the two cams.

DYNAMICAL BEHAVIOR

It is interesting to see the dynamical behavior of the distribution mechanism in two situations. The first one is characterized by the use of approximation with a 5^0 angular step of the real cam, while the second one is characterized by the use of the cam obtained with the aid of the Jarvis march.

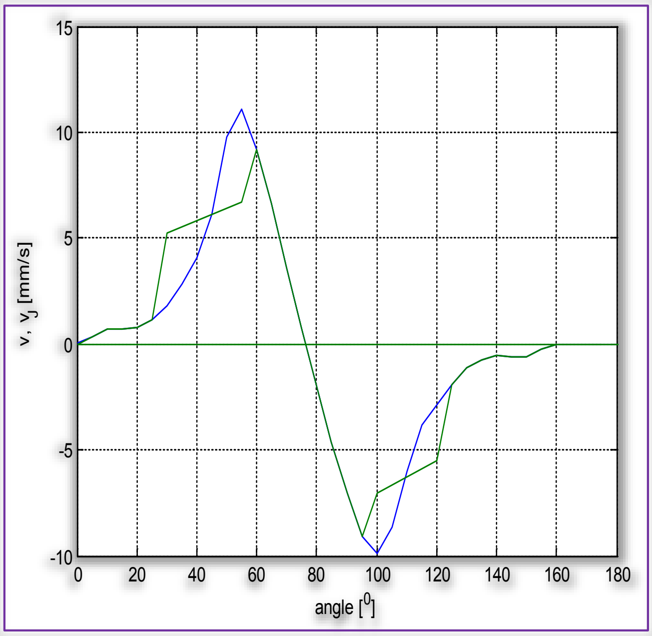

Figure 4: The variation of the valve's velocity

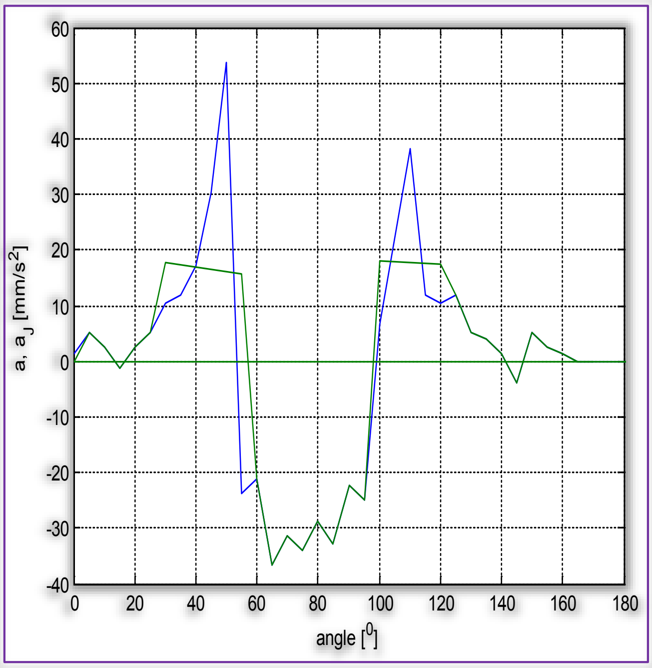

Figure 5: The variation of the valve's acceleration

In Figures 4 and 5 we presented the variations of two kinematic parameters: the velocity and the acceleration of the admission valve. In blue are plotted the variations of these parameters for the approximation of the real cam, while in green are plotted the variations of the same parameters for the cam obtained with the aid of the Jarvis march.

The graphics were obtained using the classical formula for the numerical derivation [6]. In the first situation (the approximation of the real cam) the angular step was a constant one and equal to 5^0. In the case of the second case (the cam obtained with the aid of the Jarvis march) the angular step was not a constant one, but depending on each point (some points are not found in the convex cover).

Analyzing these figures we may state that in the convex cam the velocity and the acceleration of the valve are smaller. The maximum value of the velocity decreases with approximate 25% comparing to the case of the approximation of the real cam. The changes are more dramatically for the acceleration when the maximum value is 3.5 lesser than that obtained in the first situation

CONCLUSION

Our paper demonstrates that the use of the convex cam obtained with the aid of the Jarvis march leads to smaller values for the velocity and acceleration of the valve. This thing implies an engine of smaller mass, increasing of the efficiency and reduction of the wear.

Our study will be extended in the following directions:

» different shapes of the follower not only the flat tappet which was used in the present paper;
» for a cam that characterizes the Miller–Atkinson cycle;
» practical validation of the theoretical aspects.

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