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A METHOD TO DETERMINE THE SELF FREQUENCIES OF A CRANKSHAFT FROM A SINGLE CYLINDER ENGINE WITH VARIABLE COMPRESSION RATIO

A. Gabor[1], P. Grigore[1]
[1] Transilvania" University of Brasov, Brasov, ROMANIA, adrian.gabor@unitbv.ro, v.munteanu@unitbv.ro

Abstract: *Determining the self frequencies of a crankshaft from a single cylinder engine is a method to research the noise, vibration and harshness produced by the engine. Vibration is an important factor in the reliability and quality of an engine, noise is of importance to vehicle users and environmentalists, harshness is related to the quality and transient nature of vibration and noise and is strongly linked to engine refinement.*
Knowing the self frequencies of the crankshaft using finite-element and multi-body systems analysis software can be very useful in the development of a new engine and can be a way to improve the engine from the designing phase.
Keywords: *self frequencies, noise, vibration, crankshaft*

1. INTRODUCTION

Using finite-element analysis software, the self frequencies of the crankshaft were determined, with the help of ANSA software. Validation of the results was obtained by the following method: using other engine parts as: piston, connecting rod, rotating cylinder jacket or cylinder head, the self frequencies were determined by laboratory measurements using the impact hammer method, then the same measurements were done, with ANSA software, on the same engine parts. Since the results obtained with both of the methods were very close, the virtual method was validated and used to determine the self frequencies of the crankshaft.

2. DETERMINING THE SELF FREQUENCIES USING THE IMPACT HAMMER METHOD.

The impact hammer method, for determining the self frequencies, is illustrated using the piston of the engine. For experimental determination of the frequencies the following equipment was used in testing the engine components: data acquisition platform type 3050 Bruel&Kjaer (Pulse Platform 12), 3 monoaxial accelerometers type 4507B Bruel&Kjaer, impact hammer type 8206-003 Bruel&Kjaer dedicated Bruel&Kjaer software for analysis in the frequency domain.

Figure 1 – The impact hammer, the accelerometers and the Bruel & Kjaer platform

Testing was realized using an impact hammer method as self frequency identification method and consisted of the following steps:

-calibration of the accelerometers using a Bruel&Kjaer calibrator;
-configuration of equipment to acquire corresponding signal;
-installation of the accelerometers on the piston that will be tested;
-performance of successive knocks with the impact hammer;
-signal acquisition and processing in frequency domain;
-data export in Me'scope VES v.5 software and analysis of the modal parameters frequency and damping;
For the piston were used a total of 3 accelerometers and applied a number of 10 strikes in different parts of the piston. Recorded signals were further analyzed in frequency domain, the response forms are presented in the figure 2. Modal testing procedure allows estimating the self frequency of the tested parts, modal masses, modal damping and the natural modes of the parts. Under the excitation action inserted into the system with the impact hammer, structures, at resonance frequencies, act as an response amplifier, which is well shown in the frequency response. Based on these aspects a modal test has been done with the impact hammer method for all the engine tested parts.
The modal analysis, performed with different software or in laboratory conditions, identifies basic frequencies where a piece might vibrate, this being useful when the part is an element of an aggregate and when it starts to vibrate, the possible source of vibration can be identified, with some precision (the connecting rod, the piston, the crankshaft etc).

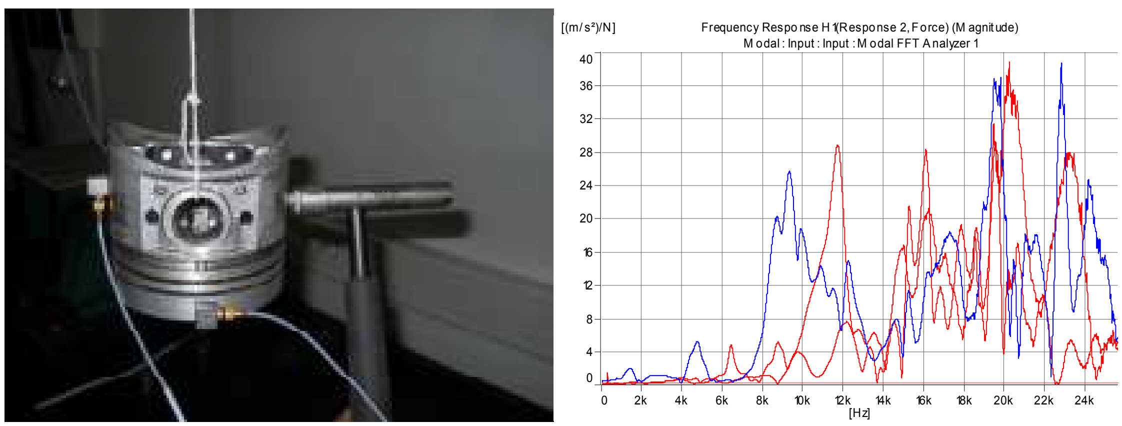
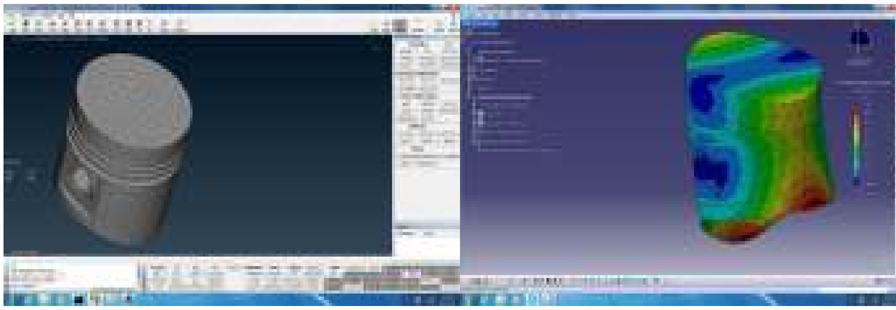


Figure 2 – Obtaining the frequency response using the impact hammer

Frequency [Hz]	Amplitude [dB/m/s^2/N]
2616	31.8
2871	59.2
849	7.70
1008	20.3
4742	61.2
5748	31.6

3. DETERMINING THE SELF FREQUENCIES USING FINITE ELEMENT ANALYSIS SOFTWARE

The first step in using the finite element analysis software was to design the piston, using CATIA V5 software, to obtain a .cad type file, necessary to be imported in the ANSA software, Figure3. Next using the ANSA modules, the geometry of the part was analyzed and the eventual errors made during the design of the part were corrected, then the surface mesh was done. After the surface mesh was analyzed and the errors were corrected, the next step was to prepare the volume mesh, which will be used to determine the self frequencies of the piston.



Frequency (Hz)
2593.4
3432.0
4905.7
5182.7
5363.3
6318.3

Figure 3 – Finite element method analisys and the frequencies obtained

In the end the two methods were compared and it was found that the results are suitable, so the virtual method was validated for obtaining the self frequencies and it can also be used for other tested parts without the necessary need of laboratory testing. Then it was proceeded to determine the natural frequency of the engine crankshaft. The same steps as the piston were followed.

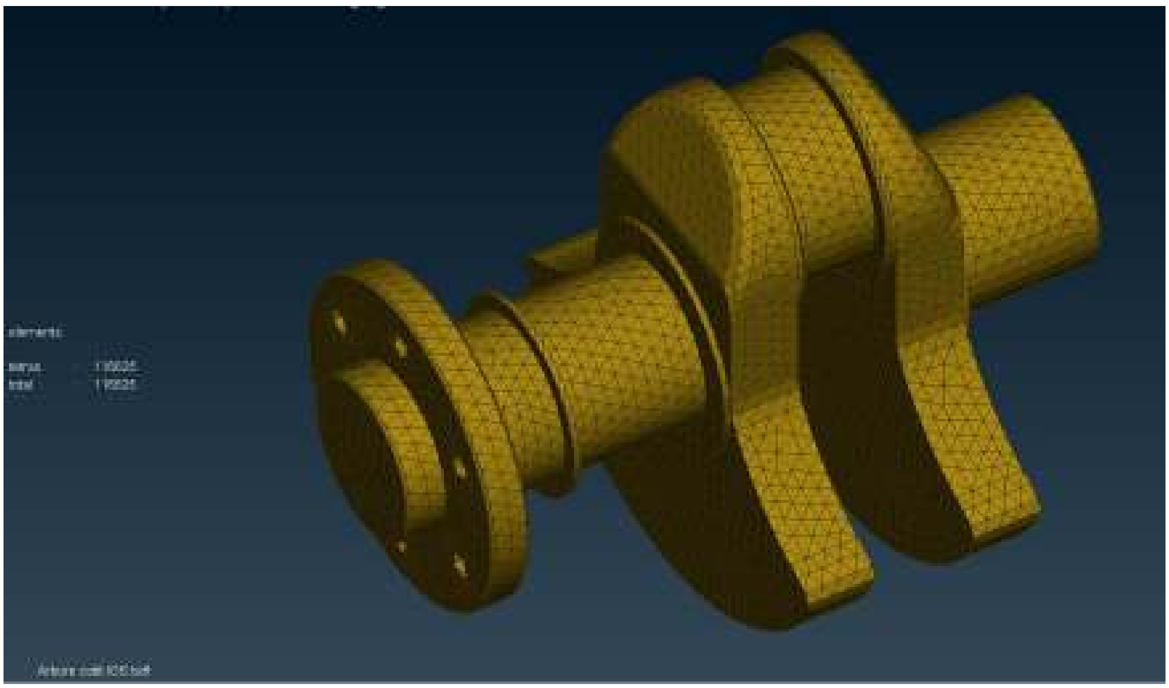


Figure 4 – The crankshaft volume mesh

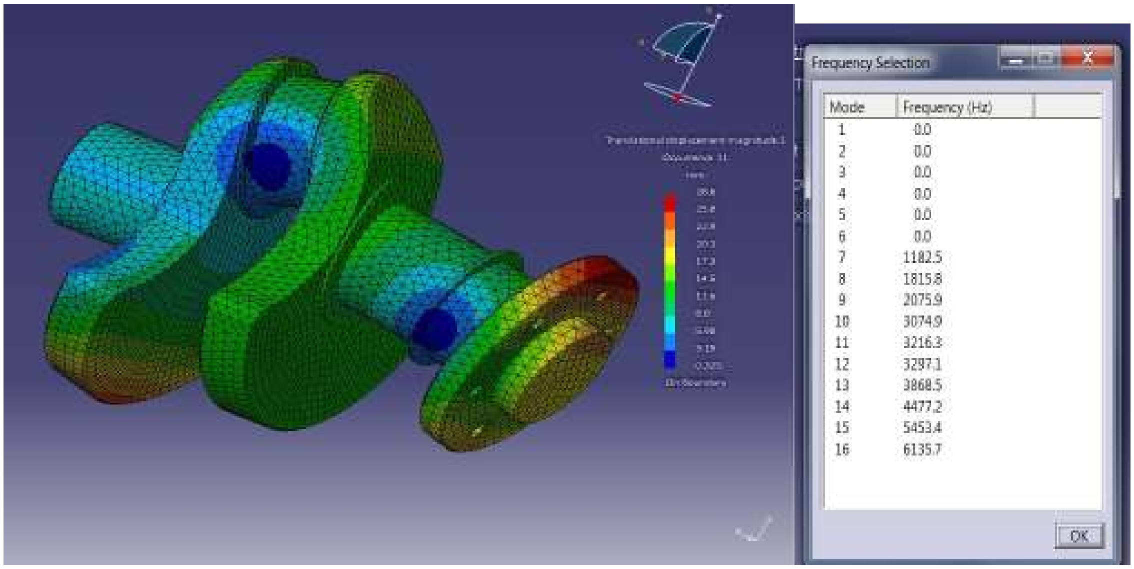


Figure 5 – The crankshaft finite element analysis and the self frequencies of the crankshaft

4. CONCLUSIONS

In the finite element method analysis the spectrum contains the natural characteristics of the system and depends only on the distribution of the masses and the elastic properties of the material of the analyzed part of the engine.
Noise and vibrations analysis has in recent years been aided by developments in finite element and multi-body system analysis software like ANSA, but still exists a need to apply basic vibration and noise principles in engine or vehicle design. Also with development of laboratory equipment the laboratory analysis for vibration and noise should be used as a back-up solution.
Reducing noise and vibration for the new engines in the development stage is a solution to reduce costs later, in the manufacturing process or even after, in the exploitation of the engine.

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