Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 8, S. 84-90, 3, 2024

Araştırma Makalesi

IJANSER

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 8, pp. 84-90, 3, 2024

Research Article

Determination of Frequency Vibration of Crankshaft with Different Mesh Structure with *LS DYNA* Finite Element Program

Ilyas Bozkurt[1]

[1]*Department of Mechanical Engineering, Architecture and Engineering Faculty, Mus Alparslan University, 49250 Mus, Turkey*

Email of the corresponding author: i.bozkurt@alparslan.edu.tr

(Received:16 April 2024, Accepted: 25 April 2024)

(2nd International Conference on Scientific and Innovative Studies ICSIS 2024, April 18-19, 2024)

ATIF/REFERENCE: Bozkurt, I. (2024). Determination of Frequency Vibration of Crankshaft with Different Mesh Structure with LS DYNA Finite Element Program. *International Journal of Advanced Natural Sciences and Engineering Researches*, 8(3), 84-90.

Abstract **–** In this study, the vibration behavior of the crankshaft used in internal combustion engines was analyzed with a finite element program. The study was carried out with the *LS DYNA* finite element program. The shaft model created with *Solidworks* was then converted to finite element analysis by entering the material and boundary conditions into the *Lst-prepost* program. The effect of the mesh size used in the study on the calculation results was analyzed. Steel were used as shaft materials. The eigenvalue material card was used for 10 different frequency modes. The maximum error for different mesh size was determined as 2.2%. Therefore, it has been determined that the size of mesh used is an effective parameter on vibration. The results presented here are intended to shed light on future studies on crankshaft geometry changes.

Keywords – Internal Combustion Engines, Crankshaft, Vibration Analysis, Finite Element Method, LS DYNA

I. INTRODUCTION

Internal combustion engines use a crank-piston system to convert reciprocating motion to rotary motion. The crankshaft is a key element of this system. Its torque is not constant over time but varies in complexity, depending on the position of the crankshaft for each cylinder [1].

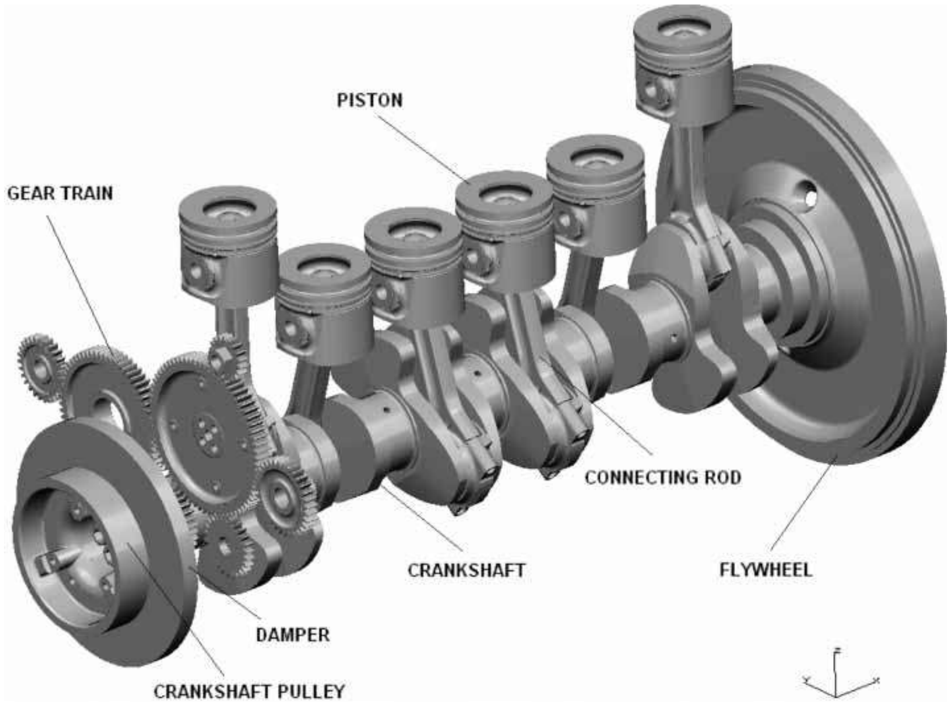


Figure 1. Loading state of the crankshaft during operation.

In many cases, the vibration phenomena can be decisive for the proper functioning of the shaft. Vibration can cause an engine as well as an aircraft's work disturbance. The resonance amplification of the vibration amplitude threatens to damage of the shaft and its associated components. Regardless of the dynamic system in which the engine works, the greatest danger to its crankshaft are torsional vibrations. Among of many forces acting in the crank-piston system, crankshaft rotational force is caused by tangential force around the crank. Force, which is one of two component forces acting along the connecting rod axis, is the periodic force [2]. Its period for a two-stroke engine is 2π, and for four-stroke engines 4π [3]. Variation of force induces acceleration in the crankshaft rotation of the engine, causing the formation of torsional vibrations, which additionally change with the change in shaft speed. The resonance may occur when the frequency of the forced oscillation equals or is multiple of the vibration frequency of the shaft.

The vibration frequency of the shaft depends on the size and distribution of the masses, how the shaft is supported and its geometrical properties [4]. Very often design support processes are used in the form of computer simulation. Modern design methods allow for a considerable reduction in design time [5]. In the field of mechanics and machine construction, the use of computing power allows for faster verification of proposed technical solutions [6]. This approach avoids undesirable design errors as well as shortens design time [7, 8]. There are many studies in this field in the literature [6,7,8]. However, the number of studies on its effects on mechanical properties is limited. With the development of computer systems, increased computing power is available. This allows for more complex simulation processes. In the field of mechanics, simulations are mainly used for testing the strength of the tested parts of machines or devices. Most of simulations are based on the FEM Finite Elements Method.

In this study, the vibration behavior of the crankshaft used in internal combustion engines was analyzed with a finite element program. The study was carried out with the *LS DYNA* finite element program. The shaft model created with *Solidworks* was then converted to finite element analysis by entering the material and boundary conditions into the *Lst-prepost* program. The effect of the type of mesh size used in the study and its mechanical properties on the calculation results was analyzed. The eigenvalue material card was used for 10 different frequency modes. The results presented here are intended to shed light on future studies on crankshaft geometry changes.

II. MATERIALS AND METHOD

A. Finite Element Analysis

To commence the simulation, the first step involved determining the type of simulation required. A frequency simulation was chosen to analyse the vibrations, employing the Lanczos solver within the *LS DYNA* software. This software offers flexibility in specifying the number of vibration patterns and defining frequency limits. For this study, a frequency range of 10 Hz to 6000 Hz was selected after initial assessments.

The analysis focused on the crankshaft's inherent vibration characteristics, necessitating a model that remained unfixed. Due to the intricate geometry of the crankshaft, a Free Tet mesh grid was utilized for discretization. Material properties were defined using cast iron, as detailed in Table 1. Figure 2 presents the model with mesh grids for both materials.

Table 1. Material properties of the analyzed shaft.

Name Value	**Steel**
Young Modulus 7197 kg/m3	178 GPa
Poisson Number	0.33
Density	7197 kg/m^3

Tablo 2 provides a visualization of the first 10 free frequency modes of engine crankshaft vibration for different materials. These modes represent the assumed frequency range specific to the crankshaft of the opposed piston engine. The *LS DYNA* software automatically calculates the frequency value for each mode, while the colors represent displacements. Resonance occurs when the system vibrates at specific frequencies, resulting in significant displacements.

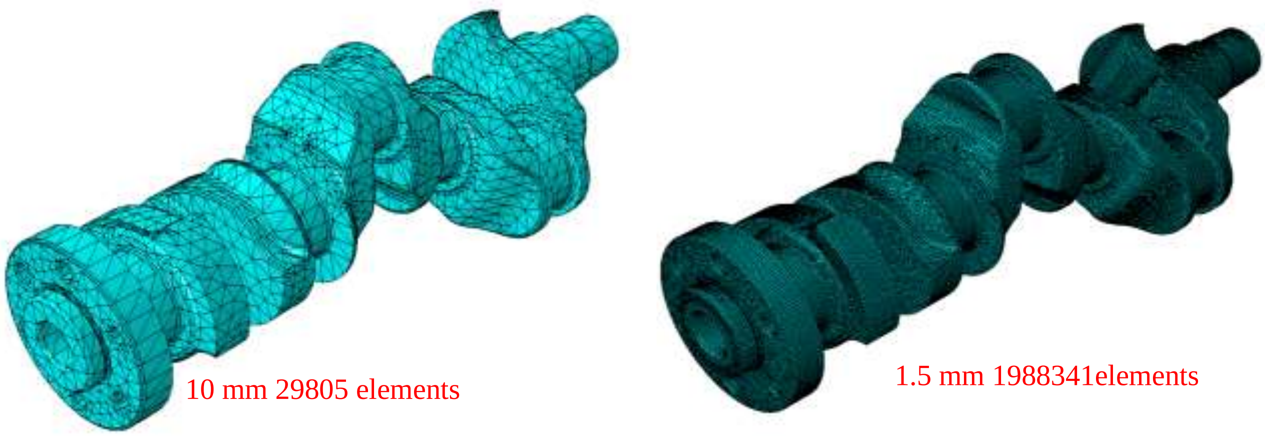
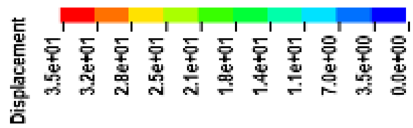
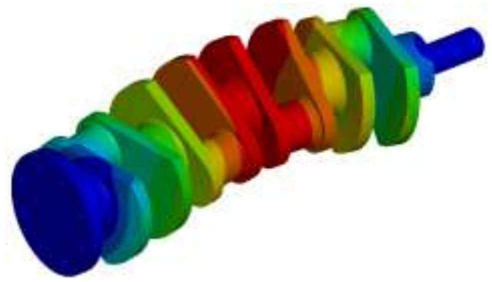
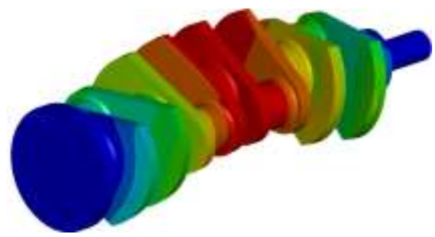
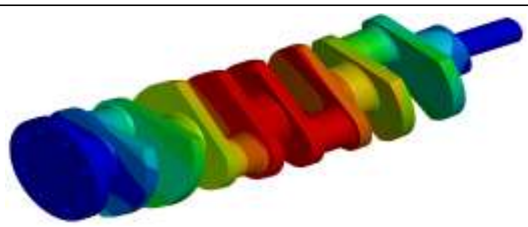
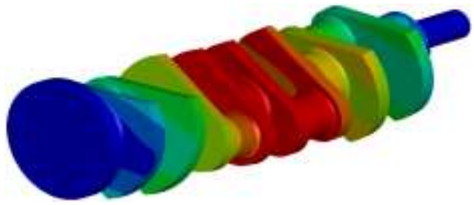
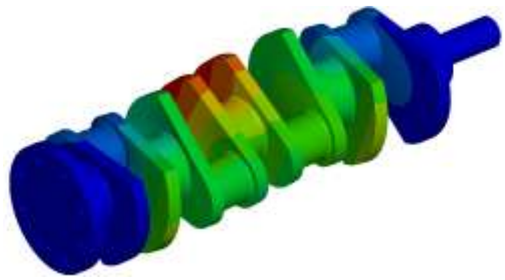
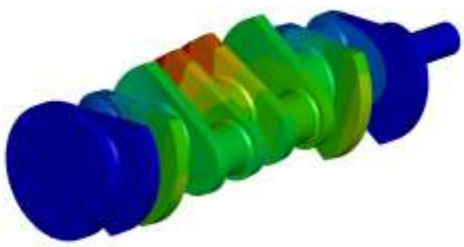
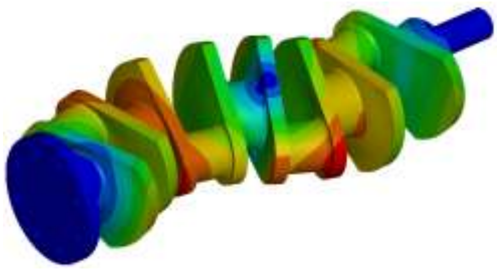
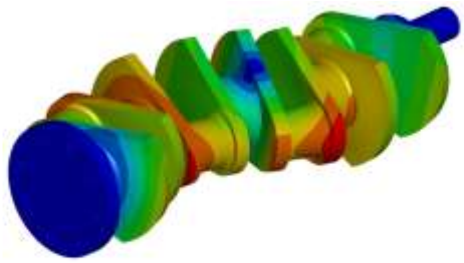


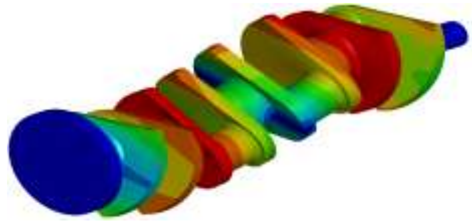
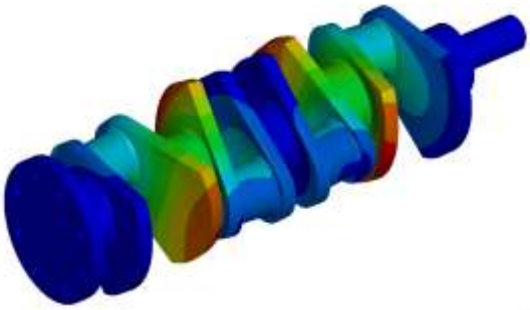
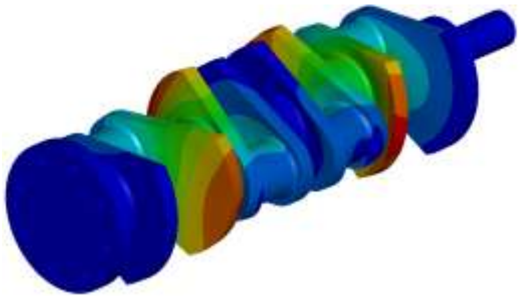
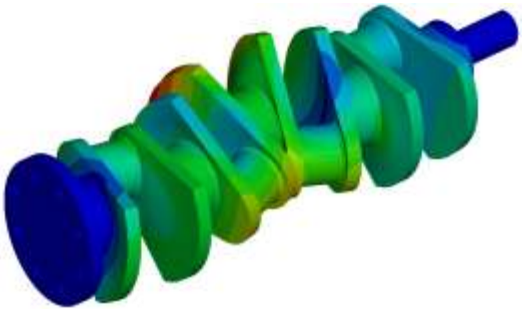
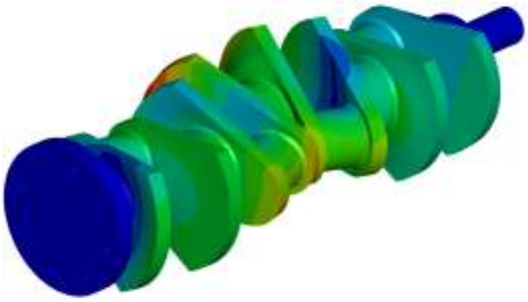
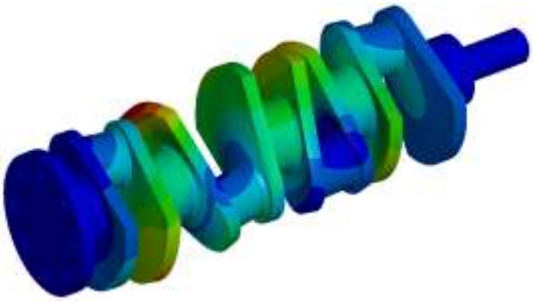
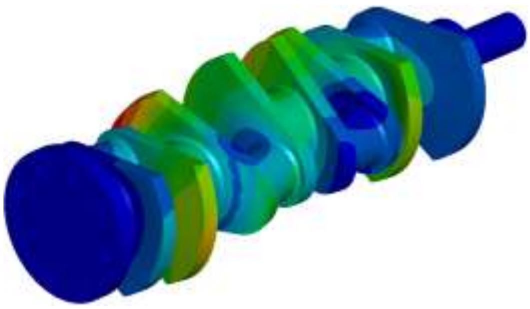
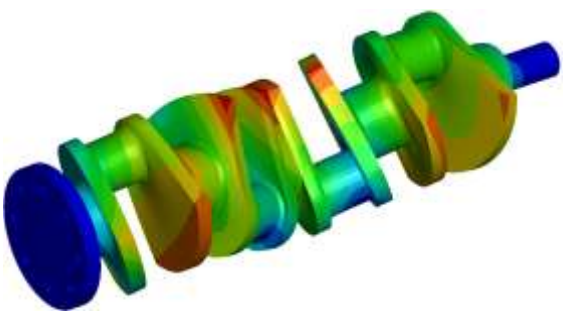
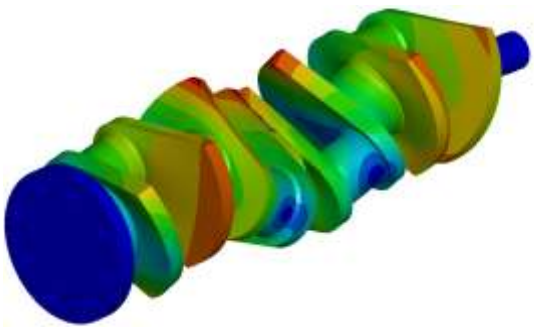
Figure 2. FEM model.

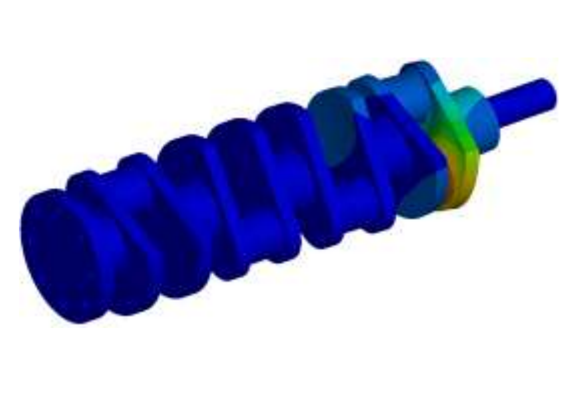
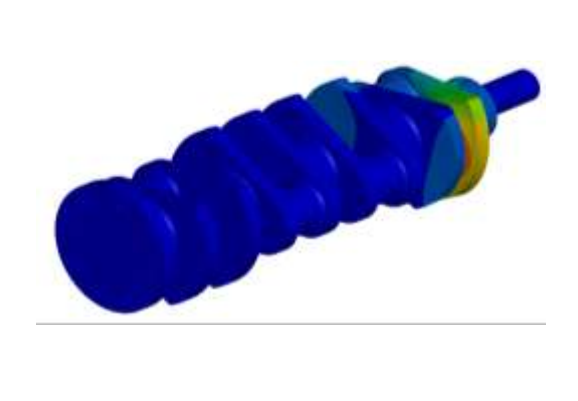
III. RESULTS

As can be seen from the results of simulation calculations presented in Table 2, vibration values in individual modes differ among themselves. These differences reach up to 50 Hz at higher vibration values, but the maximum dimensionally is 2 .2%. According to some studies, these deviations are mainly because the roundness of the analyzed solid is not reflected if the mesh grid is of poorer quality. Along with the mesh structure, it causes distortion of the crankshaft geometry, which affects other mass distributions in some parts of the crankshaft and therefore affects the simulation results. In Figure 3, the effect between these two materials is clearly shown graphically.

Table 2. FEM shape change of crankshaft according to frequency mode.

		
Mode 1		
Mode 2		
Mode 3		
Mode 4		

Mode 5		
Mode 6		
Mode 7		
Mode 8		
Mode 9		

Mode 10		

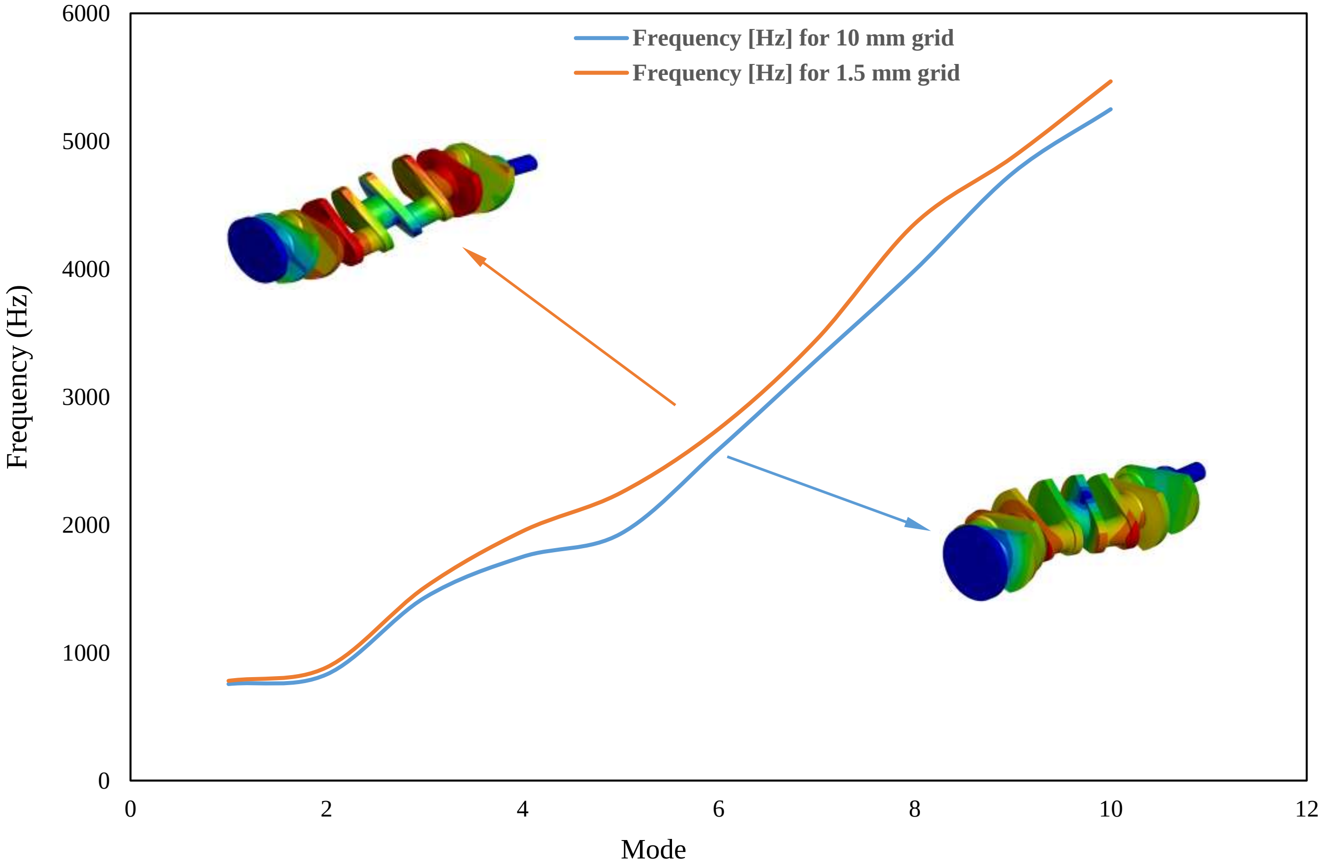


Figure 3. Frequency values depending on materials.

IV. CONCLUSION

In this study, the vibration behavior of the crankshaft used in internal combustion engines was analyzed with a finite element program. The study was carried out with the *LS DYNA* finite element program. The shaft model created with Solidworks was then converted to finite element analysis by entering the material and boundary conditions into the Lst-prepost program. The effect of the mesh size used in the study and its mechanical properties on the calculation results was analysed. The following conclusions can be drawn regarding the study:

- In this study, the effects of the mesh size of the specimens on the vibration frequency were examined. Other frequencies can be examined with different variations by using different material properties.

- The eigenvalue material card was used for 10 different frequency modes. By increasing the number of frequencies, situations at different frequencies can be examined.
- It has been determined that a frequency deviation of 2.2% occurs when the mesh size of the crankshaft is 1.5 and 10 mm. Thus, it was determined that mesh size was effective on frequency.
- The results presented here are intended to shed light on future studies on crankshaft geometry changes.

REFERENCES

[1] W. Mitianiec, K. Buczek, Technical Journal, Cracow University of Technology Publish House, z.8-M/2008 (2008).
[2] A. S. Mendes, Proceedings of the Institution of Mechanical Engineers Part K Journal of Multi-body Dynamics 222, 2 (2008).
[3] W. Homik, Pol Marit Res, no 3, 43-47, (2011).
[4] S.S. Mohtasebi, H. Afshari, H. Mobli, J of ApplScien, 6, 3 (2006).
[5] T. Łodygowski, Kąkol W., Finite element method inselected problems of mechanics engineeringstructures (in polish), Poznań University ofTechnology Publish House, (1994).
[6] R. Neugebauer, C. Scheffler, M. Wabner, CIRP Journal of Manufacturing Science and Technology 4(2011).
[7] A. Zielińska, P. Wyciślok, High-speed TrackedVehicles (in polish), 18, 2 (2003).
[8] P. Magryta, M. Biały, K. Siadkowska, Logistyka 3(2015).