TEKA Kom. Mot. Energ. Roln. – OL PAN, 2007, 7A, 17–22

CORRELATION ANALYSIS OF AN INFLUENCE OF A PISTON'S GABARIT-MASS MODIFICATION IN A S-4002/3 ENGINE ON VIBRATIONS IN CONDITIONS OF LIMITARY CLEARANCE

Zbigniew Burski[*], Joanna Tarasińska[**]

[*] Dep. of Vehicles and Engines, Agricultural University in Lublin, Poland
[**] Dep. of Applied Mathematics, Agricultural University in Lublin, Poland

Summary. In the paper the analysis of correlation is used to estimate an influence of gabarit-mass modification in a conventional piston of a S 4002/3 engine on the level of vibrations in the cylinder liner with limitary clearance. The researches were made by the method of experimental simulation with a different volume of compression chamber. It is shown that, in comparison to technological clearance, exploitation wear of p-r-c set causes a decrease of correlation coefficients between vibration level in different conditions of research. It concerns the most of measurement planes.

Key words: agricultural tractor, engine, vibration dynamics of p-r-c, simulation experiment

INTRODUCTION

Exploitation process of tractor's engine has got a great influence on wear of the set piston-rings-cylinder liner . Heaviness and variability of gass and mass forces are of great importance here [7,9]. So far most of field researches on optimization of working life was conducted during passive and active-passive experiments At present , because of financial costs, such researches are also carried out by the methods of experimental and computer simulation with using some elements of mathematical statistics [4, 5, 6, 9,10].

THE AIM OF THE PAPER

So far, the researches on gabarit-mass modification of crank-piston set concerned automotive vehicles [8]. However there are efforts of such researches on many other working machines and, in agricultural engineering, tractor's engines [2,3]. The present paper is the continuation of such researches , because of a significance of piston's dynamical influence in the final period of an engine's exploitation. The presented results are an attempt of using correlation analysis to evaluate the interdependence of cylinder-liner vibrations in the considered research conditions and piston's modifications.

THE METHOD OF RESEARCH

The researches were carried out by the method of experimental simulation on the model stand using a single crank-piston set of S4002/3 engine [1]. The cylinder liner was supplied with rubber packing ring that was unloaded of gas forces concentration by four stabilizing openings. Because of considerable and practically permanent influence of gas forces on the exploitation process of a self-ignition engine, instead of a typical head, two experimental chambers (I, II) of different compression pressure were applied (Tab. 1).

The research object was the acceleration of cylinder liner vibrations in the form of linear level (LIN). It was measured with measurement equipment SVAN 912 AE of SVANTEK company cooperated with IBM PC computer supplied with software Svan PC.

Five size modifications of piston were made: four on piston's guiding part (denoted by "1", "2", "3", "5") and one (denoted by "4") on the sealing part. The original number of piston rings was kept.

The values of coefficients $\gamma_{M/L}$ (mass/length), together with other working parameters are given in Tab. 1. Because of the limited range of this elaboration the remaining data concerning the stand and research conditions can be found in the previous papers of the authers [2,3,4,5]. The measurement points of cylinder liner vibrations are given in Fig. 1. according to directional selection of measurement detector as recommended by Cempel [7].

Table 1. The basic research conditions of the p-r-c unit at the limitary clearance

Specification	piston's modification						
	Chamber	0	1	2	3	4	5
compression pressure (ps) [MPa]	I	0.295	0.295	0.295	0.280	0.258	0.200
	II	0.116	0.116	0.116	0.116	0.116	0.106
Prędkość obrotowa wału (n)[r/min]	I	375	405	435	435	440	440
	II	445	445	445	455	460	460
coefficient of piston's modification $\gamma_{M/L}$ [g/mm]		9.4	9.6	9.8	10	10.3	10

RESULTS OF RESEARCH

The obtained results of calculated correlation coefficients are presented graphically in Fig. 2-8. The statistical significance of the following correlations for cylinder liner's vibrations were studied:

- between different values of gass and mass force,
- between measurement points of the analyzed planes of acting forces in the investigated system.

Fig. 2-7 present changes of correlation coefficient as a function of considered piston's modifications for particular measurement points. It can be noticed that the runs of changes are considerably differentiated.

In transversal plane (acting force Nmax) and longitudinal one (force Pg) the differentiation is larger for final piston's modifications. There are different runs in conditions of friction of piston's skirt and rings (with acting force Pp).

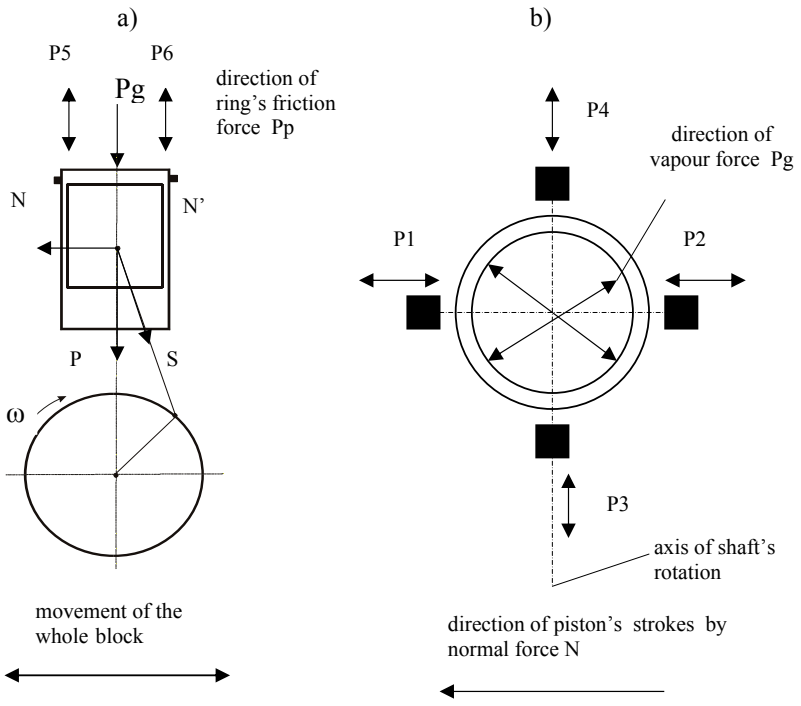

Fig. 1. a,b. Localization for vibrations measurements of a cylinder liner and the model for the action of basic forces in unit p-r-c

During an evaluation of changes of correlation coefficient between measurement points in a particular plane it can be observed that the largest changes are in transversal plane (i.e. the plane of acting Nmax force). It is presented in Fig. 8.

The correlation coefficients for the remaining measurement points are in most cases statistically significant (r_{kl}=0.6÷0.99).

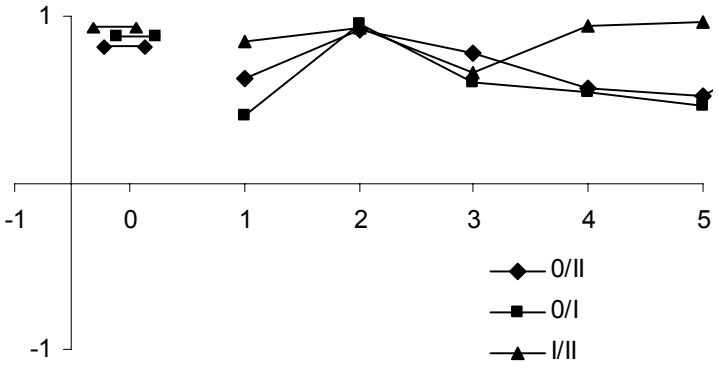

Fig. 2 .Spectrum amplitude's correlation coefficient value changes in transversal plane vibrations of a liner (P1) in case of acting mass force (O) and gas force (I,II)

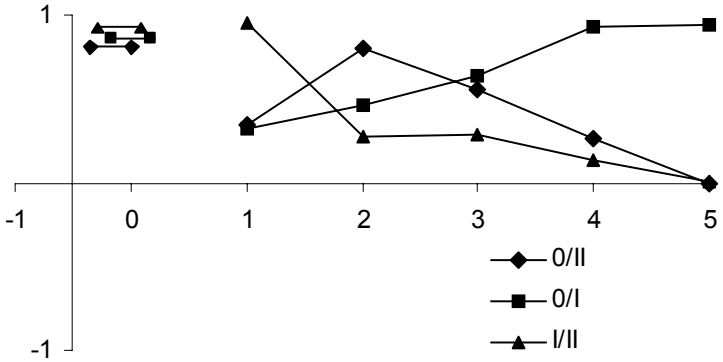

Fig. 3. Spectrum amplitude's correlation coefficient value changes in vertical plane vibrations of a liner (P5) in case of acting mass force (O) and gas force (I,II)

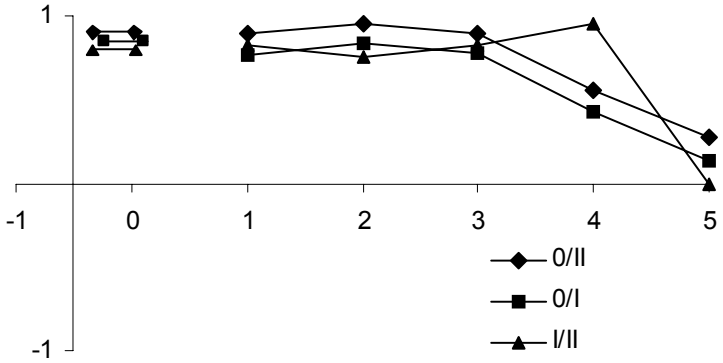

Fig. 4. Spectrum amplitude's correlation coefficient value changes in longitudinal plane vibrations of a liner (P3) in case of acting mass force (O) and gas force (I,II)

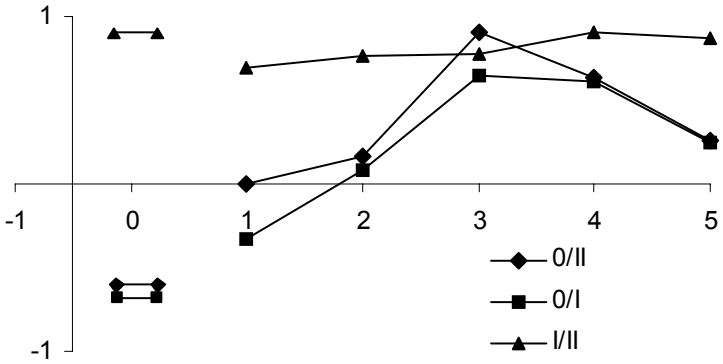

Fig. 5. Spectrum amplitude's correlation coefficient value changes in transversal plane vibrations of a liner (P2) in case of acting mass force (O) and gas force (I,II)

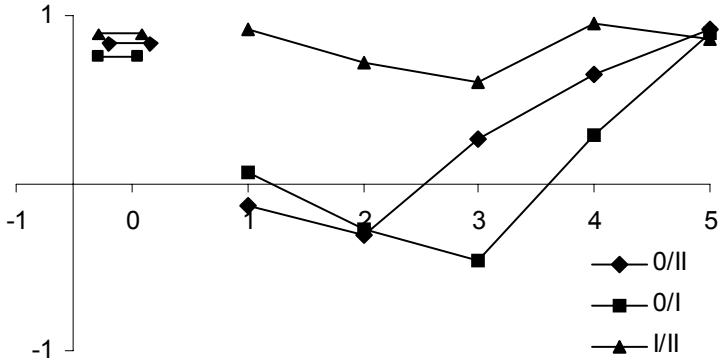

Fig. 6. Spectrum amplitude's correlation coefficient value changes in vertical plane vibrations of a liner (P6) in case of acting mass force (O) and gas force (I,II)

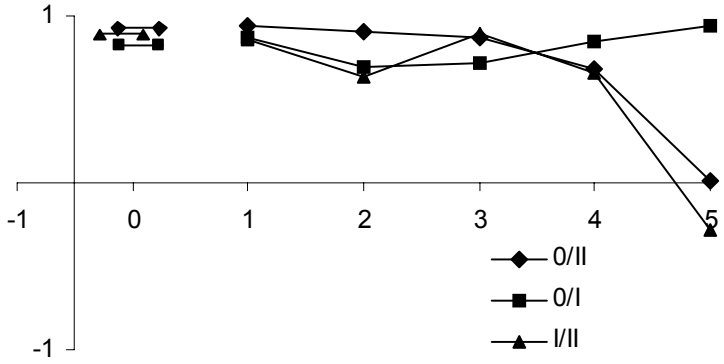

Fig. 7. Spectrum amplitude's correlation coefficient value changes in longitudinal plane vibrations of a liner (P4) in case of acting mass force (O) and gas force (I,II)

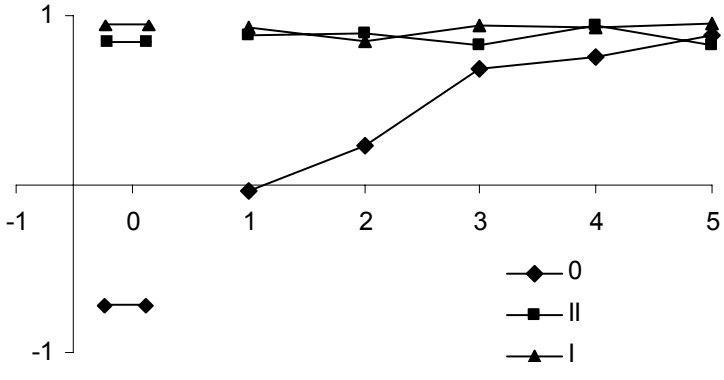

Fig. 8. Spectrum amplitude's correlation coefficient value changes in transversal plane between measurement points 1 and 2.

CONCLUSIONS

The researches proved that, in comparison to technological clearance, exploitation wear of p – r – c set causes a decrease of correlation coefficients:

- between most of forces in particular measurement planes,
- between measurement points in particular planes, except transversal plane of mass force acting.

In case of technological clearance the differentiation of correlation coefficient falls in the first two piston' modifications [6]. In case of limitary clearance it concerns also the two final ones.

REFERENCES

Burski Z. 2001: Badania symulacyjne drgań tulei cylindrowej silnika ciągnika na stanowisku modelowym w aspekcie tribologicznym. (in Polish). Eksploatacja Silników Spalinowych, Politechnika Szczecińska, Szczecin.

Burski Z., Słowik T. 2001: The simulation researches on the influence of firing load upon the vibrations of a cylinder sleeve in tractor's engine in connection with its strain in the condition of technological clearance. Teka KMiER Wyd. PAN o/Lublin, p. 73-85.

Burski Z., Słowik T., Kulewicz W. 2001: The optimalization of the vibrations of a cylinder sleeve in a tractor's engine in experimental simulation researches for technological clearance. III Int. Research And Technical Conference. PAN o/Kraków, PAN o/Lublin, Motrol 4, Lublin, p. 60-70.

Burski Z., Tarasińska J. 2005: Testing an influence of the piston mass and height on the vibrations dynamics in the cylinder liner of an agricultural tractor in proecological aspect. Teka KMiER, Wyd. PAN o/Lublin, p. 16-24.

Burski Z., Tarasińska J., Reichenbach J. 2006: Ocena wpływu modyfikacji tłoka na dynamikę drgań tulei cylindrowej silnika ciągnika w warunkach luzu granicznego zużycia. (in Polish). Inż. Rolnicza 5(80). Wyd. KTR PAN Kraków, p. 95-103.

Burski Z., Tarasińska J. 2007: Application of correlation analysis in proecological evaluation of influence of gabarit-mass modification in tractor engine's piston on vibration dynamics of a cylinder liner. Teka KMiER, Wyd. PAN o/Lublin (in printing).

Cempel Cz. 1985: Diagnostyka wibroakustyczna maszyn. (In Polish). (in Polish).Wyd. Polit. Poznańskiej, Poznań.

Iskra A. 1998: Straty tarcia powierzchni bocznnej tłoka-weryfikacja modelu obliczeniowego. (in Polish). Teka KN-PM. Wyd. PAN o/Kraków, 2-15, Kraków, p. 20-25.

Niziński S. 2002: Eksploatacja obiektów technicznych. (in Polish). Wyd. Inst. Technologii Eksploatacji, Radom.

Piekarski W., Dzieniszewski G. 2005: Evaluation of the technical state of an engine prc system by means of fumes contents. Teka KMiER, 5, p. 177-191