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Influence of the Factors of the Rotor Supported in the Slide Bearing Systems on the Occuring Possibility of the Chaotic Motion

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In this work the dynamic of the rigid rotor supported in the slide bearings in respect to the chaotic motion has been numerical examined. The system is subjected to the kinematic input from the ground in the whole range of factors like viscosity, clearance, bearing length, load and rotation speed. The bifurcation curves have been generated.

Keywords: Slide bearing, chaotic motion, bifurcation curve

1. Introduction

Normally, theoretic works regarding to the slide bearings taking into account entity problems, properties and assign periodical solutions that describe such phenomena or effects. Assuming, these systems maintain in the time as a determinant. It means, they are described by deterministic differential equations, which allow predicting how the system will behave under initial conditions. Mostly form these deterministic equations we obtain irregular curves in relation to the time. The curves possess character of chaotic motions. In this work the rigid rotor supported on the slide bearings was taken into account. The influence of the non–linear hydrodynamic uplift forces on the bearing journal under the kinematic input from the ground has been investigated. This work develops the problem, which were presented in the position [1].

2. Model of the system and equation of motion

The model of the rigid rotor supported in the cylindrical slide bearings presented on the figure no1 is taken into account.

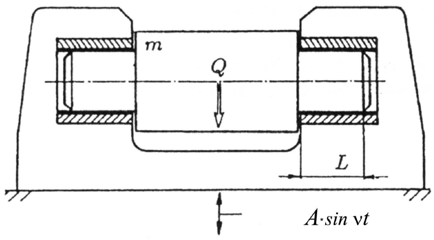


Figure 1 Model of the system

where:

L	– bearing length
m	– rotor weight
Q	– external load
A	– amplitude of the ground movement
ν	– frequency of the ground movement

3. Equation of motion

For the considered system and the assumed model of the bearing support and for the input function applied to the system presented in Fig. 1 according to the literature position [2] the equation of motion can be written as the following form (1)

$$\begin{aligned}\ddot{\xi} &= -\frac{12\mu\cdot L}{m\cdot\delta^3}\left[\frac{\beta^2(\omega-2\dot{\alpha})}{(1-\beta^2)(2+\beta^2)}+\frac{\beta\dot{\beta}}{(1-\beta^2)}\right]\cos\alpha \\ &\quad -\frac{12\mu\cdot L}{m\cdot\delta^3}\left[\frac{2\dot{\beta}}{(1-\beta^2)^{3/2}}\arctan\frac{(1+\beta^2)^{1/2}}{(1-\beta^2)^{1/2}}\right]\cos\alpha \\ &\quad -\frac{6\pi\mu RL}{m\delta^2}\frac{\beta(\omega-2\dot{\alpha})}{(1-\beta^2)^{1/2}(2+\beta^2)}\sin\alpha \end{aligned} \tag{1}$$

$$\begin{aligned}\ddot{\eta} &= -\frac{12\mu\cdot L}{m\cdot\delta^3}\left[\frac{\beta^2(\omega-2\dot{\alpha})}{(1-\beta^2)(2+\beta^2)}+\frac{\beta\dot{\beta}}{(1-\beta^2)}\right]\sin\alpha \\ &\quad -\frac{12\mu\cdot L}{m\cdot\delta^3}\left[\frac{2\dot{\beta}}{(1-\beta^2)^{3/2}}\arctan\frac{(1+\beta^2)^{1/2}}{(1-\beta^2)^{1/2}}\right]\sin\alpha \\ &\quad -\frac{6\pi\mu RL}{m\delta^2}\frac{\beta(\omega-2\dot{\alpha})}{(1-\beta^2)^{1/2}(2+\beta^2)}\cos\alpha+\frac{Q}{m\varepsilon}+\frac{A}{m\varepsilon}\nu^2\sin\nu t \end{aligned} \tag{2}$$

Because the motion of the journals centre are analysed in the Cartesian co-ordinate system ξ, $\eta$the expression (1) can be written in the form (2)

$$\begin{aligned}
\beta &= \sqrt{\xi^2 + \eta^2} \\
\dot{\beta} &= \frac{\xi\dot{\xi} + \eta\dot{\eta}}{\sqrt{\xi^2 + \eta^2}} \\
\dot{\alpha} &= \frac{\dot{\eta}\xi - \dot{\xi}\eta}{\sqrt{\xi^2 + \eta^2}} \\
\cos\alpha &= \frac{\xi}{\sqrt{\xi^2 + \eta^2}} \\
\sin\alpha &= \frac{\eta}{\sqrt{\xi^2 + \eta^2}}
\end{aligned}$$

where:

ξ, η – the journals centre dislocation in the Cartesian co-ordinate system
$\dot{\xi}$, $\dot{\eta}$ – the journals centre velocity in the Cartesian co-ordinate system
μ – absolute viscosity lubricate factor
ε – clearance
β – relative eccentricity
$\dot{\beta}$ – radius velocity of journal
ω – rotor rotation speed
$\dot{\alpha}$ – tangential velocity of journal
δ – absolute clearance

4. Numerical results

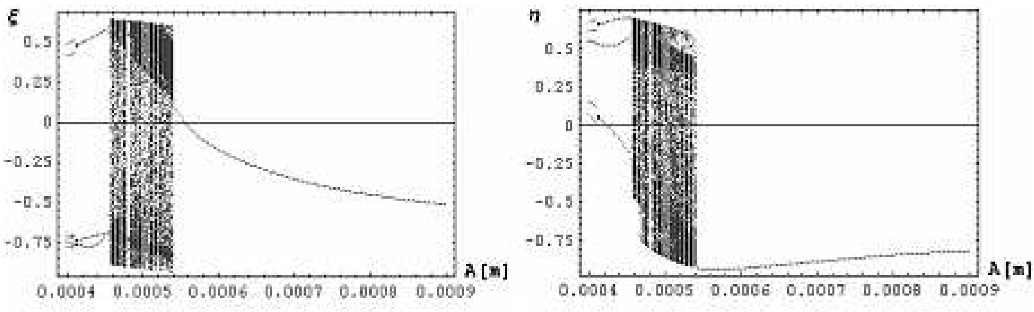
The equations system (1) completed by dependence (2) are strongly out of line and also coupled to each other, therefore it is impossible to answer them in an analytical way. That is why for these analyses we are obliged to use digit simulation methods. The results are presented in the bifurcation curves taking into account the difference of the geometrical parameters such as: clearance, bearing length and physical such as: load of rotation speed and viscosity.

5. Final remarks

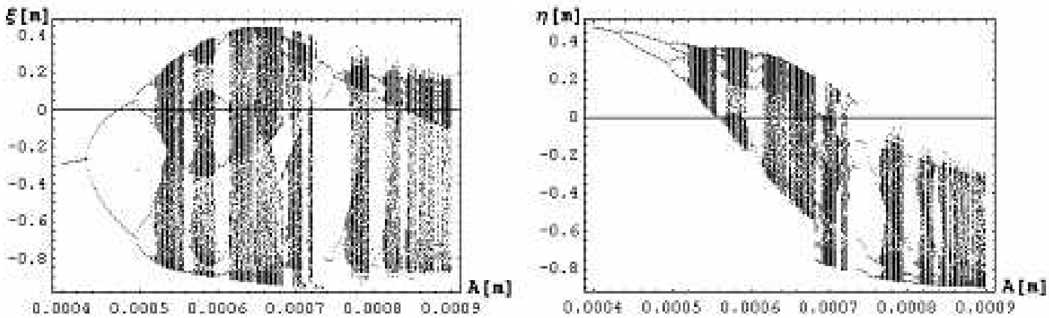
- Achieved analysis have shown the possibility of occurring chaotic motions in the real journal coordinate
- Observed influences on both geometric (clearance, bearing length) and physical parameters (rotation speed, viscosity, external load) on the areas of chaotic motions
- Obtained results have been confirmed by examination of a Poincare map, spectro analysis method and time curves

The influence of the velocity on the irregular and chaotic motion areas in the supported bearings

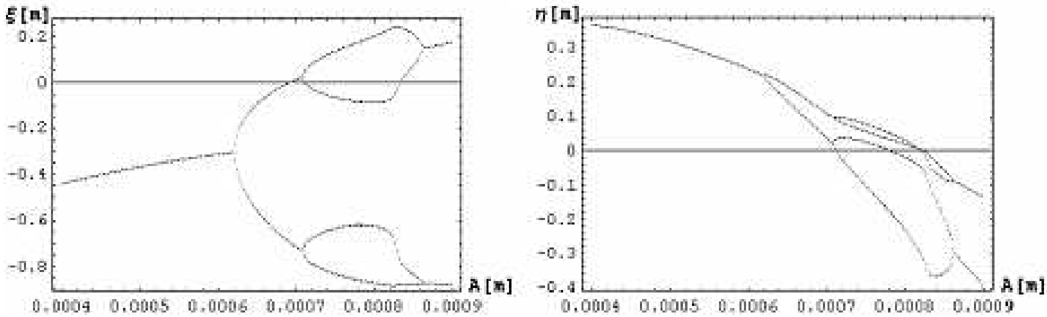
$\mu = 0.005$



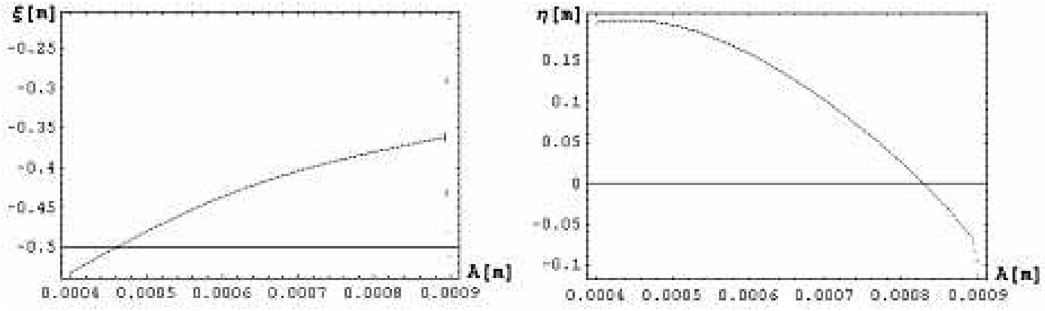
$\mu = 0.01$



$\mu = 0.015$

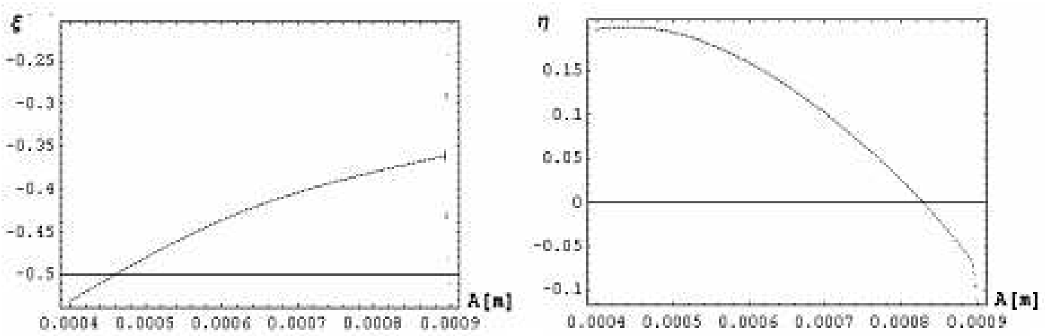


$\mu = 0.02$

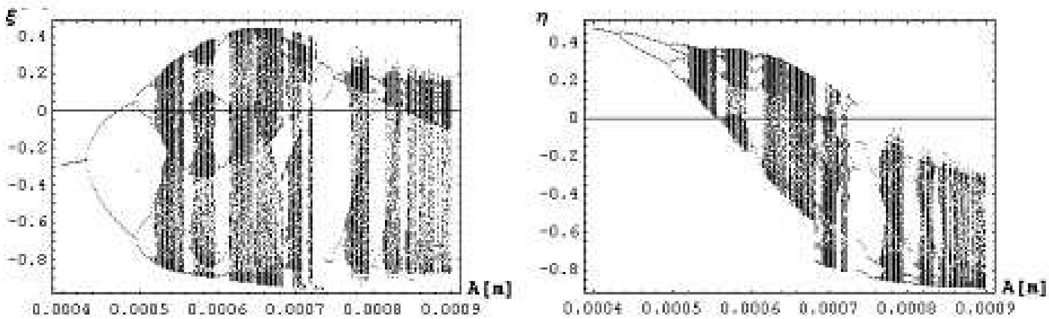


The influence of the external load on the irregular and chaotic motion areas in the supported bearings

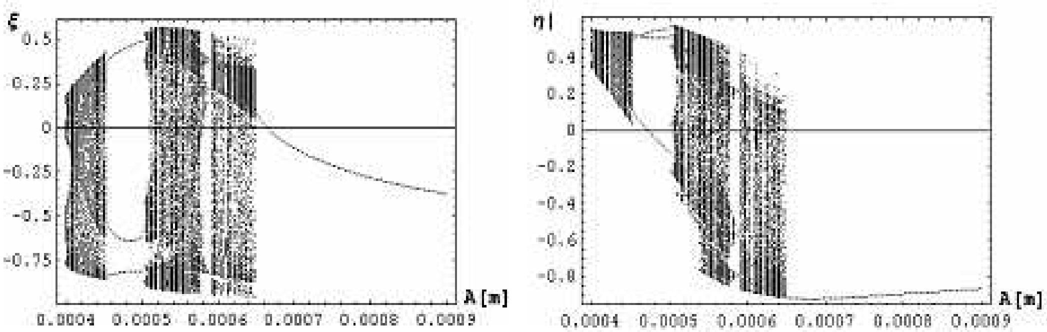
$Q = 250$ [N]



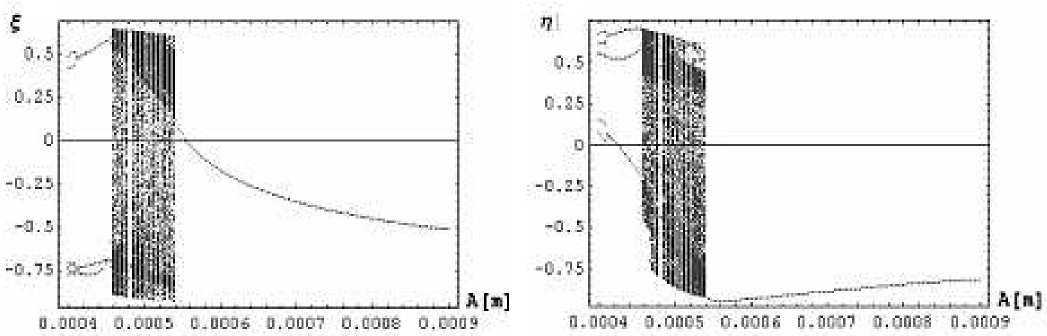
$Q = 500$ [N]



$Q = 750$ [N]

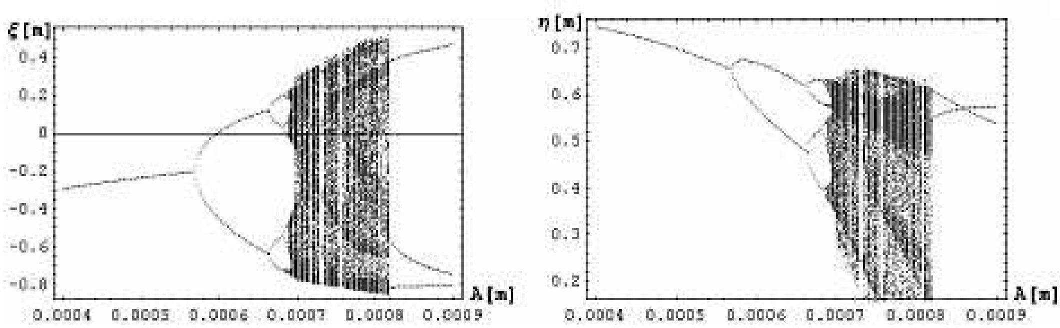


$Q = 1000$ [N]

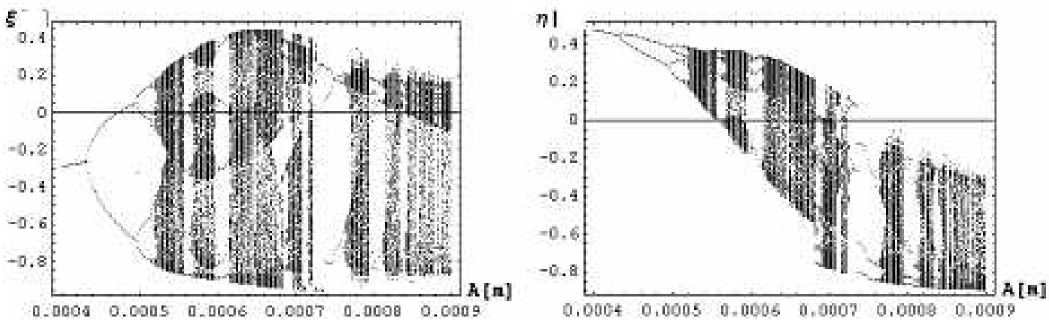


The influence of the rotation speed on the irregular and chaotic motion areas in the supported bearings

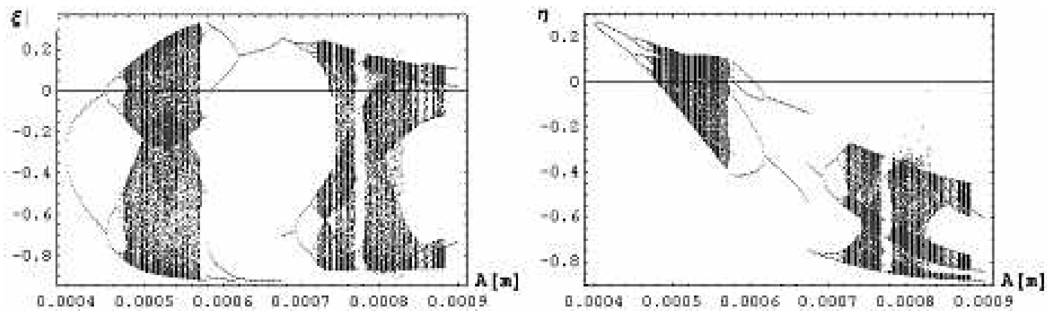
$\omega = 50$ [rad/s]



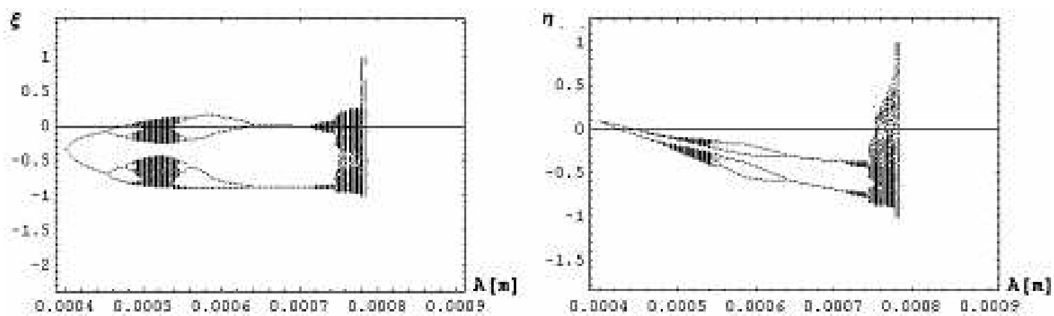
$\omega = 100$ [rad/s]



$\omega = 150$ [rad/s]

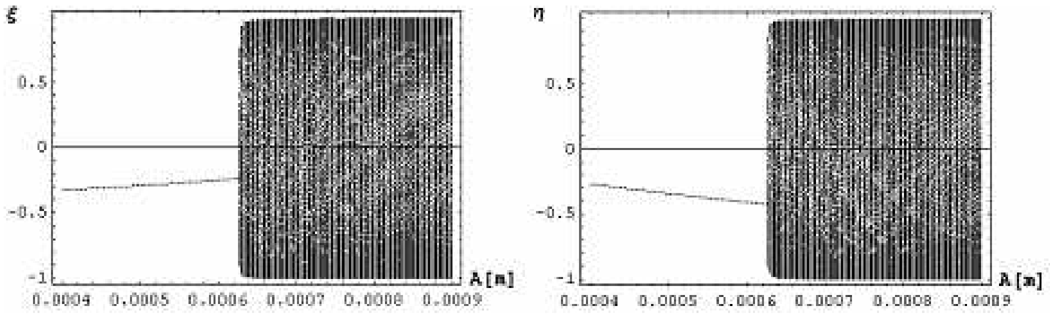


$\omega = 200$ [rad/s]

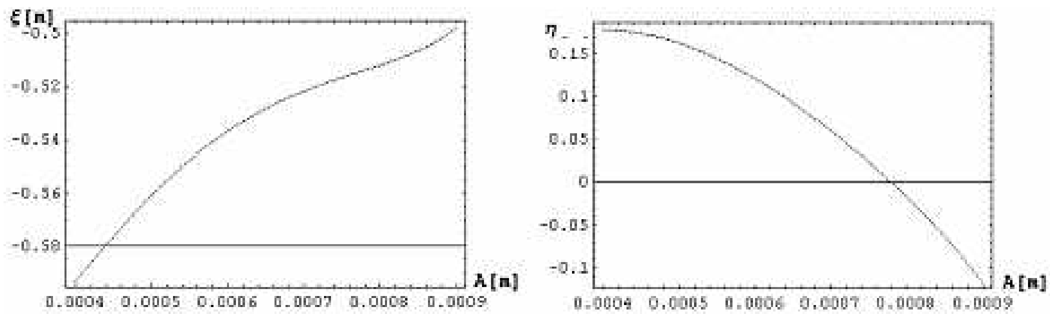


The influence of the bearing clearance on the irregular and chaotic motion areas in the supported bearings

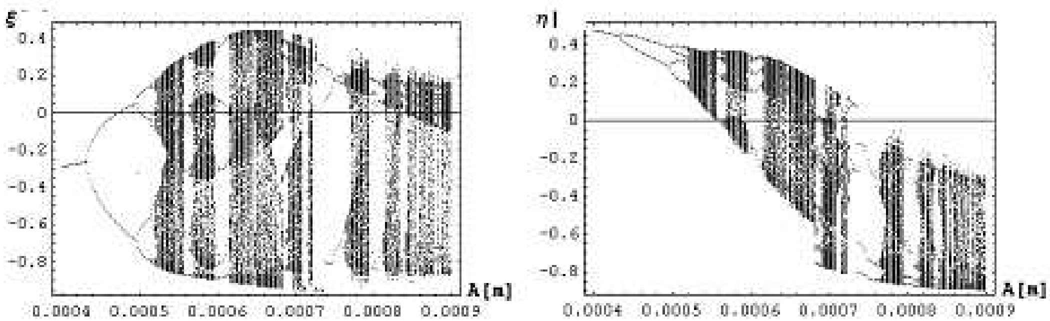
$\varepsilon = 0.0002$



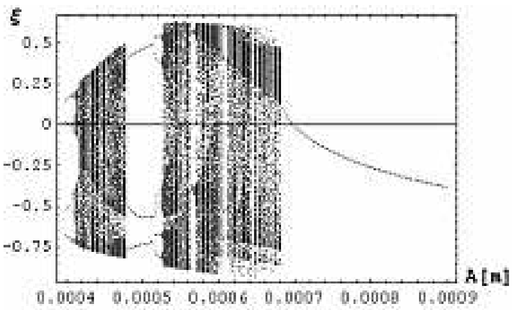
$\varepsilon = 0.0003$

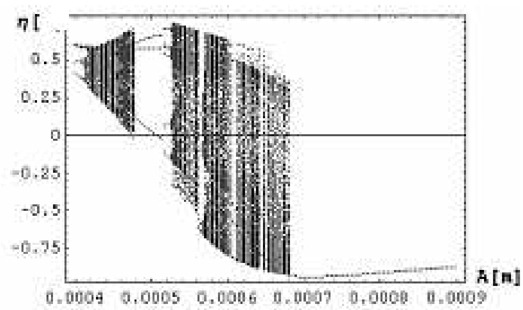


$\varepsilon = 0.0004$



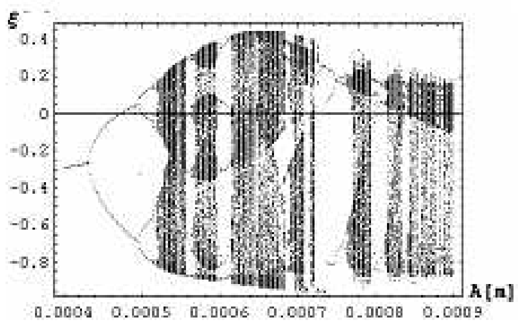
$\varepsilon = 0.0005$

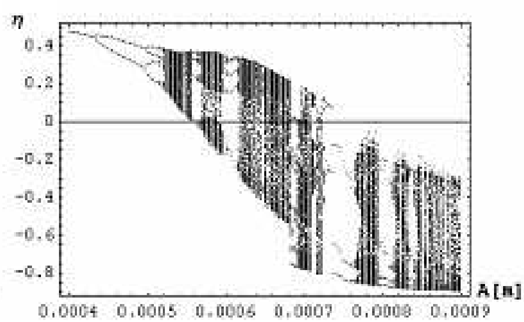




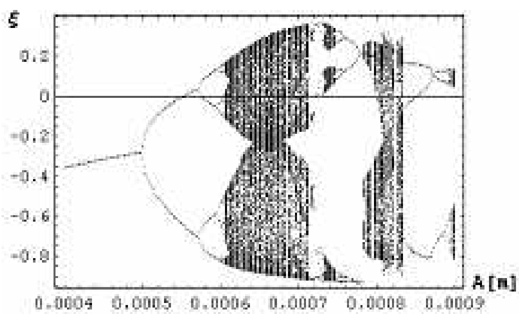
The influence of the bearing clearance on the irregular and chaotic motion areas in the supported bearings

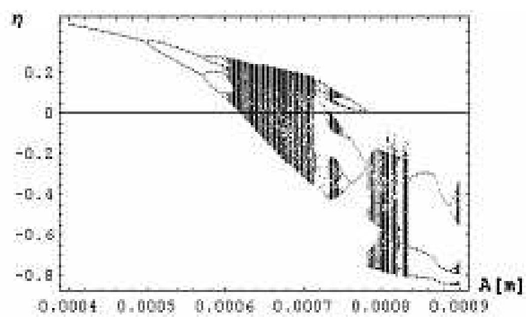
$L = 0.05$ [m]



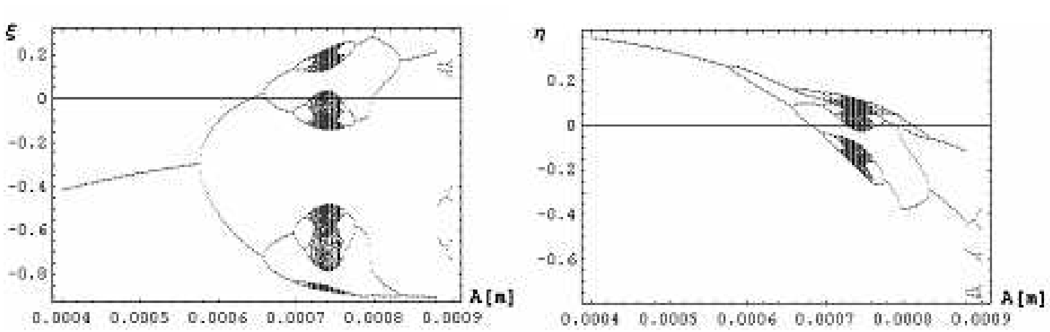


$L = 0.06$ [m]

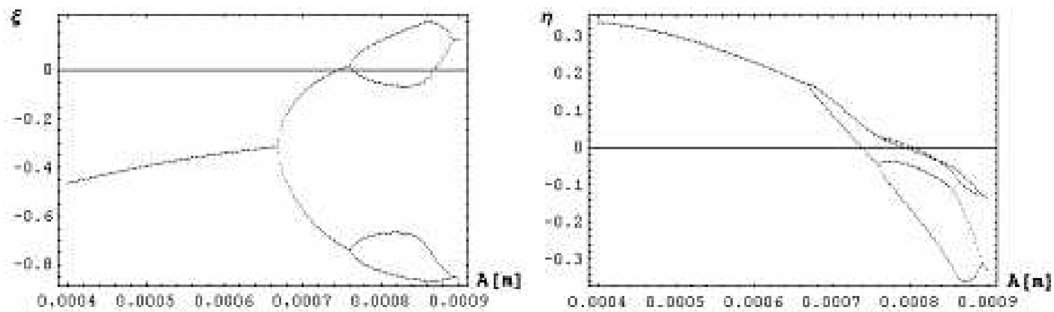




$L = 0.07$ [m]



$L = 0.08$ [m]



References

[1]] **W. Kurnik, Z. Starczewski**: Chaotic vibration of journal bearing system, *Journal of Applied and Theoretical Mechanics*, 3,(33), 627-641, **1995**.

[2]] **W. Kurnik, Z. Starczewski**: Transverse vibration of a rotor in hydrodynamics bearings subjected to kinematic excitation, *The Archive of Mechanical Engineering*, Vol.XLI, No 2, 89-101.