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STUDY OF THE PALETTE-OBSTACLE IMPACT FOR A CONCRETE MIXER

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ABSTRACT

In this paper the numerical simulation of the concrete mixer was developed in SimMechanics, a toolbox for Matlab environment. The virtual model for mixing equipment simulation has been computed to estimate the increase loads on its mechanic components at shock input due to the irregularity of aggregates size of the concrete composition.

KEYWORDS: concrete mixer, palette, obstacle, impact, simulation

1. INTRODUCTION

Modeling and simulating the dynamics of mechanical systems represent a common problem in the fields of engineering and physics with applications in diverse industries (e. g. automotive, communications, chemical, computing, etc).

In this paper, mixer with palettes used in the process of mixing concrete is analyzed. This equipment is considered such a mechanical system whose dynamic response to the action of disturbing factors must be known.

When we study a mechanical system, firstly we identify whose points of the system that have distinct velocities: v for translation or ω for rotation motion. These parameters which defined the initial motion steady are called the inputs of mechanical system. Speed movement of the palettes on mixture have a certain value to ensure intensive mixing without causing segregation of concrete components because of high speed rotation [2].

The concrete mixer is equipped with two horizontal shafts that rotate in opposite direction to each other, leading to forced mixing between the blades, giving a high quality to the final concrete and offering high resistance, a maximum degree of mixing concrete.

The horizontal shafts of the mixer are equipped with mixing arms whose number varies according to the size of the mixer (fig.1).

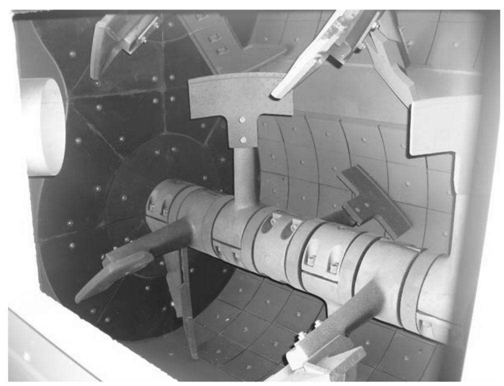

Fig. 1. Usual mixer with palettes, for concrete mixing

Also horizontal axis positioning system significantly reduces wear pads mixer drum, by exerting a low concrete wall friction as opposed to planetary or vertical axis mixers.

2. DYNAMIC LOADS ON THE CONCRETE MIXER

Generally, the shaft loads of the mixer are subjected by the following actions:

- Torsion due to transmitted torques because of resistant forces that action over the pallets;
- Bending from transverse loads (gears, sprockets, etc.).

In this study, the second type of actions is neglected.

Because particles can vary over the maximal admissible dimension (regulated by national standards), they give an irregular functioning to the equipment or, sometime, they are blocking the horizontal shaft motion. In figure 2 is given an example of the response of the system subjected to a shock input.

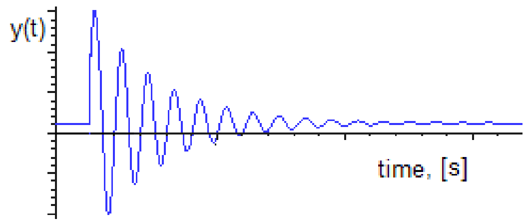

Fig. 2. Response of signal vs time

In this case, the system response *y(t)* may be written by the following expression:

$$y(t) = y_t(t) + y_s(t) \tag{1}$$

where $y_t(t)$ denotes the transient response;

$y_s(t)$ - the steady-state response.

When we analyze the rotation motion of systems we choose coordinate system (n,t) and we project the resistance forces that are acting on the palette (fig. 3).

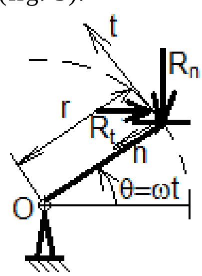

Fig. 3. Schematic representation of the forces that act on the palette

The coordinates of forces and torque can be written according to the following expressions

$$F_t = -\sum_{i=1}^{k}\left(R_{ni}\cos\varphi + R_{ti}\sin\varphi\right), \tag{2}$$

$$F_n = \sum_{i=1}^{k}\left(R_{ni}\sin\varphi - R_{ti}\cos\varphi\right), \tag{3}$$

$$M_z = -r\sum_{i=1}^{k}\left(R_{ni}\cos\varphi + R_{ti}\sin\varphi\right), \tag{4}$$

where k represents the number of palettes, φ is the inclination of the palette on the arm, r is the radius of disposal of the palettes.

Here, R_t is the tangential component of the mixing resistance, and R_n is the normal component of the same resistance.

Most common behavior of mixer shaft consists of a fluctuating torque in combination with a fluctuating moment and that is subjected to fatigue.

The torque of mixer shaft can be calculated as

$$M_{shaft} = \frac{P}{n}\eta\,, \tag{5}$$

where P represents engine power; n – revolution per minute; η - efficiency.

3. MODELING OF MECHANICAL SYSTEM USING SIMMECHANICS

This paper focuses on studying the transient regime of the concrete mixer using SimMechanics, a toolbox for Matlab/Simulink environment.

The basic elements that compose a mechanical system are: inertia (mass or moment of inertia), spring (translational or torsional) and damping (translational or dashpot).

The main components of mechanical systems of mixer equipment (shaft and arms) were modeled such elastic elements.

Stiffness coefficient value of components was obtained from its geometry after 3D modeling (fig.4) and material modulus of elasticity in shear.

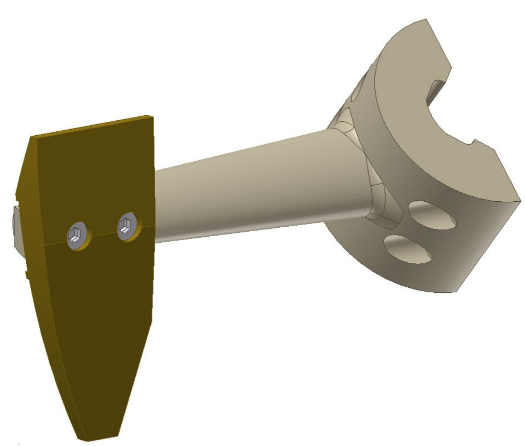

Fig.4. Modelling of the palette-arm system [1]

The mechanical system was modeled in Matlab/SimMechanics which contains a complete set of block libraries for modeling machine parts. [3].

The model given in fig.5 represents the block diagram of the mechanical system.

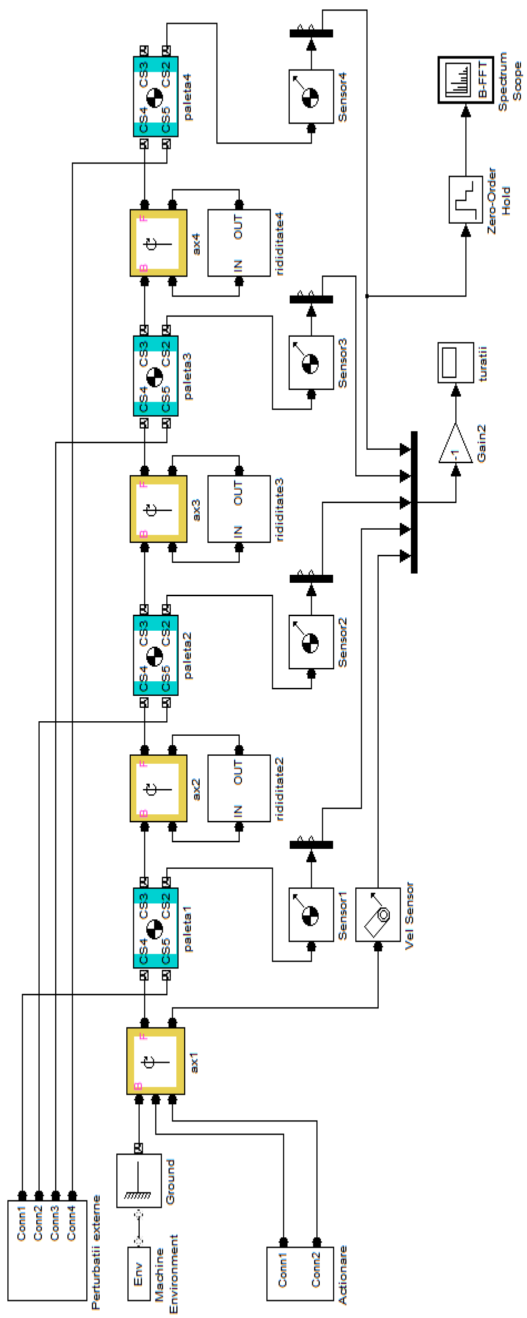

Fig. 5. Model of mechanical system in Matlab/SimMechanics

4. SIMULATION OF MIXER WORK

To simulate the working regime of the mixing equipment the following assumptions were made:

- Power source is an electric engine;
- Shaft mixer is equipped with four arms;
- On during mixing process (at time *t=0.8 s*), at the palette appears one obstacle that it disappears after 0.2s when it hits the palette;
- Obstacle appears at the interface between the third palette and the drum mixer;
- Input parameters are the torque and the angular velocity of the shaft engine;
- Output parameters are the angular speed and the resistant torque at each arm with the palette.

In table 1 are given the main parameters whose are needed for numerical simulation.

Table 1. Input parameters

Parameter	Value
Engine power for mixing	30 kW
Angular speed	0.65 rad/s
Specific resistance to mixing	1.5 daN/cm^2
Radius of disposal of palettes	0.5 m
Resistance torque	4 kNm

Simulation of the shaft blocking movement and resumption of nominal work regime of the mixer emphasize the existence of a short-term transient phase.

In consequence, during the 0.2 s (from 0.8s to 1s) the torque created by the obstacle resistance with respect to the mixer shaft has an irregular behavior until motion becomes stable (when palette passes over the obstacle).

The envelopes of signals (analyzed torques) are shown in fig. 6. When hitting the obstacle of the third arm of the mixer, in Figure 7 it is observed that the maximum peaks of the transient phase correspond to the last arm movement. From upper and lower envelopes of vibration signals (angular speeds of those four arms) we find its mean. After, wards we find the difference between the original signal (reference value of angular speed) and the mean value. The results of the analysis showed different irregularities of those signals, given in table 2.

Table 2. Angular speeds of the palettes arms

Angular speed [rad/s]	$\omega_{1,2}$	ω_3	ω_4
Maximum value [rad/s]	1.35	2.05	2.2
Reference value [rad/s]	0.65		

The effects of vibrations to mechanical system must be minimized so that the safety index must be at limited value.

One solution could be a suitable modification of parameters may also reduce the excitation level. For example, by changing the shape palette arm, the inertia and stiffness are suitably modified to reduce the response of mechanical system to an external excitation. In this way, the free vibrations into mechanical elements may disappear after a shorter time.

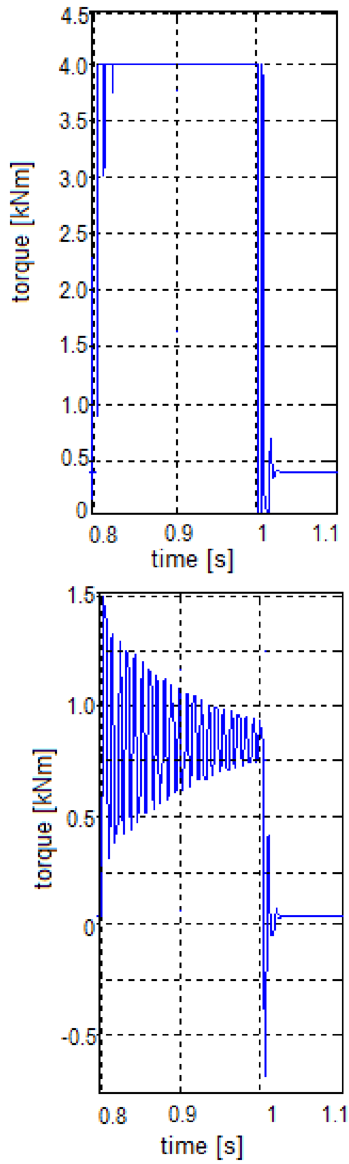

Fig. 6 Torque vs time
a) at the engine shaft;
b) at the third palette.

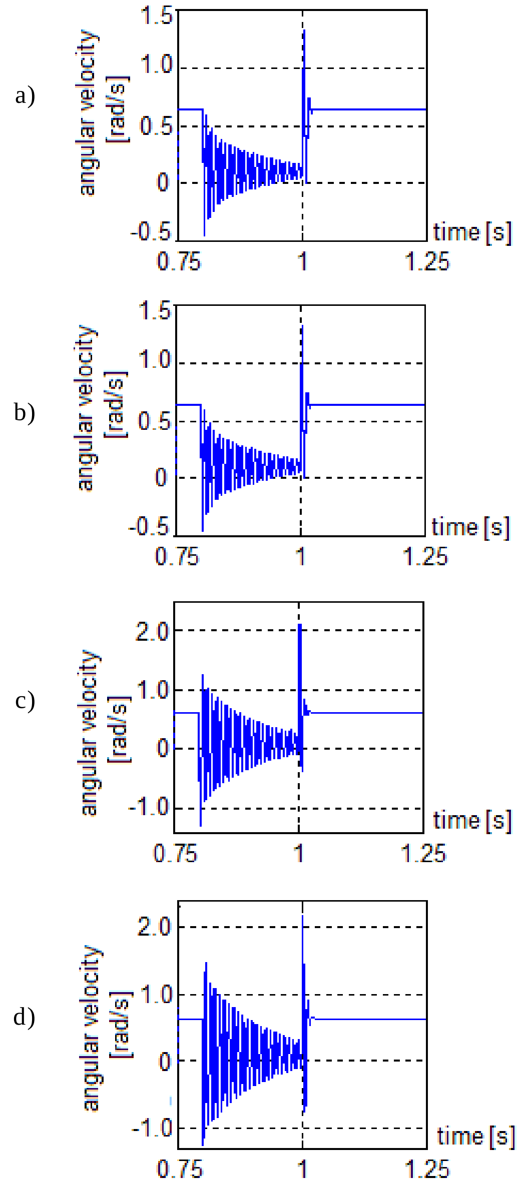

Fig. 7 Angular velocity vs time
a) at the engine shaft; b) at the first and second arm; c) at the third arm; d) at the fourth arm.

5. CONCLUSIONS

In this paper, using SimMechanics/Matlab, modeling and simulation of mechanical equipments (concrete mixer) are presented.

These simulations were useful to understand the influence of disturbance action effect on the dynamics of the entire mechanical system. Vibrations to which are subjected the elements of concrete mixer is undesirable because of unwanted noise, high stresses, undesirable wear, etc.

The results could be useful for establishing adapted control laws for maintaining a uniform motion of mixer during working process.

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