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ADVANCED MODELLING OF THE KARAKURI MECHANISM

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ABSTRACT

Karakuri is a mechanical device that utilizes natural physical phenomena (most frequently gravity force and electromagnetism) and elemental mechanisms (cams, springs, levers, rollers etc.) to perform handling operations in a less-energy or low-energy mode. Karakuri mechanisms as part of so-called low cost automation (LCA) are usually utilized for handling operations. The paper deals with the advanced modelling of the mechanical behavior of the karakuri trolley that uses accumulation of potential energy in compression springs. The presented research was focused on the mechanical characteristics of the specific karakuri trolley that has significant potential for use in industry or services.

Keywords: low cost automation, karakuri, equations of motion, modelling, mechanism.

INTRODUCTION

A new phenomenon in the low cost automation design is among others need for energy consumption reduction. This aspect leads to the so-called low-energy or no-energy automation. One of this forms of LCA are karakuri mechanisms with their minimal impact on the environment. During last two decades karakuri-based devices were designed and realized mainly in the automotive industry to save energy, to decrease work-load or to reduce time of production or handling operations. Theoretical and practical problem of karakuri mechanisms is their mechanical behavior. For this reason a research aimed at karakuri trolley (Fig. 1) mechanical behavior mainly at the reversal points was realized.

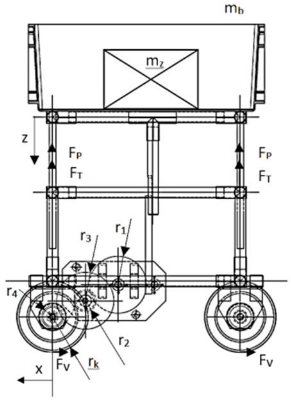

Fig. 1 - Experimental karakuri trolley

Theoretical part of the research was focused on the behavior of dynamical systems with friction damping described by the differential equation of motion of 2nd order (1). The equation was solved using mathematical software MAPLE with graphical output. The method of weight reduction trolley with consideration of the influence of friction in moving parts was utilized.

$$m_r\,\ddot{x} + 4\,k\,\frac{r_2 r_4}{r_3 r_k}\left[z_0 + \frac{r_2 r_4}{r_3 r_k}(x - x_0)\right] = \left[(m_b+m_z)\,g - 4\,F_T\right]\frac{r_2 r_4}{r_3 r_k} - m_{celk}\,g\,\frac{\xi}{r_k}$$

$$\overset{*}{m}_r\,\ddot{x} + 4\,k\left(\frac{r_2 r_4}{r_3 r_k}\right)^2 x = \left[(m_b+m_z)\,g - 4\,F_T\right]\frac{r_2 r_4}{r_3 r_k} - m_{celk}\,g\,\frac{\xi}{r_k} - 4\,k\,\frac{r_2 r_4}{r_3 r_k}\left(z_0 - \frac{r_2 r_4}{r_3 r_k}\,x_0\right) \qquad (1)$$

The dynamic behavior of the karakuri trolley has also been tested through repeated physical measuring of time and distance by standard measuring instruments, calibrated scale and by video-records analysis. The goal of research was also compare theoretical and experimental values from the point of view of travel and velocity.

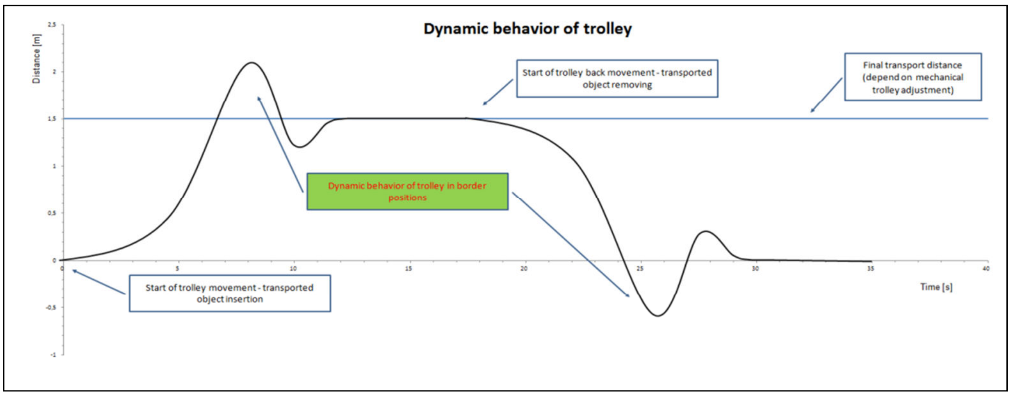

Fig. 2 - Curve describing mechanical behavior of karakuri trolley

RESULTS AND CONCLUSIONS

The results obtained by calculations and experiments showed for instance the following:

- Both traveled distance and velocity of trolley depend on weight of transported object.
- Mechanical behavior depends on the stiffness of the springs and friction.
- Distance travelled by karakuri trolley can be extended by utilization of the kinetic energy accumulation to the deformation energy of compression springs at the reversal points.

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