Modernization of a vibrating machine

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Abstract: This paper deals with a structural modification of parts of a vibrating machine and subsequent verification of the functionality of individual components and the whole unit. A new concept of driving parts was developed as a part of the machine modernization. It allows to improve the functionality and extends the capabilities of the machine settings. Because an intervention in the driving parts was considerable a re-design of bearings and drive shafts had to be carried out.

Keywords: Vibrator; bearings; centrifugal force.

1 Introduction

The machine which was modernized is a vibrator for technological purposes. This device is used during manufacturing of building blocks which are compacted while shaking. The device is a part of a loading machine which fills a mold with concrete and compacts it to its shape. The function of the device is based on forced rotation of eccentric weights placed on a rotating shaft. This system is put into motion by an electric motor through a V-belt. The vibrating machine consist of a pair of vibrating housings on a common base. The original design was working properly but was outdated and difficult to operate. The main requirement of this modernization was to enable force effect changing of the vibrator without a need of stopping.

2 The original design

The original design of one vibrating housing consisted of two eccentric weights on one shaft. This shaft was mounted on four bearings (two radial ball bearings and two radial roller bearings) which were placed at both ends of the shaft. Two eccentrics were located between the bearings. This type provided the compact size of bearings as the force distribution was favorable. This original solution did not satisfy the terms of maintenance during changing of the vibrator force. The force effect of the vibrator could be changed by mutual rotation of two eccentrics but only at a standstill of the machine and after removing of related covers.

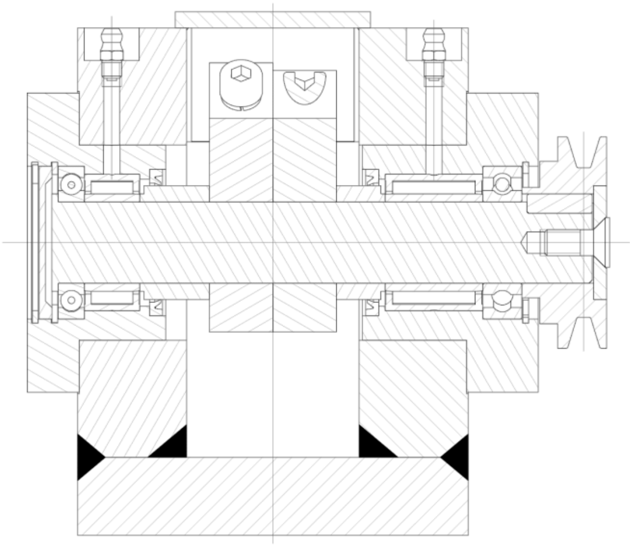

Fig. 1: The original design

3 The upgraded design

The original solution was sufficient in terms of functionality but not in terms of efficiency. It was necessary to change the design to allow adjustment of the intensity of vibration without stopping the machine. The ideal way to achieve this requirement was to split each vibrating housing into two parts so that the eccentrics can be continuously mutually turned. Vibration intensity is then given by a phase rotation of the eccentrics in each housing. This design change necessitated the addition of a second driving servo-motor and adding of a second drive train with a toothed belt. The vibrator is put into operation with no vibrating effect and the vibration can be turned on and off as needed by rotating of one eccentric weight about a desired angle.
The shaft was divided into two shafts during upgrade. Each shaft carries its own eccentric and is supported by two bearings. Force effects acting on the shaft bearings after the split are substantially more unfavorable which is reflected in size of the bearing. The position of bearings had to be modified as well.

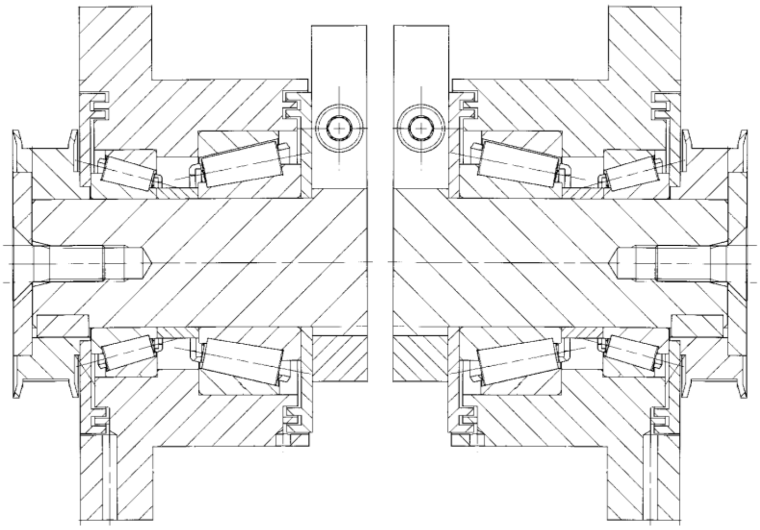

Fig. 2: The upgraded design

3.1 Inertial moments

The first requirement was to choose a right servo-motor by the starting torque to reach machine's operating speed. Each of the drive branches includes a pair of shaft with eccentric cams, two idler pulley and one drive pulley. Effect of individual components was examined based on the inertia and rotating speed of those geared parts.

Tab 1. : Effects of inertial moments

Component	Percentage effect	Inertia moment of components
Motor	*2%*	$408\ mm^2 \cdot kg$
Pulley 26t	*12%*	$222\ mm^2 \cdot kg$
Pulley 56t	*27%*	$4637\ mm^2 \cdot kg$
Shaft + Eccentric weight	*59%*	$1089\ mm^2 \cdot kg$

Total time dependence of starting torque could be examined after considering effects of all rotating parts.

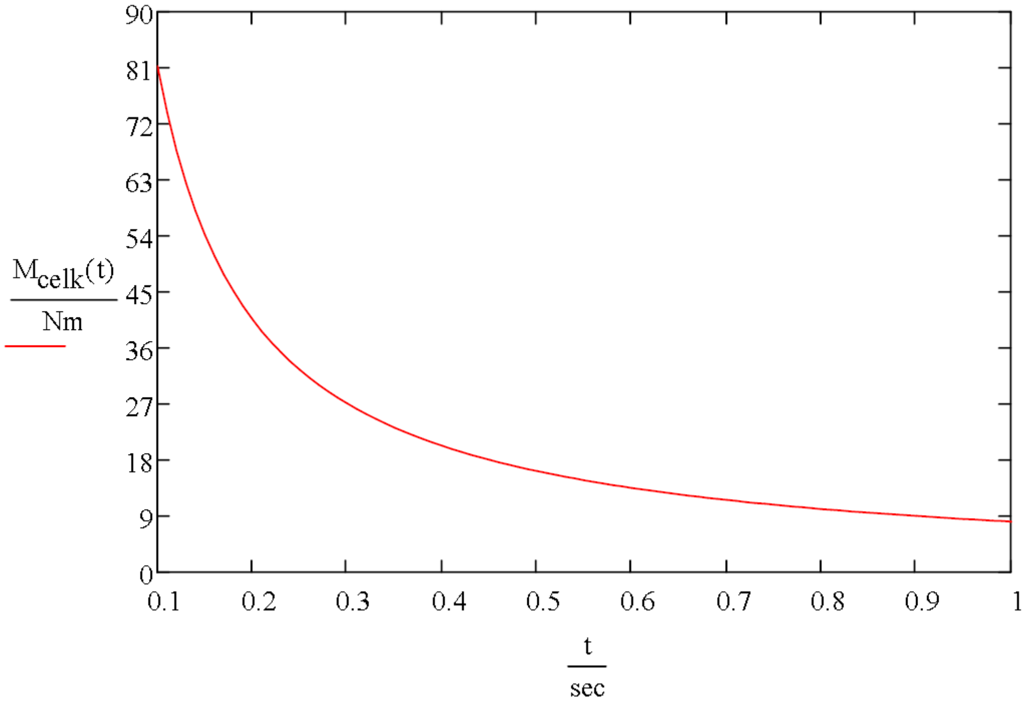

Fig. 1: Time dependency of starting torque

As the force effect of the vibrator is changed by rotation of one eccentric weight it was necessary to verify this motor torque demands as well. This torque is again dependent on the amount of time needed to make this adjustment. This dependence is described in the following graph.

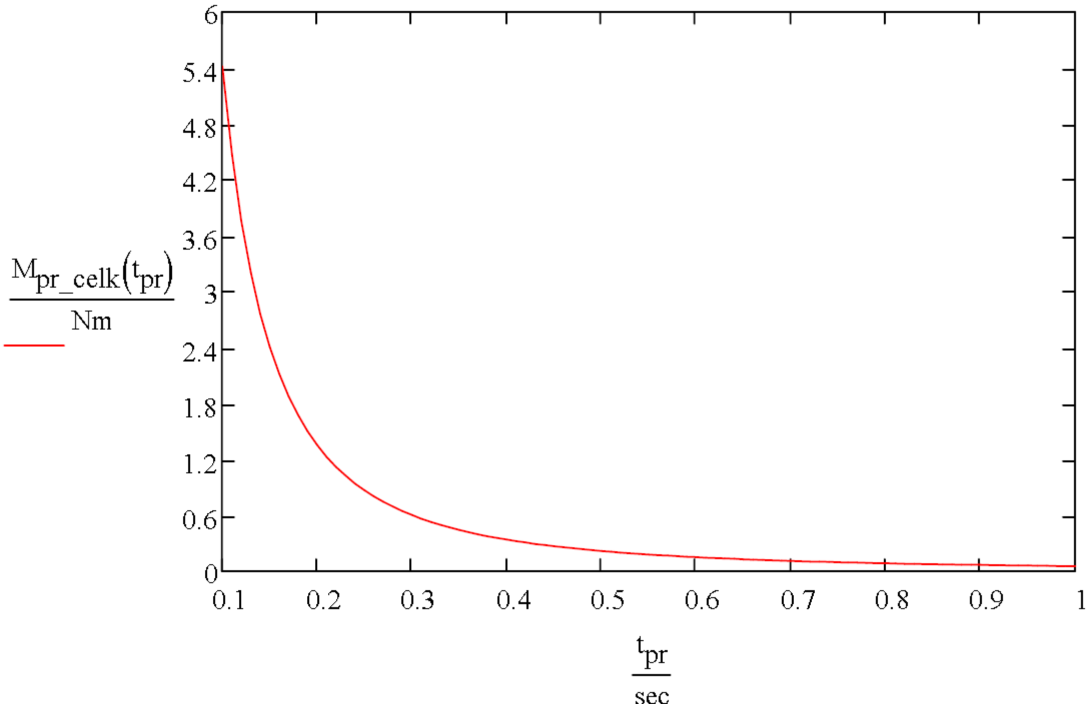

Fig. 2: Time dependency of mutual rotation torque

3.2 Centrifugal forces

Another requirement was to design appropriate bearings. Since each of the shafts is a beam on two supports it was necessary to determine bearing reactions. These reactions depend on the centrifugal force (Fd) generated by the rotation of the eccentric weights.

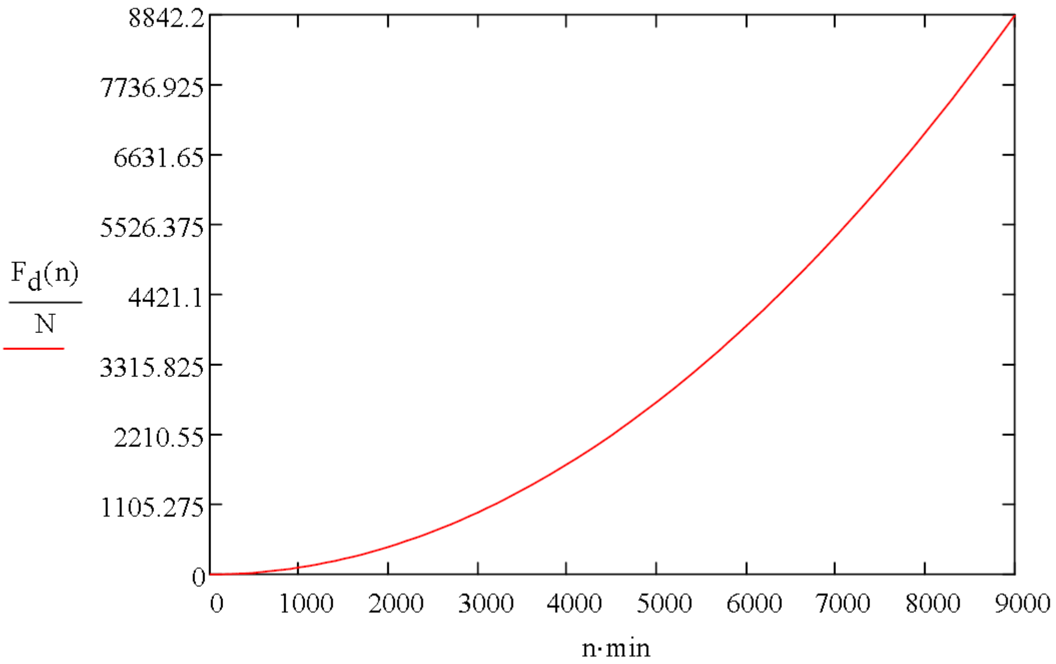

Fig. 3: Revolutions dependency of centrifugal force

The machine operates at three different states which are 9000 1000 and 5000 revolutions per minute. As the shaft is supported beam, the centrifugal force (Fd) generates reactions in the bearings. The table below contains calculated reactions in the bearings for each state.

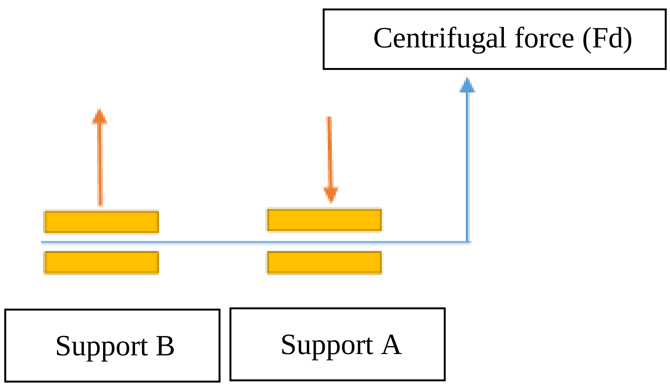

Fig. 4: Shaft support scheme

Tab 2: Reaction forces

Operation state	Reaction force (support A)	Reaction force (support B)
State 1 (Fd = 8 842 N)	*13 008,41 N*	*4 166,21 N*
State 2 (Fd = 109 N)	*428,68 N*	*319,51 N*
State 3 (Fd = 2 729 N)	*4 609,74 N*	*1 880,66 N*

Compared to the original solution, the new concept with the split shafts has disadvantage in terms of force effects and the bearings had to be adjusted from the original proportions to higher dimensional ranges. Bearing type had to be changed to the taper bearing which is characterized by reducing the force ratios by moving the shaft support towards the eccentric weights.

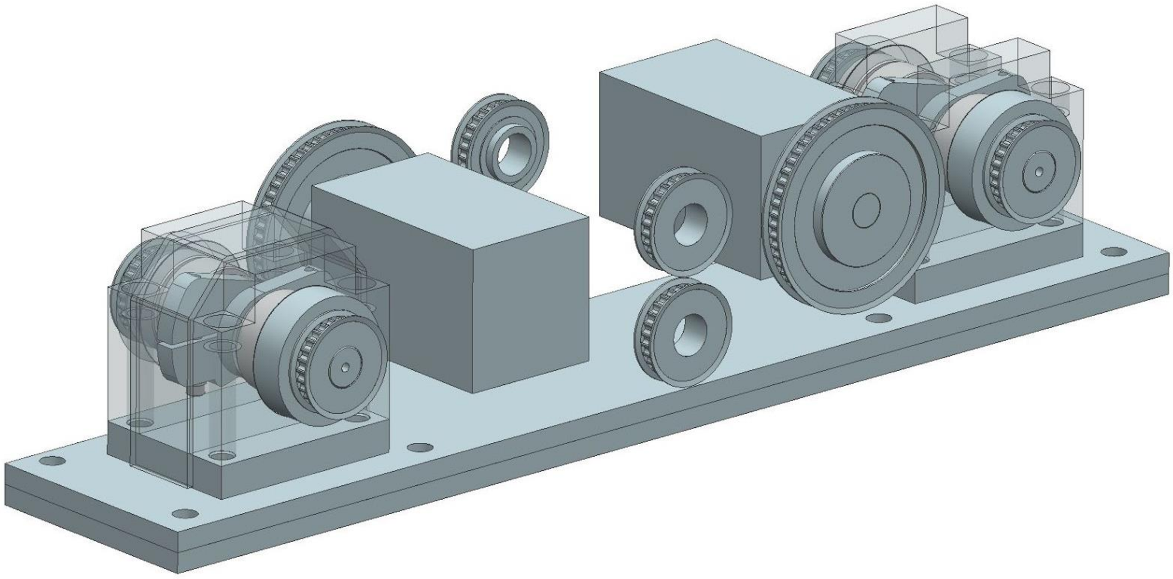

Fig. 5 : Design structure of improved device

4 Conclusion

The modernization of this vibrator was made by dividing driven shafts to separate controllable groups which extended the functionality of the device. This extension is especially advantageous in terms of service but also in terms of technological processes. The force effect of the vibrator can now be changed while running and quickly adapted to the actual requirements of a vibrated product. The new design meets all the requirements and can be safely put into operation.

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