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LABORATORY TESTS OF A GENERATOR FOR A LINEAR MR DAMPER

LABORATORNÍ TESTY GENERÁTORU MR TLUMIČE

Abstract

The paper is devoted to laboratory testing of an experimental electromagnetic generator supplying a linear magnetorheological (MR) damper. The structure of the generator is briefly outlined. Results of experiments performed for the generator during the idle run and under load are discussed.

Abstrakt

Tento příspěvek popisuje laboratorní testy experimentálního elektromagnetického generátoru podporující lineární MR tlumič. Dále je popsána základní struktura generátoru a výsledky experimentů činnosti generátoru během nečinného a pracujícího stavu.

1 INTRODUCTION

The study deals with the electromagnetic-energy harvesting technique that utilizes a magnetic field for the mechanical to electrical energy conversion, according to the Faraday's law. This technique uses the relative motion between the coil and permanent magnet which causes a change of the magnetic flux that induces voltage in the coil.

The work provides selected results of laboratory tests conducted for the generator developed for a linear MR damper of RD-1005-3 series of Lord. Co. [3]. The aim of tests was to prove the adequacy of numerical study of the generator described in [1].

2 DESCRIPTION OF THE GENERATOR

The schematic diagram of the generator which displays the axial symmetry is shown in Fig 1 [2]. The generator incorporates two systems of permanent magnets, upper (1) and lower (2), and a cylindrical coil (3). The magnets are ring-shaped magnets with axial magnetization and fixed on a non-ferromagnetic rod (6). The magnets are arranged such that their poles are alternating and the directions of magnetization are indicated with an arrow. The systems of magnets generate the magnetic field in the coil region, with the predominant radial component of magnetic flux density. In the spacing between the systems of magnets there is a ferromagnetic spacing ring (5). The coil, wound onto a carcass (4), has an insulated foil winding covered by copper. The generator is placed inside a ferromagnetic casing (7).

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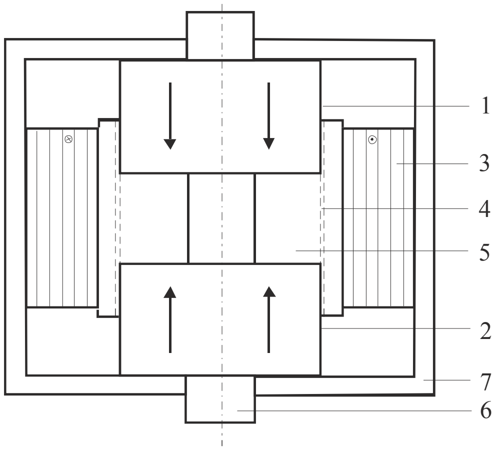

Fig. 1. Schematic diagram of the generator

3 RESULTS OF GENERATOR TESTING AND DISCUSSION

The schematic diagram of the experimental setup in which the generator was tested is shown in Fig. 2. The generator and the RD-1005-3 damper were held in the testing machine (Model 835 Damper Test System) of MTS Systems Co. [4] by a special handle. The data acquisition system was based on a PC with and a multifunction card installed, and supported by LabView environment running on MS Windows.

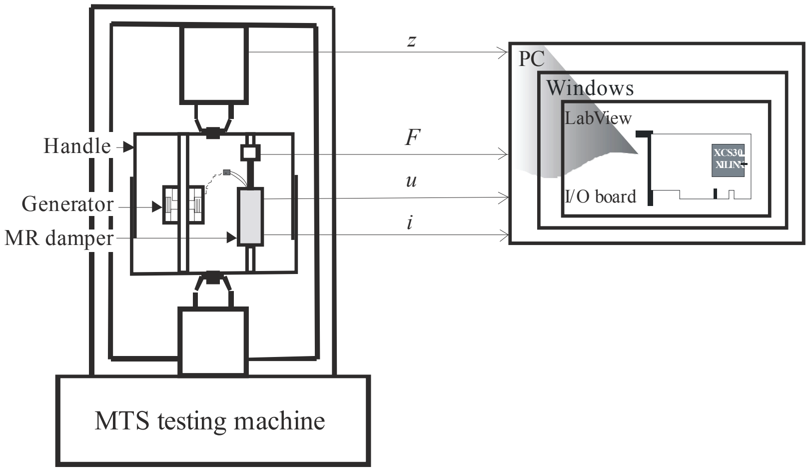

Fig. 2. Schematic diagram of the experimental setup

The testing machine was programmed to produce triangular and sine displacement excitations of the piston with the amplitude of 7 mm and frequency in the range (0.5, 6.5) Hz and thus enabling us to achieve the velocity of the damper piston in the range (14, 160) mm/s. The data were acquired in 10 cycles (a cycle is denoted as a piston displacement up and down). The sampling frequency for each channel was 1 kHz per cycle.

The generator was first tested during the idle run, when no connection was provided between the generator and the damper and then under load, when the generator was connected with the damper. When the generator was tested during the idle run, we measured the voltage *u* at the generator output and damper force *F*. Under load condition, measurements were taken of the voltage *u* and the current *i* in the damper coil and damper force *F*. Selected results of measured quantities are shown in Figs 3−7.

a) b)

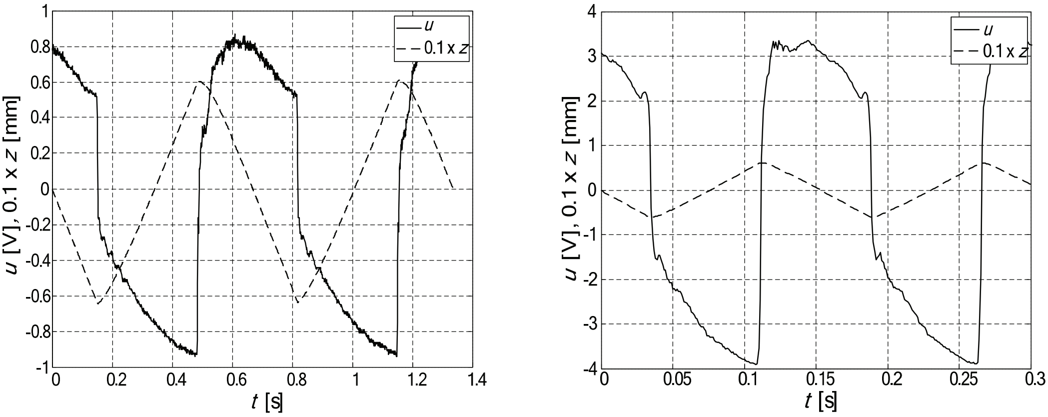

Fig. 3. Voltage *u* for displacement excitation of the piston *z* with frequency: a) 1.5 Hz, b) 6.5 Hz

a) b)

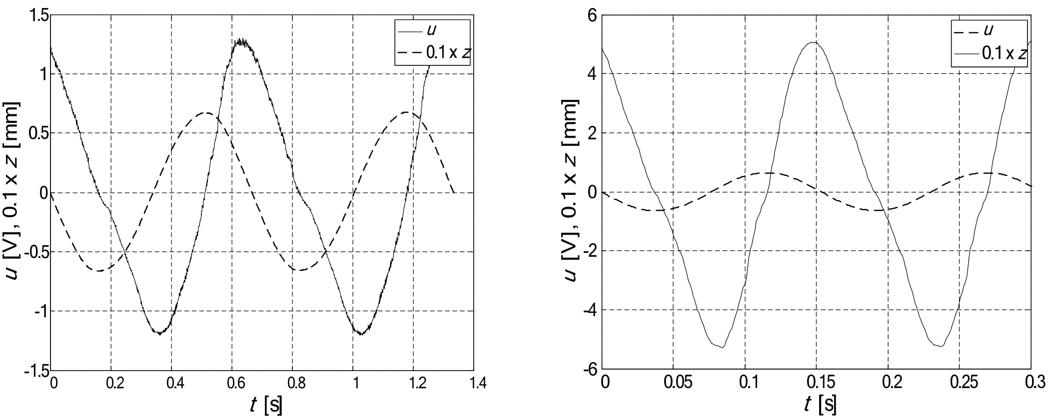

Fig. 4. Voltage *u* for sine displacement excitation of the piston *z* with frequency: a) 1.5 Hz, b) 6.5 Hz

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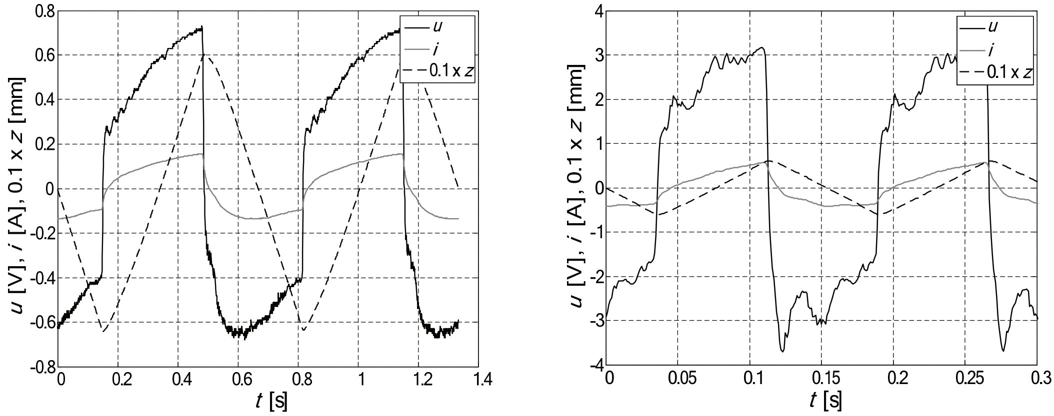

Fig. 5. Voltage *u* and current *i* for triangular displacement excitation of the piston *z* with frequency: a) 1.5 Hz, b) 6.5 Hz

a) b)

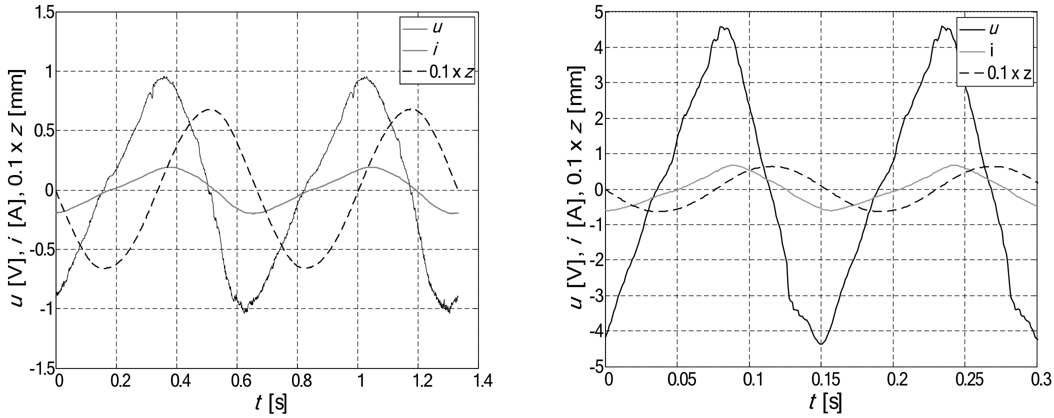

Fig. 6. Voltage *u* and current *i* for sine displacement excitation of the piston *z* with frequency: a) 1.5 Hz, b) 6.5 Hz

The plots in Figs 3 and 4 present the voltage induced in the damper coil *u* measured during the idle run for triangular and sine displacement excitation of the piston *z* with frequency 1.5 and 6.5 Hz.

Tests performed during the idle run reveal that the higher the piston velocity (i.e. larger frequency of displacement excitation), the higher voltage *u*. For example, under triangle excitations with the frequency 1.5 and 6.5 Hz, the effective voltage is 0.69 and 2.93 V respectively, whilst for sine excitations it equals 0.82 and 3.41 V.

The plots in Figs 5 and 6 present voltage *u* and current *i* obtained under load for triangular and sine displacement excitation of the piston *z* with frequency 1.5 and 6.5 Hz. Tests performed under load show that the higher the piston velocity, the higher current *i*. For example for triangle displacement excitation with the frequency 1.5 and 6.5 Hz, the effective current is 0.11 and 0.35 A respectively , whilst for sine excitations it equals 0.13 and 0.41 A. Reduction the *u* is the consequence of voltage drop on the internal impedance of the generator.

The plots in Figs 7 show the force produced by the damper *F* measured during the idle run and under load for triangular displacement excitation of the piston *z* with frequency 1.5 and 6.5 Hz. The data obtained during the idle run show only the influence of the piston velocity (frequency of displacement excitation) on the force *F*. Tests performed under load illustrate the effects of the current level in the coil on the force *F* whose role dominates that of the piston velocity.

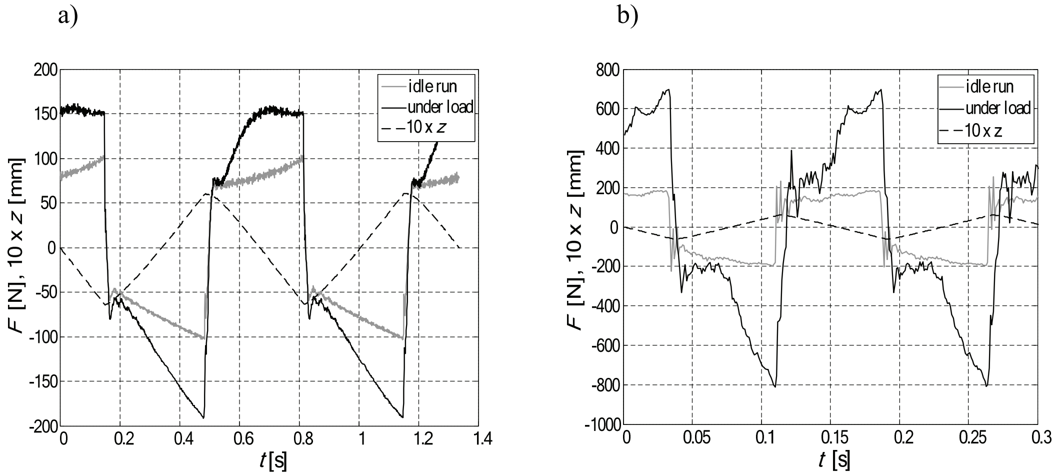

Fig. 7. Force during idle run and under load for triangular for displacement excitation of the piston *z* with frequency: a) 1.5 Hz, b) 6.5 Hz

4 CONCLUSIONS

The work presents the structure and selected results of laboratory tests conducted for the electromagnetic generator developed for the RD-1005-3 damper. The obtained results of voltage and current confirm the adequacy of the generator's design. The range of the measured force corresponding to voltage and current fluctuations guarantees that the generator should perform well in applications projected in the scientific research project.

ACKNOWLEDGEMENTS

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