Energy Harvesting Potential of Piezoelectric Materials from Train-Bridge Interaction using Finite Element Modelling

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Summary

This paper investigates the potential for the harvesting of energy from the interaction between a train and a bridge through the use of piezoelectric materials. Two piezoelectric materials are considered in this regard, Lead Zirconate Titanate (PZT) and PolyVinyliDene Fluoride (PVDF). A finite element analysis of train bridge interaction is carried out. The friendliness of the different trains in terms of energy harvesting potential is assessed and quantified. The speed zones conducive to maximum harvested energy are identified. The use of train-bridge interaction ensures that the energy harvesting is carried out while the bridge is under operational conditions, with minimal to no impact on the existing operation of the bridge or the rail network during energy harvesting operations. The approach is useful in terms of designing a new generation of smart bridge infrastructures and potential retrofitting of existing structures.

Keywords: energy harvesting, piezoelectric, train-bridge interaction, finite element analysis.

1. Introduction

The potential of energy harvesting from large scale civil infrastructure elements has received little investigation till date. The aim of this paper is to investigate the potential levels of energy harvested from train-bridge interaction through the use of PZT and PVDF based harvesters. A three dimensional finite element model of train-bridge interaction is created in this regard. The level of generated energy from two trains at varying speeds is presented. Also investigated are two trains passing from opposite directions at varying speeds and the effect of such on energy harvesting levels.

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2. Modelling of Energy Harvester

Two piezoelectric materials were chosen for use as the basis of the energy harvester, one ceramic material, Lead Zirconate titanate (PZT), and the other a polymer, PolyVinyliDene Fluoride (PVDF).

3. Modelling of Train-Bridge Interaction

Two locomotives were chosen for the purposes of this paper, a 071 Loco and a 201 Loco in Republic of Ireland. Strand7 finite element software was used for the modelling of the train-bridge interaction (Fig. 1). Voltage generated due to passage of vehicle for the two piezoelectric solutions are presented in Fig. 2.

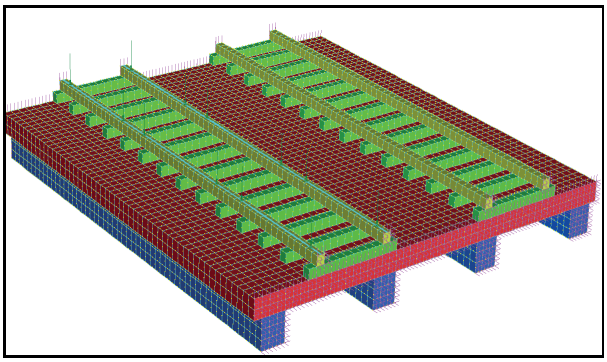

Fig. 1: Three Dimensional Finite Element Model

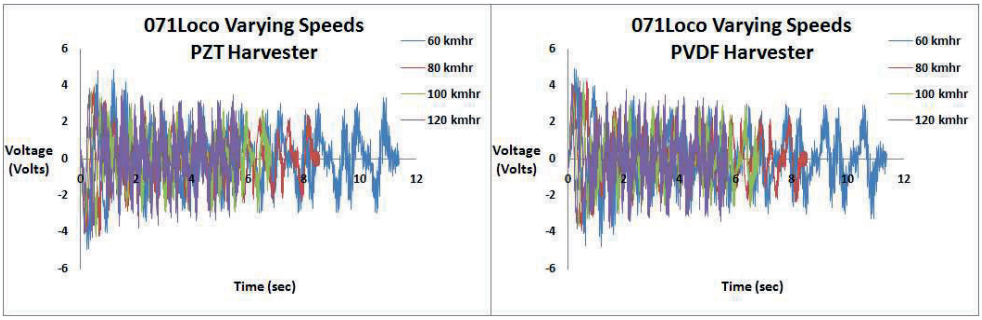

Fig. 2: Harvester Voltage Output for 071Loco Single Train at Varying Speeds

4. Conclusions

Two piezoelectric based energy harvesters were investigated for the purposes of energy harvesting from train-bridge interaction, one created using PZT and the other PVDF. A Finite Element model of Train-Bridge interaction was created and analysed for two trains. It was observed that energy harvesting from train-bridge interaction is feasible and that both a PZT and PVDF based energy harvesting system offer a viable energy source.