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Performance requirements for vibration dampers

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Abstract

An analysis method introduced in a recent paper has been applied to four ACSR conductors. Calculations are carried out to further illustrate the method, showing the relationship between wind energy input to the conductor and energy loss from the conductor when it is vibrating at a constant loop velocity equal to 200 mm/s. The difference between the two energy curves defines an energy gap or shortfall that must be supplied by vibration dampers. This energy gap is seen to depend strongly on the conductor tension, the conductor diameter, and the conductor span length. An illustration is given showing how well a Stockbridge damper or an impact damper fills the energy gap. One additional illustration is given applying the same principles to a triple-conductor bundle and an impact type of damping spacer. Finally, field tests conducted earlier on the four sample conductors are compared with the calculated results.

Keywords: Damping devices; Vibration dampers; Transmission line vibration; Conductor vibration

1. Introduction

It has been more than seventy years since G.H. Stockbridge, Superintendant of California Edison Company, experimented with a 230 kV transmission span of 1000 ft (300 m) length [1]. His experiments included: (i) a solid 6 ft (1.8 m) aluminum spiral wrap over a 300 ft (90 m) length of the conductor; (ii) a festoon of 660 kcmil ACSR conductor; (iii) a 30 in. (0.8 m) length of cable with two 7 lb (3.2 kg) concrete weights; and (iv) a canvass bag of loose iron pieces.

The first two did not work very well in the control of conductor vibration. The last two worked quite well. The third type has become known as the Stockbridge type of damper, and the fourth type as the impact type of damper. Both enjoy widespread use in the control of aeolian vibration today.

This paper considers the quantitative prediction of damper requirements in terms of energy or power dissipation as a function of either frequency or wind speed. The two are interchangeable through the Strouhal relation, which also involves the conductor diameter.

In a recent paper, Richardson developed the general methodology including the wind energy input and the conductor energy loss [2]. A clearly defined energy deficit exists which must be made up by external dampers. The wind energy input is based on the early work of Farquharson and McHugh [3] and the analysis of the dynamic features of the conductor span on the work of Claren and Diana [4]. The conductor span is considered to have an infinite number of vibration modes, each occurring at a discrete vibration frequency, and each having an integer number of loops in the span. At any particular time the wind may excite two or three modes which combine to form a vibration characterized by beats, or by narrow-band noise.

The maximum loop (antinode) amplitude is considered to be moving at a maximum loop velocity of 200 mm/s. Damper requirements are developed for that loop velocity (IEEE limit).

Recently a revised *IEEE Guide on the Measurement of the Performance of Aeolian Vibration Dampers for Single Conductors* [5] was published and included several recommended methods for laboratory testing of dampers. This paper is written to be consistent with that guide. In another paper, by Diana et al. [6], power measurements are presented based on the testing of a damper on a laboratory span. Two examples are given in the present paper, showing how to match either Stockbridge damper tests as in Ref. [6] or impact damper tests as in Ref. [5] with specific requirements obtained by calculation.

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Table 1
ACSR conductors for wind energy calculation

Case no.	Ref. no	Conductor diameter		Span length	
		(in)	(mm)	(ft)	(m)
1	[7]	1.24	31.5	1484	452
2	[8]	1.24	31.5	2165	660
3	[9]	1.20	30.5	1201	366
4	[9]	1.38	35.0	1201	366

The calculation method is introduced by way of four specific examples chosen to illustrate a range of diameters and span lengths. A calculation example is also included for a triple-conductor bundle. In the case of a single conductor the effect of changing tension on vibration damper requirements is illustrated. In the case of a triple-conductor bundle an impact type of damper is matched to the power required.

Finally, the calculated results for the four case studies are compared with field test data for each case [7–9]. The method of comparison uses the loop velocity of 200 mm/s to define a 'cross-over wind speed'. That wind speed is where a balance is achieved between wind energy and conductor loss. The calculations compare favorably with the field tests.

2. Calculations

Calculations were performed using the methods described in Ref. [2]. The wind energy is based on the formula fitted to the wind tunnel data of Ref. [3]. The energy loss in the vibrating conductor is based on the formula introduced in Ref. [2], and on actual vibration tests on a span length of 144 ft (44 m) of an Ortolan ACSR conductor. Four case studies are considered having the parameters listed in Table 1. The four case studies are shown in graphical form in Fig. 1(a)–(d). The format of the graph is a plot of wind energy input and of energy loss versus wind speed.

The wind energy is a series of computed points while the energy loss is a linear curve. Each is calculated assuming that the given conductor is vibrating in sine

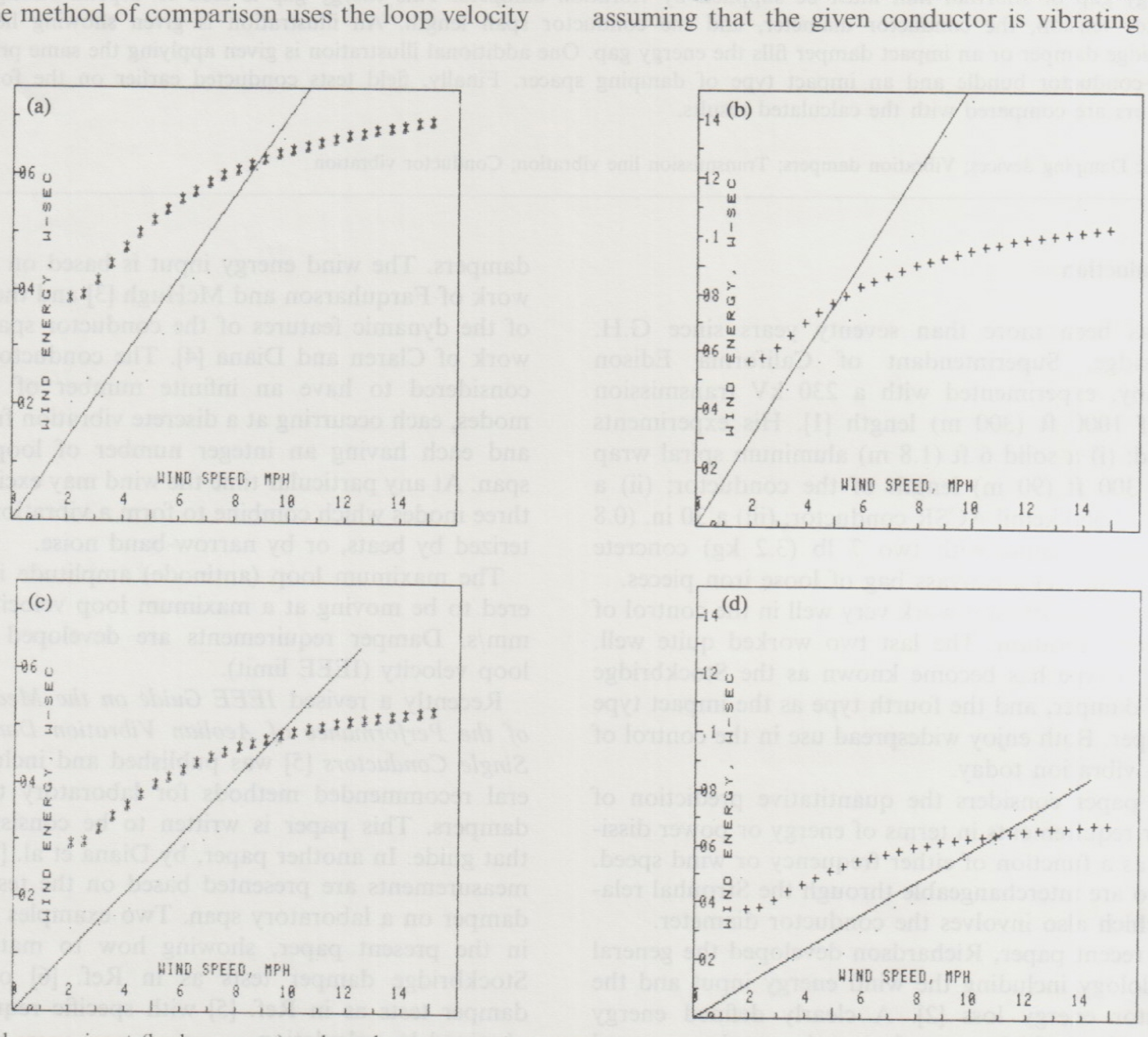

Fig. 1. Wind energy input (broken curves) and conductor energy loss (full curves) vs. wind speed: (a) case 1; (b) case 2; (c) case 3; (d) case 4.