In this paper the parametric excitation of vibrations in printing machines is analysed both experimentally and theoretically. Initially, selected results from experimental studies of these drive-belt-induced torsional vibrations are discussed. For this, twelve different drive belts are used during experiments at a test rig and at a sheet-fed offset printing machine. Measured vibration amplitudes from machine and test rig correlate very well. Depending on the chosen drive belt, large vibration amplitudes occur during printing in the vicinity of a critical production speed, where the first drive belt order coincides with the machine’s first eigenfrequency. This results in a clearly visible rhythm during printing and is therefore unacceptable. It is demonstrated experimentally, that active vibration control can be used successfully to reduce these parametrically excited torsional vibrations in sheet-fed offset printing machines. Furthermore, the machine is modelled as a dynamical multi-degree of freedom system with time-periodic coefficients, and the parametric excitation of torsional vibrations is studied numerically. First, a numerical stability analysis is carried out employing Floquet theory. The system’s damping parameters are derived from measured machine data. Accordingly, a simulation model with drive control results in parametrically excited torsional vibration amplitudes that match very well with measured amplitudes.

1. INTRODUCTION

Figure 1 schematically shows a printing machine, whose torsional vibrations are studied in this paper. Numbers 1 to 19 correspond to the rotational dof in the dynamical system that will be explained later in detail. The machine illustrated in Fig. 1 is a so-called Speedmaster XL 162-6+L, which represents a typical sheet-fed offset printing machine produced by Heidelberg Druckmaschinen AG. This type of machine has a length of 25.9 m and a height of 3.4 m, and it consists of feeder and delivery unit as well as six printing units and a coating unit as illustrated in Fig. 1. The maximum sheet size that can be handled by this machine is equal to 1.62 m × 1.21 m.

Currently, fastest sheet-fed offset printing machines print 18,000 sheets per hour (5 Hz), and typical print products of high quality include magazines, catalogues, brochures, business cards, posters, books, packages, wrappers, etc. All cylinders in a sheet-fed offset printing machine are coupled by gear wheels. Consequently, one single main drive is used to drive the whole machine via a gear train. The drive torque is transmitted by one V-ripped drive belt. This single drive belt leads to the parametric stiffness excitation of vibrations examined in this paper. In Fig. 1, the small belt pulley (dof 19) is driven by a main drive. The drive belt then transmits the drive torque to the large belt pulley (dof 18) that drives the impression cylinder of printing unit #1 etc.

Dof 1–14 are so-called paper-transporting cylinders. These cylinders contain gripper systems for transporting the sheets of paper. Each printing unit operates on three main cylinders: plate cylinder, blanket cylinder, and impression cylinder (see Fig. 1). Printing units also contain inking and dampening unit. During printing, these units contact the plate cylinder to cover the printing plate with a thin film of ink and dampening so-