1 Introduction

The aim of this thesis was to develop a mathematical model that could describe the phenomenon of self-excited oscillations of flexible tubes induced by fluid-structure interaction between the tube wall and the inner fluid flow.

The term *self-excited* means that the studied system has no oscillatory inner sources or boundary conditions, the harmonic motion originates in the system itself. Let us show some examples for the occurrence of this phenomenon in the human body:

Pedley ([**?**]) mentions that vessel collapse is most readily seen in veins, such as in the veins of a hand raised above the level of the heart or in the jugular vein when a person is standing erect ([**?**]). In arteries[1], such a collapse can be observed only in some special cases, for example in the case when additional outer pressure is applied to the artery. One example is blood pressure measurement using a sphygmomanometer cuff. During this measurement, the so-called Korotkoff sounds, which are strongly believed to be connected to these self-excited oscillations of the brachial artery wall, appear. These Korotkoff sounds are used by medical doctors for pressure diagnostics and are known from the beginning of the 20th century[2]. They disappear when the cuff is removed. Artery collapse is also probable if an artery is filled with cholesterol plaques, which stiffen its walls and restrict the blood flow.

This phenomenon is not restricted to the human body, whose physical conditions are very hard to model – thick multilayered arterial walls made of anisotropic visco-elastic material. The fluid medium – blood – itself is a complex non-homogenous non-Newtonian liquid. However, in laboratory conditions, the same self-excited oscillations can be simulated and studied in reasonably simple experimental setups. The tubes are made of homogenous elastic materials and distilled water is taken as the inner medium. Among others, let us mention an experimental study by Chlup ([**?**]), who obtained stable self-excited oscillations on latex tubes of different thicknesses and diameters, with distilled water used as the inner flow medium (see *Experimental Results* on page **??**).

Before starting to describe possible mathematical models, let us focus on the physics underlying the self-excited oscillations. There are basically two mechanisms how the self-excited oscillations work. At the beginning, the low transmural pressure initiates the first collapse of the tube[3]. During the collapse the tube is narrowed, which leads to a local increase of the fluid velocity, which in turn causes the inner fluid pressure to drop. This decreases the transmural pressure and the collapse is even accelerated. In a developed collapsed state, when opposed walls of the tube come near to each other, the frictional losses between the fluid and the tube wall and within the fluid itself cause the fluid velocity to decrease dramatically. The flow slows down (or even stops), the inner fluid pressure recovers to its former value and the tube starts to inflate again. Then the whole process starts again. We have just described the first mechanism. The second mechanism differs only in that opposed walls of the tube touch each other, which brings in the need to consider additional physics phenomena. This mechanism

[1] We are refering to large and middle sized arteries that contain, contrary to veins, elastic and collagen fibers.

[2] The Korotkoff sounds were discovered by Nikolai S. Korotkov in 1905 ([**?**]).

[3] The transmural pressure (difference of the inner and outer pressure) can be decreased by an increase of the fluid flow rate, by an increase of an outer pressure or by an increase of a pressure drop from the upstream to the downstream tube end.