The main aim of the project is to analyse the properties of tuned mass damper (TMD) with inerter and non-linear damper. TMDs are widely used to mitigate vibrations of mechanical and structural systems which translates into increase of stability, higher safety and lower operating costs. The first TMD was patented by Frahm in 1909. In 1934 Den Hartog modified it to a currently used construction. The device is a linear oscillator that consists of mass on a linear spring and linear damper. The natural frequency of the device is tuned to be identical to the damped system natural frequency. If both natural frequencies match, the motion of the main system is completely mitigated in the resonance. However, the decrease of the amplitude is observed only around the resonant frequency of the damped body. If the machine or structure is working under constant conditions (close to resonant frequency) then such TMD does what it needs to do. Nevertheless, if the excitation frequency is changing, we have to be aware that the TMD causes the appearance of two new resonances – one before and one after the resonant frequency of the main body. The increase of the amplitude is always dangerous and may lead to failure or damage of the system. For this reason, scientists are continuously developing new – better and more efficient TMDs constructions, which are suitable to damp out vibrations in a wide spectrum of excitation frequencies.

Recently, there are a lot of papers showing the advantages of non-linear components of the TMD (non-linear spring and non-linear damper). Spectacular reduction of the main body amplitude is observed for the TMD with purely nonlinear spring. Such TMD does not have a natural frequency, hence it can absorb energy in a wide spectrum of frequencies. However, due to the non-linear characteristic of this device, it cannot be applied in all cases because there is a risk of the coexistence of different solutions for the same values of system's parameters.

Inerter has been introduced in early 2000s by Malcolm C. Smith. Recently we observe a rapid increase in the amount of papers devoted to the dynamics of systems with inerters. Inerter is a two terminal element which has the property that the force generated at its ends is proportional to the relative acceleration of its terminals. Its constant of proportionality is called inertance and is measured in kilograms. Hence, inerter can be considered as an additional mass added to the TMD when the device is moving with non-zero acceleration. The aim of most studies devoted to TMDs, is to design a light and powerful device which can damp out vibrations of the main body in wide spectrum of excitation frequencies. One of the requirements for such devices is low mass compared to the mass of the damped system. Thus, the additional inertia introduced by an inerter help to fulfill this condition. In some cases the addition of a non-linear damper also improves the properties of TMD. It helps to ensure a smooth dynamics of the system and eliminate the possible rapid jumps of the amplitude.

The TMD considered in the project has both aforementioned elements (inerter and non-linear damper). Such system has never been analyzed. Basing on preliminary results we claim that using the combination of properly chosen inerter and non-linear damper we can crate very effective and efficient TMD. In the project we are going to perform full bifurcation analysis of the new type of TMD to have an overview of its dynamics. The main aim of the analysis is to detect the values of system's parameters for which the TMD is highly effective in absorbing the energy of the main body vibrations. Moreover, using bifurcation diagrams and analysis of the coexistence of solutions we will be able to select the ranges of parameters' values where only one solution exists. Finally, the analytical and numerical results will be verified experimentally on the rig designed based on the theoretical studies.