Chapter 17
Theoretical Study of the Effect of an Elastic-Damping Mechanism in the Tractor Transmission on a Machine-Tractor Unit Performance While Sowing

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ABSTRACT

The chapter deals with a numerical simulation of a machine-tractor unit with an elastic-damping mechanism installed between an engine and a tractor transmission while fulfilling an agricultural performance (sowing). The mechanism is a complex system. The description of an elastic-damping mechanism shows all its advantages. There has been given a theoretical substantiation of a transparency level effect on a machine-tractor unit performance while sowing. The purpose of the work is to conduct theoretical study to identify the effect of an elastic-damping mechanism in a tractor transmission on working characteristics of a sowing machine. There has been obtained a regression equation and identified optimum parameters of an elastic-damping mechanism installed in a tractor transmission. There has been also given a substantiation of an expediency to install an elastic-damping mechanism in a tractor transmission for sowing grain crops.

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INTRODUCTION

For promising and modernized tractors there are being developed various transmissions. The results of experimental studies of the existing types indicate a high dynamic load during such processes as starting from a standstill, shifting gears, as well as during steady modes of tractor motion. Taking into account a high cost of modern transmissions and additional costs of fixing them, the problem to reduce dynamic load in tractor transmissions is of great relevance.

It is believed that the introduction of additional elastic damping mechanisms (EDM) as active vibration filters at the entrance and exit of a transmission can provide a required level of protection of an engine and transmission elements from fluctuations of an external traction load. This makes a thorough study aimed at reducing dynamic loading especially important.

It is time consuming to carry out experiments with real objects or with physical models, so it's reasonable to develop numerical simulations (mathematical models) using the results of simpler experiments. To simulate all the processes occurring in the transmission when the tractor is working is a relevant problem.

The known numerical simulations do not allow sufficiently taking into account the real design features, conditions and modes of a controlled tractor motion, their interaction with an environment, with an intensity of changes and their features.

We have proposed a tractor model with an elastic-damping mechanism (EDM) installed in a tractor transmission. An EDM is needed to reduce vibrations in the engine-transmission system. It is closely installed to the engine and well protects the engine and transmission from fluctuations of external loads. An EDM installation reduces a number of external effects, thereby protects an engine and transmission from high dynamic loads, and allows decreasing a possible drive wheel travel reduction (slip).

The proposed simulation (model) allows to study the effect of external traction load oscillations on the working characteristics of an engine, transmission, a whole unit. This model has made it possible to conduct a multi-factor experiment to find optimum parameters of the elastic-damping mechanism. The conducted study has proved the effectiveness of an EDM to reduce dynamic load of transmission units.

BACKGROUND OF THE PROBLEM

The Effect of Transmission Elasticity on an MTU Performance

There are many constructive solutions aimed to reduce dynamic loads in a tractor transmission and to improve engine working conditions (Filin, et al 2016; Gabdrafikov, &Safina, 2017). The source of oscillations frequency of an engine crankshaft rotation can be not only fluctuations of traction resistance, as the studies have shown (Kostyuchenkov, & Plaksin, 2010; Babanin, & Polivaev, 2015; Zech, et al 2019), but also vibrations of transmission shafts; therefore, to reduce dynamic loads on an engine it is necessary to increase transmission flexibility (Shekhovtsov, et al 2016; Zech, et al 2019). However, among the researchers there is no consensus concerning the installation location of elastic elements in a transmission.

The fluctuation compensation of a resistance moment is the most reasonable way to optimize the loading modes of a machine-tractor engine. A lot of researchers have proven the effectiveness of introducing various elastic mechanisms into the elements and links of a MTU (Feuerhuber, 2013; Polivaev, 2017).