Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 177 (2017) 381 – 386

Procedia Engineering

www.elsevier.com/locate/procedia

XXI International Polish–Slovak Conference "Machine Modeling and Simulations 2016"

Energy absorbers in the investigations of hand impact tools for soil compaction

Andrzej Kabała, Michał Śledziński*

Chair of Basics of Machine Design, Poznan University of Technology, Poznan, 60-965, Poland

Abstract

The analysis of the application possibilities of substitute soil - neoprene (type of synthetic rubber) was conducted during the comparative investigations of hand impact tools for soil compaction. The impact tool was experimentally investigated for the different types of soils: sand, moulding sand and neoprene. It was stated that actual soils are useless for the verification investigations. Neoprene as the energy absorber is characterized by the satisfying sample repeatability and this feature ensures the stability of impact tool work. Therefore, neoprene can well be used as substitute soil. This fact was confirmed during the numerical analyses.

Peer-review under responsibility of the organizing committee of MMS 2016

Keywords: hand impact tool; impact energy absorber; neoprene;

1. Introduction

Since the mid 20th century hand impact tools (rammers) have become a popular tool in various industrial and construction applications. They have not been phased out by the progress in use of automatic tools and are still in use today. The subject of this analysis are pneumatic impact tools designed for soil compaction. Tools of this type are generally designed to maximise the efficiency of compaction effort by defining the optimum impact energy and frequency of load applications, geometric and weight parameters. However, the tool designers are pushed by the market to follow the principles of human centered design. High expectations of the market require the tool designers and manufacturers to apply sophisticated testing of products. Thus testing the prototypes, as well as the finished products has become one of the key elements of the design process. For comparative testing with repeatable subgrade reaction it is necessary to use the impact energy absorbers to simulate, as far as practicable, the behaviour of the actual subgrade under the effect of the tested tools in field conditions [1-3].

* Corresponding author.
E-mail address: michal.sledzinski@put.poznan.pl

Peer-review under responsibility of the organizing committee of MMS 2016
doi:10.1016/j.proeng.2017.02.216

2. Testing impact tools – use of energy absorbers

Hand impact tools have been the subject of various studies [4, 5, 6, 7]. With a high level of energy involved in their operation the pneumatic impact tools generate vibrations which are harmful to both people and to the environment. However, high impact energy is indispensable to achieve the desired effect of the process. Due to the complexity of processes involved in the exchange of compressed air in the work chambers and variation of forces acting on the piston and cylinder body the pneumatic impact tools are considered a complex vibrating system. Variation of forces caused by air movements, forces exerted on the tool by the operator, restitution of soil being compacted result in vibrations transferred via the tool handle on the operator [8, 9, 10]. Moreover, the amplitude and frequency of vibrations of the tool handle increase as a result of non-stationary leading of the tool by the operator, the forces of friction in the kinematic pairs and non-uniformity of the compacted layer. Ensuring high quality and safe hand impact tools requires comprehensive testing covering

- testing prototypes (functionality, efficiency of the process of compaction
- verification testing of the design
- comparative tests of impact tools
- modifications of existing tools
- verification of the vibration isolation and measuring of vibrations transmitted to the operator's hand-arm.In order to obtain reliable results it is necessary to ensure repeatability of subgrade reaction during all

of the above-mentioned tests. Such repeatability cannot be obtained with real-life subgrade materials (such as soil or moulding sand).As a result we need materials with constant energy performance during compression and restitution phases in order to simulate the field conditions and ensure their repeatability during the test. Such parameters can be obtained with so-called substitute subgrades, for example made of neoprene (kind of artificial rubber).

3. Experimental testing

In order to determine the physical parameters and the energy absorption capacity of soil and neoprene these two materials were subjected to static compression tests and neoprene was additionally subjected to dynamic compression test.

3.1. Testing of hand rammers on natural (soil) and substitute (neoprene) subgrades

There are number of papers dealing with the soil compaction process [11-15]. This research comprised experimental verification of the suitability of soil (specifically: moist sand) for comparative testing and defining the design features of pneumatic impact tools. Figure 1 shows the test set up for testing on soil (a) and neoprene (b) subgrade layers.

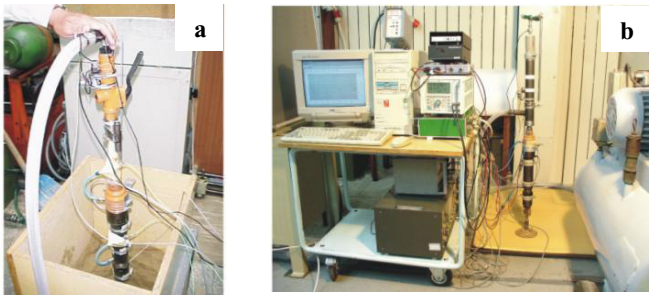

Fig. 1. Test stand for testing impact tools on: a) sand, b) neoprene.

During testing compaction on the layer of sand [6, 16] instability of the operating parameters was noted including pressures in the cylinder chambers p_1 and p_2 and displacement of the rammer as presented in the graph in Fig. 2.