Semi-destructive Tool for *"In-situ"* Measurement of Mechanical Resistance of Wood

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Abstract This contribution presents a new design of a diagnostic tool for *in-situ* evaluation of wood forming part of buildings and structures. The principle of evaluation is based on the measurement of mechanical resistance against the penetration of the tool (pin) into wood.

Keywords Wood, diagnostics, mechanical resistance of wood, pin.

1. INTRODUCTION

Most of the non-destructive tools may be used "*in situ*" in structural/technical surveys to estimate mechanical properties which, of course, are very variable and change above all according to the type of the wood. A significant impact is primarily that of density which is the elementary parameter when assessing the results. The most appropriate way of density identification is to use resistance methods that better respond to changes in the material structure unlike methods evaluating, in a comprehensive way, the whole cross section of an element, like .e.g methods based on the speed of spreading of the elastic wave.

One of the resistance methods is the measuring performed by the means of Pilodyn which may be included among semi-destructive testing methods (Ross et al., 1999). The damage of the tested material is very small and almost negligible. The maximum depth of the pin's penetration is limited, due to the design of the tool, to 40 mm, i.e. the ascertained properties that are measured are more or less surface ones (Görlacher, 1987). Similarly to Pilodyn, also the Resistograph is an option when estimating wood density (Kasal and Antony, 2004; Feio, 2005). It differs from Pilodyn, which is capable of penetration reaching only down to the limited depth of 40 mm, by providing an overview of inner damage.

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Another option of resistance identification of the density is a penetration test based on the repeated penetration of a pin into the wood by the means of a hammer with constant energy (Ronca and Gubana, 1997). In view of the features of the above methods, this article presents a similar tool that will not push the pin into wood dynamically but will gradually press it down. The principle of pressing was selected since it renders more exact measuring of force or rather labour with the opportunity to measure down to the depth of 120 mm which covers common profiles of wooden elements integrated in structures of historical buildings. The structure of the tool, the manner of reading values and other details of the tool are the subject matter discussed within the next section.

2. TOOL DESIGN

The tool body (1) is designed so that it can be mounted to the object to be tested (usually a structural component of rectangular cross section) by being embraced by a roller chain (9) which, after the adjustment of gross length by fixation (6) at one end, is tightened by a screw (5) at the other end. After the tool has been fixed to the object, the pin (4) is pressed into the wood, perpendicularly to the base of the tool, using a toothed rack (2) driven through a gearwheel (3) by the means of a one-hand ratchet wrench or in a two-hand manner using two handles placed against each other (7). The acting force is continuously scanned and recorded during the pressing of the pin (or pulling the screw out) and, simultaneously, it is related to the measured track (pin movement).

The force is measured using a load cell (8) inserted between the lower edge of the toothed rack and the test pin (4). The scanning of the movement is ensured by a non-contact incremental linear encoder which consists of a scanning sensor firmly attached to the tool body (1) and a coded strip mounted in a groove on the back wall of the toothed rack (2). Signals are transmitted wirelessly from the tool into the measuring laptop where they are evaluated.

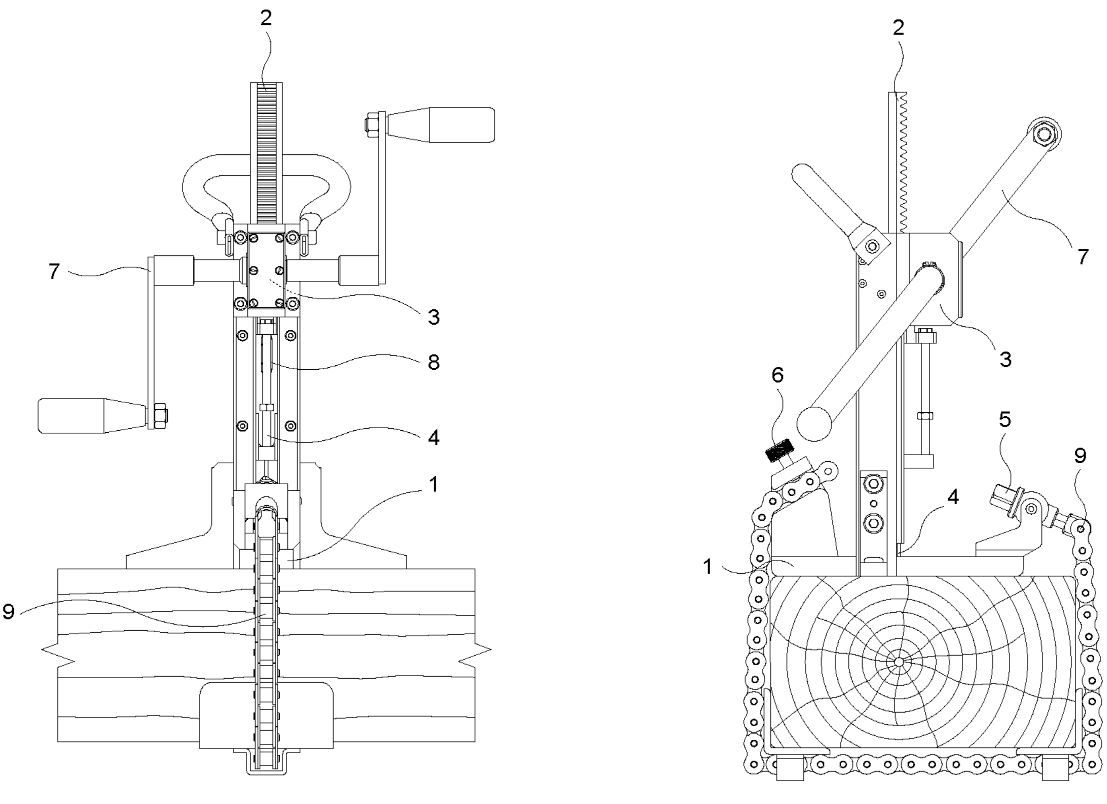

Figure 1 – Design and side view of the semi-destructive tool for *"in-situ"* measurement of mechanical resistance of wood.

Among the benefits of the technical solution is the versatility of the tool with the possibility of measuring the acting force both in the pressing in of the pin and when removing the screw. By replacing the pin with a hook for pulling out the the screw, the measured parameter can be easily changed. The tool structure is light and, thanks to its independence on the electric network, it can be easily moved. Unlike so-called Pilodyn, the length of the pin of the tool, and thus the depth of the indentation into the object, allows the localization of internal defects in wood. The slow progress of pressing also allows the continuous obtaining of variables.

The disadvantage of the tool is the need to embrace the investigated object or to anchor it using screws so that the pin might be impressed into the wood, i.e. at least one accessible surface of the assessed element is always needed. Like other resistance methods used in the diagnostics of the built-in wood, it has a significant dependence on water content in the material under review.

3. CONCLUSIONS

The tool according to this technical solution can be used for determining the mechanical resistance of wood *"in situ"* in individual layers of the studied material. It can be applied in situations where it is not possible or appropriate to use the drilling resistance and it is necessary to determine the status of wood also in the central part of the element. The slow, gradual measurement provides information on the diameter in various depths. It is advantageous especially because of its quick and easy operation without having to be connected to the mains. By replacing the pin with a hook for pulling out the the screw, the measured parameter can be easily changed, which contributes to the versatility of the new tool.

To verify the tool's functions, experiments will be used based on the comparison of values taken when pressing the pin and on the testing of standard specimens as per the CSN standards methodology.

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