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MEASUREMENT LINE FOR STATIC TORQUE

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Abstract: *This work is driven by the idea to create a design solution of semi-automatic measurement line that would provide more accurate results and increase the speed of the recalibrating process of torque tools. Tools considered here are operated by hand, therefore subjected to the performance (skill, strength and knowledge) of the operator. Since the pulling speed and the force are difficult to maintain or repeat results differ from expected values. The analysis filtered out the solution with gearbox and trapezoidal spindle which is taken as the base for prototype line to be produced. Testing has shown enhanced repeatability of the measurement, ease of operation and suitability for implementing automation features and thus fulfilling of initial requests.*
Key words: *torque, tools, measurement*

1. INTRODUCTION

Torque tools are used in everyday life by machinists, auto mechanics, steel construction workers, dentists, etc. They differ in the working principles and load ranges and therefore, in design, size, accuracy and so on. They are briefly divided into two groups: indicating and setting torque tools (ISO 6789, 2003). While indicating tool is intended to indicate torque exerted by the tool at the output drive, the purpose of setting torque tool is to exert the prescribed value of the torque followed by appropriate signal. General use of the setting tool is to set the desired amount of axial force into a screw or bolt joint. The connection between the introduced torque and the achieved force is complex though often reduced to only a few parameters on account of simplicity of calculation (Decker, 1975). However, the basic assumption that must be met to even approximately achieve the desired force is that the torque tool exerts the prescribed value of torque within the limits of acceptable tolerance (ISO 6789, 2003). In order to provide such performance, torque tools must be recalibrated periodically. The issue of this work is the recalibration procedure of the setting torque tool that should be conducted by a certified calibration laboratory and the appropriate equipment that should be used.

2. EXISTING MEASUREMENT LINE

The measurement line (Fig. 2) consists of the tool driving square adapter (2) (ISO 1174-1, 1996) mounted on the top flange of the measurement shaft (1). Four strain gages forming full bridge are attached to the outside diameter in the middle of the shaft and connected to the digital measurement acquisition system (3). The last item in the line is a PC with software compatible to the acquisition system (4).

2.1 Measurement procedure

The measurement procedure (Schicker & Wegener, 2002; ISO 6789, 2003) is conducted by hand pulling the torque tool mounted on a driving square attached to the top of the measuring shaft (Fig. 1). Due to angular deformation of the shaft electrical resistance of gages is changed and picked up by the acquisition system in the form of electrical potential change. Those changes are recorded continuously by PC software as an array of discrete points (Figures 2a, b and c).

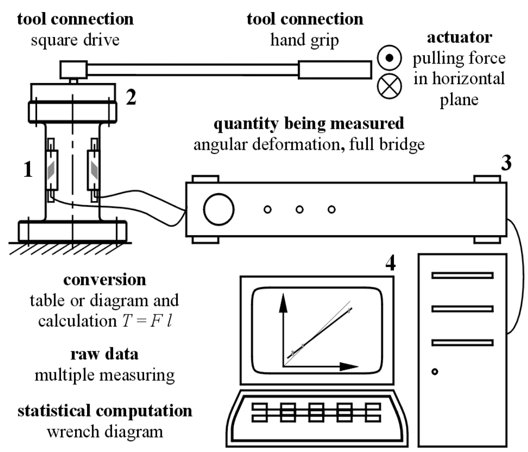

Fig. 1 Existing measurement line

Fig. 2a shows the diagram obtained by usual operation, while 2c is achieved by smooth pulling with fine force increment. Fig. 2b is the most important because of the lack of indication of tool triggering and also another peak that occurs when the tool mechanism hits the wrench casing allowing overload. Since the curves are not smooth and in cases 2b and 2c neither are they characteristic, they are not suitable for automated software processing.

It should be pointed out that the operating torque was set at 70 Nm which should be considered as a small value, thus easy to handle. Wrenches designed for higher amounts of torque are usually robust, equipped with appropriate grip extension in order to provide less force on a larger distance for the operator to have better control over the force and the speed. However, the extension requires more space for manipulation forcing the operator to maintain control over a longer path leading back to measurement inaccuracy.

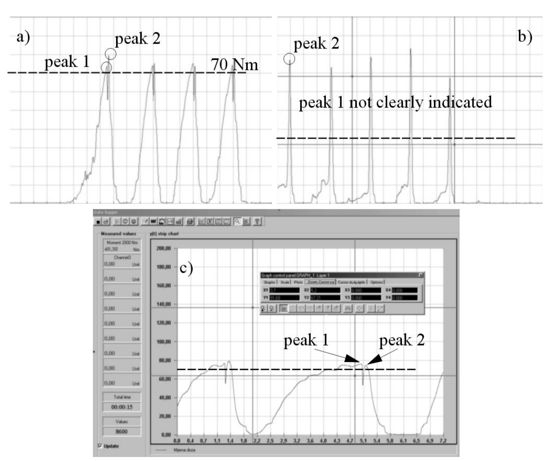

Fig. 2 Data recorded on hand pulling torque wrench set to 70 Nm: a) normally, b) aggressively, c) smoothly

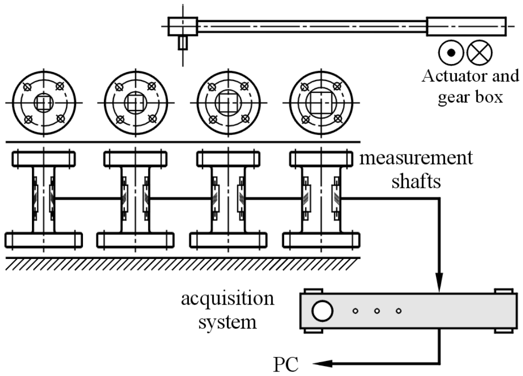

Fig. 3 Measurement line improvement solution with actuator and transmission, additional shafts and software procedure (not shown)

3. IMPROVEMENT REQUESTS

One can conclude that the operating performance has significant influence on the measuring accuracy as well as on the measuring repetition. In order to provide both, a new transmission device is considered, preferably electrically controlled with fine gradient adjustment. Instead of hand pulling, the wrench would be driven by a new actuator while the measurement shaft would stay still (Fig. 3) (Opalić et al., 2004). The equipment must be suitable for operation in both directions to meet various tools capabilities. Additionally, since the measurement shaft is optimally designed for particular torque range, several shafts should be produced to cover at least the most usual ranges. The procedure should be kept simple without the need of changing measurement shafts, thus saving the time in preparation of measurement. Finally, because of better control of the input, smooth output diagrams could be created, suitable for automated processing. Therefore, a new procedure for peak detection should be created and implemented in the existing software. On that basis, the coupling between software and the actuator could be created allowing semi-automatic operation within one measurement procedure.

4. RESULTS

Based on the requested properties a prototype of new, low-cost measurement line is produced (Fig. 4). Among the analysed design solutions the one with gearbox and trapezoidal spindle was chosen. The actuator and the transmission are chosen as compact product capable of both electrical and hand operation. The force is provided by transversal movement while adjustment in the longitudinal direction gives capability for testing various sizes of torque tools. The limiting load and the operating dimensions correspond to the tool with maximum torque value of 3000 Nm.

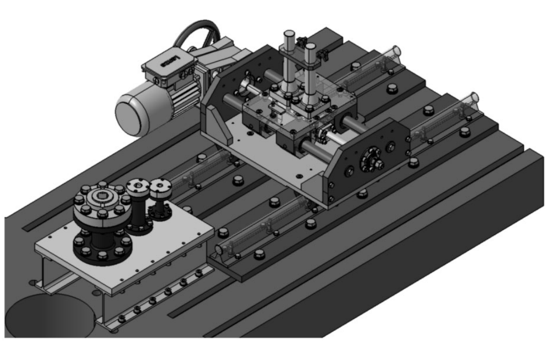

Fig. 4 Measurement line prototype

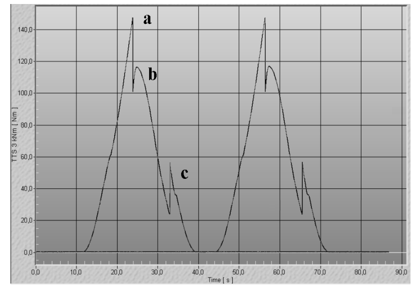

Fig. 5 Data acquisition results with new measurement line

Testing of the prototype line was conducted for three different setting torque tools with nominal torque values of 200, 760 and 2000 Nm. The equipment was operated manually by wire since the automation part has not been implemented yet. Nevertheless, the measurement results (Fig. 5) are practically identical, independent of the operator's physical performance and suitable for automated peak detection. Three significant moments could be clearly seen in the measurement cycle: a) torque peak, b) secondary load due to mechanism impact with tool casing and c) releasing of the mechanism allowing another operating cycle.

5. CONCLUSION

The undertaken analysis of recorded data (Fig. 2) outlined the weaknesses of the old measurement line as follows:

- accuracy of the measurement depends on the operator's physical performance,
- output data do not form smooth curves, and thus are not suitable for automated peak detection,

As opposed, the new line, not even finished, offers benefits in both areas. Further work on the improvement will be focused on the development of the procedure for peak detection and automated operation within the measurement cycle. For this purpose the loop back control must be created between the actuator and the acquisition system or PC. When a peak point is reached the operation of the actuator should be stopped and reversed until the measured quantity reaches zero. The measurement cycle could be repeated as many times as needed, potentially determined by the data stored about a specific torque tool. If so, the operator's concern would be to mount the tool, set the torque to be tested and introduce the tool type to the software. The rest of the work would be done by the system.

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