Design and fabrication of fully automatic tapping machine

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Abstract : This paper presents major steps of the design, fabrication, operation and evaluation of an automatic taping machine**.** The run-over tapping process of internal, through threads can be done continuously using bent-shank taps combined with an automatic workpiece feeding mechanism. The machine was operated and provided a production rate of 35 threaded nuts per minute.

IndexTerms **– thread tapping; bent shank tap; automatic machine; copper nuts.**

I. INTRODUCTION

Tapping is a common operation of cutting internal threads inside a hole using a cutting tool called tap. The taps can be either hand taps or machine taps, in the form of straight shank or bent shank taps [1]. In tapping operations, the threads are made by rotating and feeding the taps through the drilled hole. Thread tapping can be done manually (hand-tapping) or on machines, either semi-automatic or fully automatic tapping machines.

Tapping machines are basically drill presses equipped with lead screws, tap holders, and reversing mechanisms. Lead screws convert the rotation into linear motion to feed the tap into the hole to be threaded. Lead screw control is often used with large size nuts to ensure high-quality threads. In such arrangements, the spindle has to reverse its rotation twice for each cycle: one at beginning and the other at the end of the threading process. Several studies [2], [3], [4]were been done to design and fabricate machine combined drilling with tapping. For example, in an invetigation of building a drilling and taping machine [2], the authors discussed a case study and comparison of productivity of drilling, tapping and inspecting a standard block of size 50 X 50 X 75 mm. The M6 tapping processes were implemented on sampled holes with the tapped depth of 20 mm. Spindle speed, i.e. the drill speed, can be varied with the help of stepped cone pulley. The tapping operation speed was set at 100 rpm, leading to cutting velocity of 0.0314 m/s. In another work [4], a single machine used to perform both drilling and tapping operation was constructed.The machine combined drilling and tapping operations with the help for speed reduction gear box. As drilling requires high speed and tapping requires low speed [3]. Thus, the rotation speed of the spindle was reduced from 1320 rpm to 90 rpm by means of an worm gear arrangement. In the investigated experiments, thread holes M8 were produced. With such values of the spindle speed and the tap diameter, the cutting velocity can be found as 0.0377 m/s.

For mass production of nuts with through threads, it is possible to apply a continuous tapping process by using bent shank taps. This paper presents the design and fabrication results of a fully automatic tapping machine. All stages of the threading processes, including workpiece feeding, clamping and cutting are performed automatically.

II. BASIC OF THE DESIGN

The design is based on the tapping principle using a bent shank tap. Figure 1 depicts the form of such tool. This kind of tapping tools is usually used for continuously tapping small and through nuts.

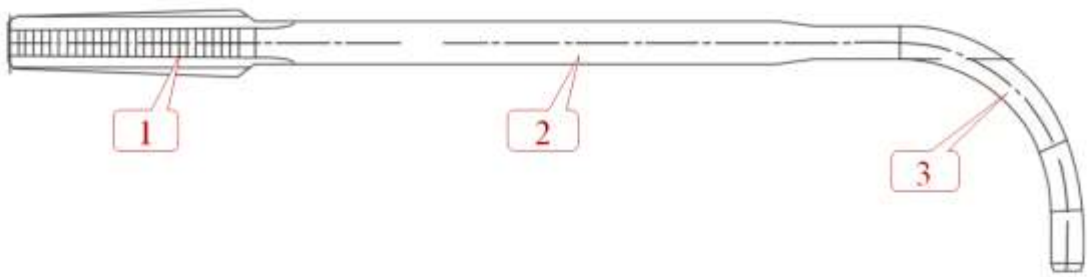

Figure 1. A bent shank tap for automatic nut tapping

As shown in Fig.1, a bent shank tap consists of three parts: the cutting edges (1), the straigh shank (2) and the bent shank (3). Given that a drilled nut is pushed onto the cutting edges, supplying a relative rotation between the nut to be cut and the tap leads to thread cutting process. The relative motion of the nut also moves itself to the straight part. A new thread cutting for the next nuts will be continued. The nuts that are already threaded will move out via the curved tail of the tap (the bent shank (3)) by means of gravitation force. It can be seen that with the use of bent shank, the nut being tapped is automatically driven through the bent shank, making it possible to thread continuously without stopping or reversing the machine. As a result, the production rate can be significantly increased.

Based on the working principle described above, an automatic tapping machine should consists of three following blocks:

- Feeding block: to store, separate, align and feed the nuts one-by-one to the cutting block;
- Cutting block: clamp the nut, providing cutting motion;
- Control block: push intermittently the nut to-be-cut onto the cutting zone of the tap with proper direction at proper time; release the nut after finish threading.

III. RESULTS OF THE DESIGN AND FABRICATION

The feeding block was designed for M4 nuts, as shown in Fig.2. The nuts are commonly used in electrical devices. Figure 2a shows the drawing of the nut to be threaded. The nuts are made from electrical copper, prepared in the form and dimensions as shown in Fig. 2a. Figure 2b illustrates some electrical devices where the nuts are being used.

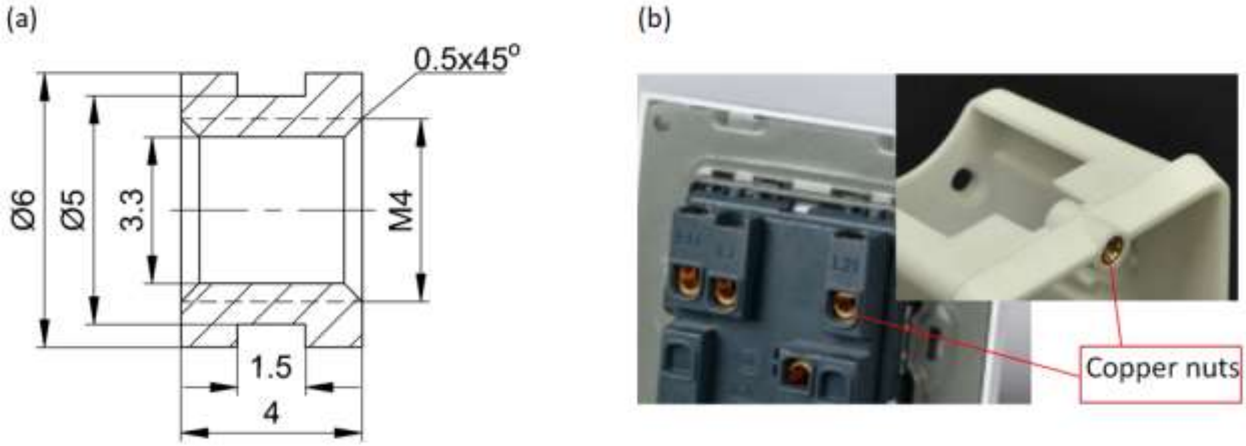

Figure 2. The workpiece to be threaded: a) a section drawing and (b) application examples

Figure 3 presents the feeding mechanism, as refered from [5]. As shown in Fig. 3a, a crank (1) rotates back and forth continuously in a slot (3). The slot has 4 mm wide, equal to the thickness of the nuts to be cut. This motion results in alignment of nuts (4) inside the slot and fall into the guide (5). Figure 3b illustrates a photo of the practical work of the feeding mechanism.

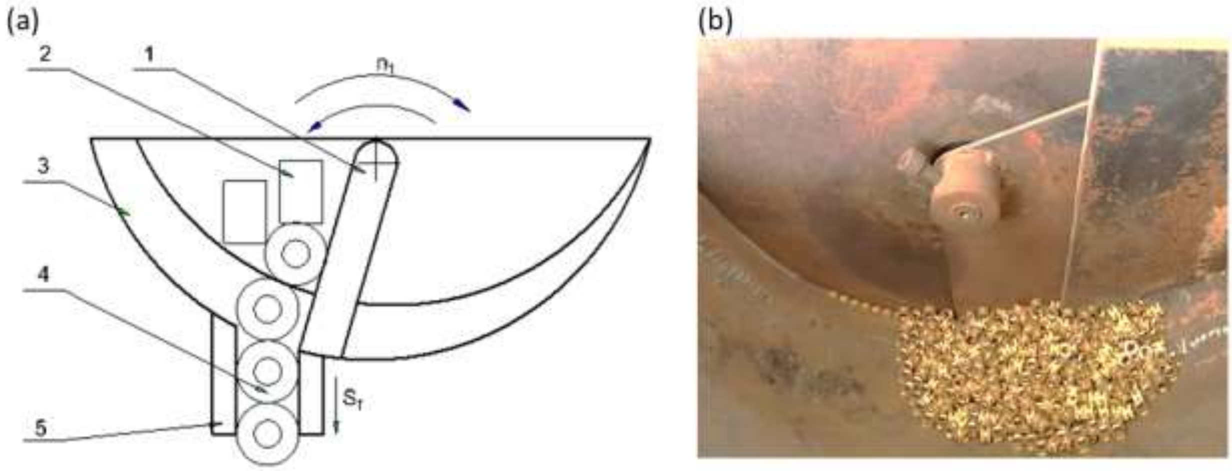

Figure 3. The feeding mechanism

The threading process is performed with the the stages as below (See Fig. 4a). Firstly, the nuts (4) follow the guide slot (5) to meet the cutting zone. Next, the controlled pin (10) pushes one nut (6) into the collet (9). The collet is concentric with the tap (7). After that, the pin moves back, the collet (6) starts rotating while the tap is fixed, providing a relative motion between the nut to-be-cut (6) and the tap (7). The thread cutting thus occurs. The nut and the collet also move along their axis to the end of the cutting edge area, i.e. to the other end of the tap. Then, after the cutting completed, the collet releases the nut. Consequently, the threaded nuts (8) are driven to the end of the bent shank tap (the S_3 direction) and fall down to the product collector. Figure 4b illustrates the real structure of the collet with the nut being cut and the tap inside.

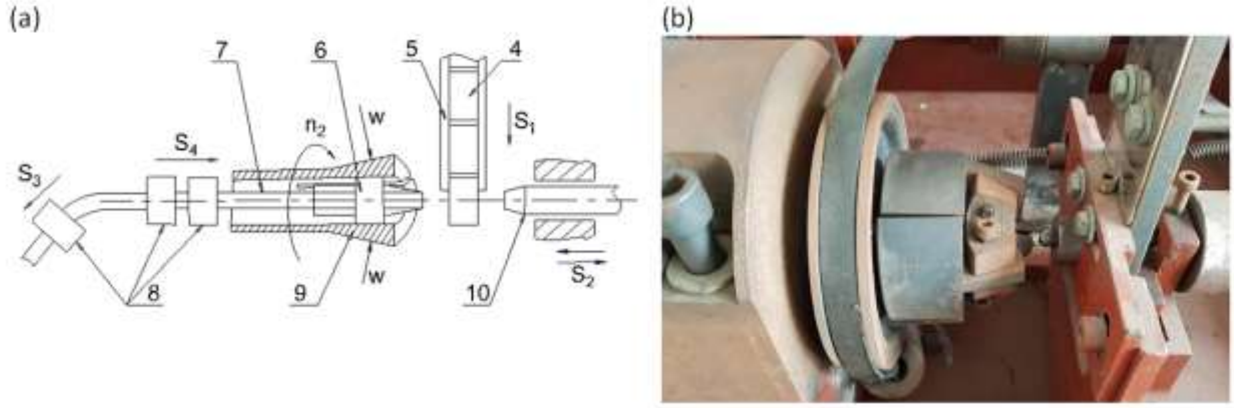

Figure 4. Diagram of the thread cutting process

To continuously threading nuts, it is required that those steps must be controlled properly. Firstly, the clamping force (w) of the collet exerting on the nut was proposed as employing the centrifugal force of weighting masses (9), as shown in Fig. 5a. A clutch (not shown there) is used to switch the shaft of the spindle on/off properly.

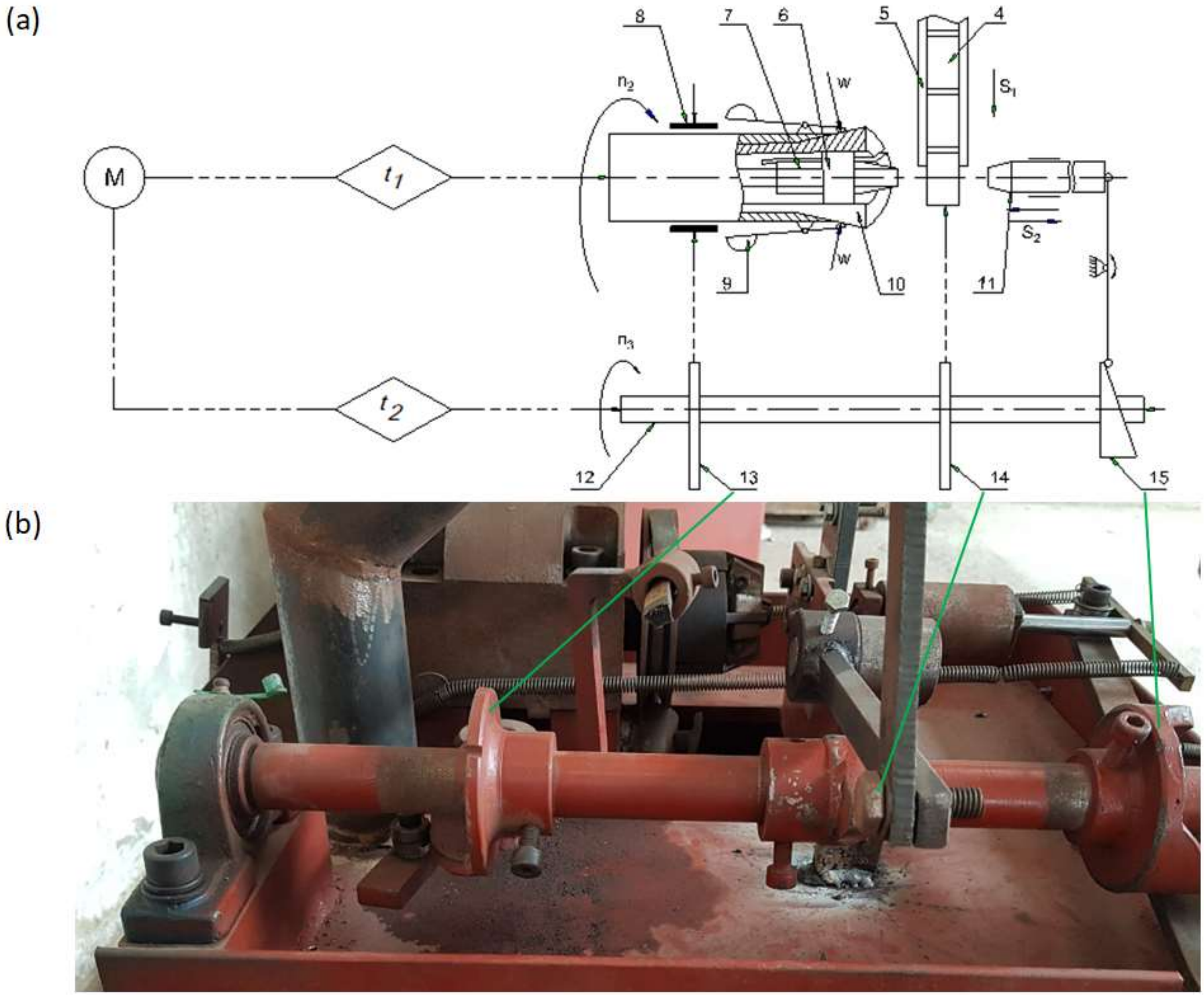

Figure 5. Schematic (a) and a real photograph (b) of the control system

The clutch is controlled by a cam (13) in Fig. 5a. When the spindle rotates, the masses (9) fly out and generates centrifugal force, providing a clamp force (w) acts on the nut (6). There are two other cam mechanisms arranged on the control shaft (12), including the feeding cam (14) and the pushing cam (15). Both the spindle and the control shaft are driven by the same motor (M). The speeds of the spindle speed and of the control shaft are calculated to ensure the production rate as well as the cutting ability of the tool. For each cycle of the shaft (12), the cam (13) switch the clutch once and thus the spindle rotates once. Also, only one nut is permitted to fall into the cutting zone, as controlled by the feeding cam (14). The pushing cam (15) release the pin (11) once for each cycle of the shaft (11) so that only one nut felt in the cutting zone is pushed to meet the tap and thus will be threaded.
The machine was fabricated with major parameters as shown in Table 1.

Table 1. Major parameters of the automatic tapping machine

Motor power	0.75 kW
Motor speed	1450 rpm
Spindle speed	1940 rpm
Control shaft speed	35 rpm

With the speed of the control shaft of 35 rpm, the production rate of the machine is of 35 pieces per minute. Increasing the speed of the control shaft leads to raise up the production rate. However, there are two thresholds should be considered. The first one is the permitted cutting velocity for the tap. The recommended cutting velocity in threading copper should be in the range of [60..80] SFM [6]. With the nominal diameter 4 mm of the M4 thread, the maximum cutting velocity can be found as [0.3..0.4] m/s, corresponding to the rotation speed of [1455..1940.5] rpm. Another factor should be cared is the inertia of the moving objects. Since the system is controlled by cam mechanisms, high speed rate may lead to significant changes of the system accelerations and thus the inertial forces. This would damage the system structure.

The machine can be adjusted to tap through nuts with difference sizes by adjusting the width of the slot inside the feeding mechanism. The thread size is also adjustable be using proper taps.

IV. CONCLUSION

A fully automatic tapping machine for through nut was designed and fabricated. Major parameters of the machine were determined by using basic calculations and recommendations from textbooks and previous studies.

V. Acknowledgment

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References

[1] H. A. Youssef and H. El-Hofy, *Machining Technology: Machine Tools and Operations*: CRC Press, 2008.

[2] N. G. Lokhande, V. B. Emche, V. M. Khanke, *et al.*, "Fabrication Of Drilling Cum Tapping Machine," *International Journal of Creative Research Thoughts*, vol. 5, pp. 44-48, 2017.

[3] N. U. Kakade, P. Bhake, S. Dandekar, *et al.*, "Fabrication Of Combine Drilling And Tapping Machine," *International Research Journal of Engineering and Technology*, vol. 4, pp. 305-308, 2017.

[4] N.Venkatesh, G.Thulasimani, S.Naveenkumar, *et al.*, "Combined Drilling and Tapping Machine by using Cone Mechanism," *International Journal of Scientific & Engineering Research*, vol. 7, pp. 11-15, 2016.

[5] S. J. Derby, *Design of Automatic Machinery*: Taylor & Francis, 2005.

[6] VikingDrill Tool., *How to Tap Effectively and Optimize Tool Life*. Available: http://www.vikingdrill.com/viking-Tap-FeedandSpeed.php, accessed at August 2019.