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FLUTELESS THREADED HOLES FORMING USING A COMBINED TOOL

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ABSTRACT

This work proposes a new method for forming threaded holes in thin-walled workpieces using a combined hole making and tapping tool. The main advantages of the developed combined tool in compare to currently widely used separate drilling and tapping tools are that it eliminates the inter-operational time related to tool changing and reduces the machining time.

An experimental testing was carried out with the developed combined tool and the axial force and torque was recorded. The developed brand-new fluteless drilling and tapping combined tool extends the conception of tapping holes, consequently it could be successfully applied in various fields of machining industry.

Keywords: fluteless drilling and tapping, combined tool, prototype.

INTRODUCTION

In this study, a new method for forming threaded holes using a combined hole making and tapping tool was developed. Fluteless friction drilling and tapping technique is a special process used to create tapped holes in thin-walled metal parts (Miler 2007, Lee, 2009). This fluteless hole and thread forming technology is applied using separate friction drilling and tapping tools (Krasauskas, 2016).

The overview of tool catalogues, research works, patents and other special literature showed that there are no analogous tools and experimental researches of combined tools for fluteless drilling and tapping. Currently widely used tools are not versatile and they do not compress the sharp-edged collar, which occurs on the top of the workpiece after the drilling, therefore an additional machining operation is required to remove the metal excess from the upper surface of the hole.

This paper proposes a combined tool able to form a hole with a neck, calibrate the hole and the neck, tap a thread. The advantages of the designed combined tool in compare to separate drilling and tapping operations are that it eliminates the inter-operational time related to tool changing and reduces the machining time, furthermore, the sharp-edged collar is compressed and an additional mechanical operation for its removal is not required.

COMBINED TOOL DESIGN

The developed combined tool is presented in (Fig. 1). As it is seen from the figure, the tool consists of six main sections: the centring section for initial tool infeed into the workpiece; the drilling section for plate penetration; the calibrating section for hole diameter calibration; the
tapping section for forming a thread in the drilled hole, the shoulder which is used to form or to cut off the collar on the upper side of the workpiece and the body for clamping the tool in the chuck. The cross-sections of the working sections of the tool are polygonal shaped, in order to ensure better metal flow during the hole forming and tapping.

The main advantages of the designed combined tool in compare to separate drilling and tapping operations are that it eliminates the inter-operational time related to tool changing and reduces the machining time. It is especially advantageous in conjunction with CNC high speed machining operations.

The combined drilling-tapping tool operates as follows (Fig. 2): due to the friction between the tool and the workpiece, the temperature in the contact zone rises over 600 °C, the centring section of the tool forms a centring hole in the workpiece, the second, drilling section penetrates the metal and pushes the metal excess downwards and, in this manner, a neck is formed on the underneath side of the workpiece.

The third calibrating section forms and calibrates the hole with the neck until the required diameter for tapping is achieved. As a result, the thickness of the workpiece at the hole zone is increased about 3-4 times compared to the initial thickness. However, during the tool plunging into the workpiece, some portion of the metal is pushed upwards, thus on the top of the workpiece a sharp-edged collar is formed.

Fig. 1 - Shape of the combined fluteless hole drilling-tapping tool

Fig. 2. Phases of hole and thread forming in a thin plate using combined tool: a - initial contact; b - former tip penetration into the material; c - material flow and hole forming; d - feed and rotational speed changing; e - thread forming; f - tool reversing and unscrewing; g - tool withdrawal
After reducing the spindle speed and feed rate to the values required for tapping, the tapping section gradually performs tapping until the nominal thread diameter is achieved. At the end of the tapping, the shoulder compresses the sharp-edged collar around the hole, the tapping feed and the spindle rotation is reversed and the tool is withdrawn from the hole.

IMPLEMENTATION AND RESULTS

The drilling and tapping operation using a combined tool is problematical since it is necessary to adjust and synchronise the feed and the spindle speed while switching between the drilling and tapping phases. This operation on a manually operated drill press is a long-lasting process as it is necessary to set the spindle feed and the rotational speed for drilling, then to switch off these both movements and to change them for tapping, to reverse the spindle after the tapping for tool withdrawal. Therefore, this operation is recommended to be performed on a CNC machine.

In order to ascertain the combined tool machining feasibility, a tool prototype was manufactured of high speed steel for drilling and tapping an M8×1.25 hole.

An experiment of drilling and tapping was carried out on an aluminium AL 1050 plate with a thickness of 1.5 mm. The experimental setup (Fig. 3) consists of a Leadwell V-20 milling centre (1) equipped with the combined tool prototype (2), the axial force and torque were measured using a universal laboratory charge amplifier Kistler type 5018A (3) and a force and torque sensor Kistler type 9345B (4) mounted on the CNC machine table. The measuring ranges of the sensor: -10…10 kN for force and 25…25 Nm for torque, sensitivity: ≈3.7 pC/N for force and ≈189.7 pC/Nm for torque. The variation of the axial force and torque was recorded to a computer (5) using a “PicoScope 4424” oscilloscope (6) software. The machining program was written using G-codes. The.

A spindle rotational speed of 3000 rpm and a feed rate of 140 mm/min was set for the drilling phase. When the hole is formed, the spindle rotational speed and the feed are changed to 300 rpm and 1.25 mm/rev for tapping an M8×1.25 thread.
The experimental results of the hole forming and tapping are presented in Fig. 4.

![Graph showing the variation of axial force and torque](image)

**Fig. 4 - Axial force and torque variation of a hole forming and tapping using the combined tool**

The graphs show that using the combined tool, the overall time of hole making and tapping is 12 s, meanwhile, using separate tools for drilling and tapping, it would take a few minutes, depending on the machining type, as the tool changing operation is required.

The experiment showed that the developed brand-new fluteless drilling and tapping combined tool extends the conception of tapping holes, consequently it could be successfully applied in various fields of machining industry.

**CONCLUSIONS**

A combined drilling-tapping tool for chipless thermoplastic extrusion forming, calibration and tapping of a hole with a neck in thin metal sheets was developed. A tool prototype was manufactured of high speed steel for drilling and tapping an M8 x 1.25 hole and an experiment to ascertain machining feasibility was carried out. The advantages of the designed combined tool in compare to separate drilling and tapping operations are that it eliminates the inter-operational time related to tool changing and reduces the machining time. It is especially advantageous in conjunction with CNC high speed machining operations. Due to the friction between the tool and the workpiece, the temperature in the contact zone rises over 600 °C, therefore the tap is formed in the still hot hole. Compare to the cold extrusion, the hot extrusion needs less tapping torque and motor power.

**REFERENCES**

