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To cite this article: Lingling Wang *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **592** 012143

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The Development and Application of Advanced Design and Manufacturing Techniques on Type 4GXJ-I of Cordless Brushless Tapping Knife

Lingling Wang^{1,2}, Jianhua Cao^{1,2,*}, Yong Zheng^{1,2}, Chang Huang^{1,2}, Sihao Wu^{1,2}

¹Institute of Rubber, Chinese Academy of Tropical Agricultural Sciences, Haikou, 571101, China

²Mechanical Equipment Subcenter-National Center of Important Tropical Crops Engineering and Technology Research, Haikou, 571101, China

*Corresponding author. E-mail: zishi-010@163.com

Abstract. As the market continues slumps and an aging rubber-cutting contingent, rubber-cutting labor shortage has become one of the bottlenecks restricting the development of caoutchouc industry. The mechanical and intelligent cutting method becomes the development direction in rubber-cutting industry. This paper introduces four types of tapping knife prototypes. This paper expounds type 4GXJ-I of cordless brushless tapping knife, including specification, main features, key techniques for application, tapping effect and practice using. The knife is light and comfortable, good effect, clean latex, lessening of harm to tree, favorable to latex flow, easy to learn, efficiency promotion and difficulty lowering. The knife is practical and worthy of wide application. The extended application of this technique has great significance to solve the problem of rubber-cutting labor shortage.

1. Introduction

Tapping reliant on hand labor is a pain point in decades of rubber development. Mechanical tapping is one of the effective means to solve the current dilemma of the industry. The study on natural rubber harvest technology mainly focuses on cutting way, tapping time and tapping tool^[1]. The traditional hand push type knife and hand pull type knife are main tapping tools such as shape V tapping knife, Jabong tapping knife^[2] and Mitchie Golledge tapping knife^[3].

The current research on mechanical tapping tool is provided for thread cutting on rubber tree. Tapping machinery directly determines the factors of tapping efficiency and speed, the degree of rubber tree injury, labors strength and natural rubber yields^[4]. The new type of mechanical tapping tools are designed with technologies of ultrasonic vibration^[5], autonomous navigation^[6], sensor^[7], recognition and image processing^[8], ergonomics^[9], modern mechanical manufacture and electronic information. The electronic portable tapping knife^[10] and the bundled full automatic tapping machine^[11] become the breach of the problem. Tapping robot^[12] is the ultimate goal on rubber tapping. The development of natural rubber harvesting mechanization in China is in the initial stage with a good development opportunity.

2. Advanced design and manufacture on type 4GXJ-I tapping knife

The paper has established a dynamic model of the optimum cutting mechanism based on the technologies and methods of vertical milling, horizontal milling, sliced and peeled. Technologies of



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mathematic statistics, generalized inverse matrix, mechanical design, parameter modeling, dynamics and simulation are used in the research. Based on the study, type 4GXJ-I of cordless brushless tapping knife is designed and manufactured.

2.1. The design of tapping knife prototypes. This paper focuses on main structure, appearance, battery, tapping blade, limit guiding device. The main technical parameter, assembly structure types and design characteristics of the tapping knife are designed. The parametric design of working resistance, displacement, speed and direction is tested. The shape size and assembly size are determined. Through the above research, four types of tapping knife prototypes are manufactured. Four types of tapping knife prototypes are as shown in Figure 1.

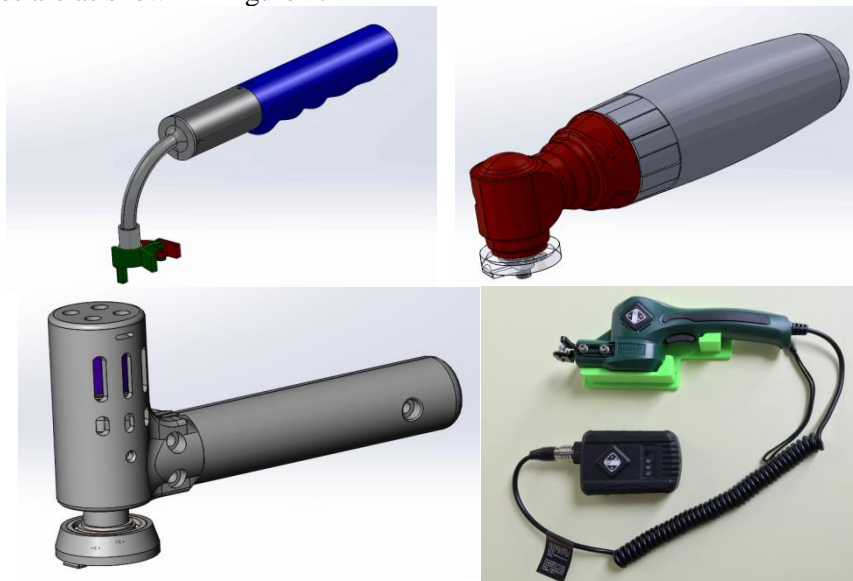


Figure 1. Four types of tapping knife prototypes

2.2. The molded type 4GXJ-I tapping knife. A lot of modification and checks have been made for the tapping knife. The knife is becoming a practical useful tapping tools. Type 4GXJ-I tapping knife is molded finally, as shown in Figure 2.



Figure 2. Type 4GXJ-I of cordless brushless tapping knife

2.2.1. Specification of Type 4GXJ-I tapping knife. The specification of Type 4GXJ-I tapping knife is as shown in Table 1.

Table 1. The specification of Type 4GXJ-I tapping knife

Model	4GXJ-I
Voltage	12V
No Load Speed	6000±10%rpm
No Load Current	≤2.0A
Cut Travel	1.5-2mm
Bark Consumption	1.0-2.5mm
Battery Type	Environmental Li-ion
Battery Capacity	2000mAh
Working Time	3-4h
Net Weight (without battery)	350g

2.2.2. Main features of Type 4GXJ-I tapping knife. The Main features include light and comfortable, good effect, clean latex, lessening of harm to tree, favorable to latex flow, easy to learn, efficiency promotion and difficulty lowering.

Light and comfortable: ergonomic design, weighing 350 gram.

Good effect: no old glue around knife tapping end to end in place, tapping line smooth.

Clean latex: long strip and schistose of complete bark, high rate, less contaminated rubber.

Lessening of harm to tree: position limitation protection device can be adjusted as needed. Depth and thickness of tapping are controlled by machines.

Favorable to latex flow: Tapping ways of less repetitive and back can effectively reduce oppressing latex vessel, favorable to latex flow.

Easy to learn: one-touch operation easy to grasp operation operator can help work after training for 3-5 days.

Efficiency promotion: 20-30% more efficient than traditional tapping knife under high proficiency.

Difficulty lowering: reducing technical difficulty of tapping and labor intensity of operator greatly by 60% and 50%.

3. Application of Type 4GXJ-I Tapping Knife

3.1. Key techniques for application

Key techniques for application include adjustment of the bark consumption, adjustment of cutting depth and adjustment of the width of the junk slot. Adjustable cutting unit of type 4GXJ-I tapping knife is as shown in Figure 3.



Figure 3. Adjustable cutting unit of type 4GXJ-I tapping knife

3.1.1. Adjustment of the bark consumption. The bark consumption can be adjusted by changing the gaskets of different thickness. Bark consumption is max when the gaskets are not used. For each additional gasket, bark consumption is reduced accordingly. Thickness of the gasket includes: 0.2mm, 0.5mm, 0.8mm.

3.1.2. Adjustment of cutting depth. The cutting depth can be adjusted by moving the blade towards direction A to direction B. Generally it is better to keep the gap between the blade and guide to be 0.1mm wide to avoid damage to the wood of rubber tree.

3.1.3. Adjustment of the width of the junk slot. The width of the junk slot can be adjusted by moving the guide towards direction E to direction F. If the old glue lines are not torn off before tapping, we should adjust the width of the junk slot and the thickness of bark consumption, in order to eject bark along with glue line. The width of the junk slot can be adjusted to 3-4mm according to actual needs, and the thickness of bark consumption can be adjusted to 1.5-1.8mm properly.

3.2. Tapping effect

Tapping effect of type 4GXJ-I tapping knife is as shown in Figure 4.



Figure 4. Tapping effect of type 4GXJ-I tapping knife

3.3. Practice using type 4GXJ-I tapping knife

The workers practice using type 4GXJ-I tapping knife is as shown in Figure 5.



Figure 5. The workers practice using type 4GXJ-I tapping knife

4. Conclusion

Compared with traditional tapping knife, Type 4GXJ-I of cordless brushless tapping knife has clear advantages in tapping efficiency and labour intensity. The research field of tapping machinery is a world-wide problem, so the research of 4GXJ-I tapping knife is an audacious innovation. The

extended application of this technique has great significance to solve the problem of rubber-cutting labor shortage. Intelligentized tapping machinery will be the developing trend with development of information technology in the future.

Acknowledgments

In this paper, the research was sponsored by Central Public-interest Scientific Institution Basal Research Fund for Chinese Academy of Tropical Agricultural Sciences (No.1630022018011) and National Key Research Project (No.2016YFD0701505).

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