The Theoretical Research on Technical Advance and Innovation Integration of Tapping Machinery

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Abstract. Mechanical tapping becomes an important issue to be resolved in urgent need at present, which is one hot problems of the technology research at present. This paper introduces the progress and frontier of tapping technology, and analyses and summarizes the research on semi-automatic tapping machinery and automatic tapping machinery. The development of mechanical tapping is still at the exploration stage, and the fundamental theory research is insufficient. The technology needs to move from prototype stage to more mainstream use for quite some time. The type 4GXJ-I of cordless brushless tapping knife designed by our team and automatic tapping machinery designed by Zhenkun Xu in China, have presented obvious advantage in the study of mechanical tapping machine. Application of mechanical tapping machines has a very important significance to sustainable development of natural rubber industrial economy.

1. Introduction
Natural rubber industry is the traditional feature industry in the world tropics. Covering more than 1,330,000 hectares of the county's land area, rubber tree mainly distributes in Hainan, Yunnan and Guangdong in China.

Tapping work is amazingly reliant on hand labor. More importantly, it is a hard work including heavy labor intensity, overloaded work, high technique required. The human cost approximately occupies more than 60%, which restricts the development of natural rubber industry in our country. Natural rubber sold under cost price leads to the enormous losses of NR enterprise and large planter in recent years. Tapping workers are very difficult to live on the income, simultaneously the old retired workers are more and more, so a shortage of workers and rising labor costs have become an important bottleneck constraining industrial development. In practice, mechanical tapping can help to resolve the predicaments in development.

2. The research on tapping technology
There are many rubber tapping research theory, methods and technology. Jieren Cheng et al.\cite{1} have researched one's mastery of tapped skills using entropy method, Delphi, and gray clustering method. Hassan Al et al.\cite{2} have found that tapped time was the decisive factor of mastering tapping basic technical. The other main factors\cite{3-10} have been researched including tapped part, secant length and direction, slotting height, tapped frequency, rotate different trees, bark consumption, tree age, tapped
efficiency, order of knife time, the degree of tree injuries, labor strength, natural rubber yield and tapping machinery. D.Y.Giroh\textsuperscript{[5]} has found that tapping skills and tapping machinery were key influence factors to low efficiency on labor tapping. Thierry Michels et al.\textsuperscript{[6]} has established a decision support system between amount of bark consumption and tree age at different intensity of rubber tapping, to raising the tapped age.

3. The research on semi-automatic tapping machinery

Electric tapping knife has been researched and designed from the end of 70's in last century. The main advantages of knife are small volume, expedient installation, small volume, light weight, low power, low cost, high stability and operation easy. The types of electric tapping knives designed include translational cutting, rotary cutting and intelligent manual cutting. With plant production constraints, the knives are not suggested to be applied in production.

3.1. Electric tapping knife of translational cutting

Minghui Wang\textsuperscript{[11]} has invented electric tapping knife of translational cutting in 1994 which was the earliest designed at home. The design is in shape V tradition of tapping way, and the knife could power tapping knife that convert the mechanical power into translational power. Yiming Zheng\textsuperscript{[12]} also has invented electric tapping knife that works something like Minghui Wang’s in 2012. Electric tapping knife of translational cutting designed by Minghui Wang is as shown in Figure 1. Electric tapping knife of translational cutting designed by Yiming Zheng is as shown in Figure 2.

![Figure 1. Electric tapping knife of translational cutting designed by Minghui Wang](image1)

![Figure 2. Electric tapping knife of translational cutting designed by Yiming Zheng](image2)

3.2. Electric tapping knife of rotary cutting

Minxian Zhou\textsuperscript{[13]} has invented electric tapping knife of rotary cutting in 2013. The design has the advantages of high cutting efficiency, saving time and energy, fast speed and portability. Two coordinate cutting blades located in the front of the knife are used to cut bark and cut old tapping line respectively. But the knife has the disadvantages of complicated structure of tool bit and great bulk. The cutting is not in place end to end, simultaneously
fragments of bark may be cut, which can contaminate natural latex. Electric tapping knife of rotary cutting designed by Minxian Zhou is as shown in Figure 3.

![Figure 3. Electric tapping knife of rotary cutting designed by Minxian Zhou](image1)

3.3. Electric tapping knife of intelligent manual cutting. Yan Zhang\textsuperscript{[14]} has invented electric tapping knife of rotary cutting in 2013. Based on shape V tradition of tapping knife, the contact alarming device is installed in the design to measure dark thickness. The design is also in theory at present. Electric tapping knife of intelligent manual cutting designed by Yan Zhang is as shown in Figure 4.

![Figure 4. Electric tapping knife of intelligent manual cutting designed by Yan Zhang](image2)

4. The research on automatic tapping machinery

The research on automatic tapping machinery began in 1979 by RRIM and Japanese Nihon Giken company. The automatic tapping machinery is main designed by Rubber Authority in Malaysia and Zhenkun Xu in China in recent years.

4.1. Automatic tapping machinery designed by Rubber Authority in Malaysia

The design achieves tapping efficiently and precisely, but it has high cost, easy to damage, and maintenance cost. So it proves infeasible widely popularizing and appilcating it in production. The automatic tapping machinery designed by Rubber Authority in Malaysia is as shown in Figure 5.

![Figure 5. The automatic tapping machinery designed by Rubber Authority in Malaysia](image3)
4.2. Automatic tapping machinery designed by Zhenkun Xu in China

The function of the automatic tapping machinery has been designed by Zhenkun Xu in China, is similar to Rubber Authority’s in Malaysia. It also can not apply widely in production. The automatic tapping machinery designed by Zhenkun Xu in China is as shown in Figure 6.

Figure 6. The automatic tapping machinery designed by Zhenkun Xu in China

5. The innovation integration of tapping machinery

To resolve the problem of mechanical tapping, our design team has designed 4GXJ-I of cordless brushless tapping knife, combined with tapping research theory, semi-automatic and automatic tapping machine design at home and abroad. 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. We confirm the samples and small scale trial production. The market recognition will becomes higher, and this will gives impetus to industrial transformation and upgrading of natural rubber.

Type 4GXJ-I of cordless brushless Tapping Knife is as shown in Figure 7.

Figure 7. 4GXJ-I of cordless brushless tapping knife

6. Conclusion

In conclusion, 4GXJ-I tapping knife designed by our team and automatic tapping machinery designed by Zhenkun Xu in China are more suitable for industrial markets now. Mechanical tapping is the inevitable trend to promote the development of natural rubber industry. The establishment and operation of manufacture technology and quality control system on mechanical tapping machine are very important and necessary. So how can we improve the efficiency, fast and efficient design of mechanical tapping machine, has become an issue in front of the designer. The research of mechanical tapping machine is also still a hot topic.

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