Development of a new special combination tool for substation secondary service

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Abstract. In order to ensure the safety of power production, enhance substation secondary professional capability, especially improve the efficiency of the secondary professional in stripping cables. For conventional wallpaper knives, wire strippers, etc. used in traditional work. We carried out an overall improvement and upgrade, and combined the improved tools into a special combination tool for substation secondary inspection. It has been proved by practice that after using the special combination tool for substation secondary service, the work safety factor can be effectively enhanced, and the working efficiency of the secondary professional stripping cable is greatly improved. The special combination tool for substation secondary inspection proposed in this paper is of great significance for standardizing secondary professional operation standards, ensuring work safety and improving work quality.

1. Introduction
With the continuous development of the electric power industry, the workload of the secondary substation consisting of relay protection and automation in the power system is increasing. Among them, the basic work of stripping cables is heavy and time-consuming. [1] While ensuring work safety, it is necessary to improve work efficiency and ensure operating standards. This puts new demands on the seemingly simple basic work of stripping wires. [2-3]

In the past, most of the wire stripping work relied on the experience of the staff. The tools used were traditional wallpaper knives, wire strippers and insulating tape. The working order is that the wallpaper knife breaks the overall outer skin of the cable, and the wire stripper separately breaks each wire, and then is insulated by an insulating tape to prevent accidental electric shock. However, traditional stripping tools have many shortcomings in terms of safety, efficiency, and economy. [3-4]

2. Experimental data analysis using traditional tools
In order to better understand the status quo of secondary electric stripping work of substation and facilitate data analysis, this paper uses traditional wallpaper knife and wire stripper to carry out two sets of experiments: overall stripping and stripping. The subjects were composed of first-line workers with different work experience, and two sets of experiments were conducted. [5]

The experimental data are as follows: Table 1 is the stripping data of the traditional wallpaper knife, Table 2 is the data of the traditional stripping pliers.
Table 1 Traditional wallpaper knife stripping experimental data

| Number | Name | Experience (year) | Total number of times | Cable length (m) | Number of injured hands | Hand injury probability | Per capita hand injury probability | Average time (s) | Per capita time (s) | Number of errors | Number of errors per capita |
|--------|------|--------------------|-----------------------|-----------------|------------------------|------------------------|----------------------------------|----------------|----------------|----------------|--------------------------|
| 1      | A    | 9                  | 100                   | 50              | 1                      | 1%                     | 2%                               | 40s            | 47s            | 5              | 5                        |
| 2      | B    | 13                 | 100                   | 50              | 1                      | 1%                     | 2%                               | 44s            | 6              | 6              | 3                        |
| 3      | C    | 10                 | 100                   | 50              | 1                      | 1%                     | 2%                               | 35s            | 3              | 3              | 3                        |
| 4      | D    | 5                  | 100                   | 50              | 2                      | 2%                     | 4%                               | 45s            | 5              | 5              | 5                        |
| 5      | E    | 3                  | 100                   | 50              | 4                      | 4%                     | 4%                               | 60s            | 7              | 7              | 7                        |
| 6      | F    | 3                  | 100                   | 50              | 3                      | 3%                     | 3%                               | 58s            | 9              | 9              | 9                        |

It can be seen from the test data in Table 1 that after 100 times of stripping work, 6 first-line production employees with different work experience have a per capita injury probability of 2%, and the average per capita time is 47s. The number of per capita errors is 5.8 times. Obviously, when using traditional methods for stripping work, the safety, efficiency, and economy of the work cannot be guaranteed.

Table 2. Traditional wire stripper experimental data

| Number | Name | Experience (year) | Total number of times | Standard stripping cable length (cm) | Correct stripping times | Stripping correct rate | Per capita stripping accuracy | Time(s) | Average time(s) |
|--------|------|--------------------|-----------------------|--------------------------------------|------------------------|------------------------|-------------------------------|---------|----------------|
| 1      | A    | 9                  | 100                   | 2                                    | 85                     | 85%                    | 77.7%                         | 320s    |                |
| 2      | B    | 13                 | 100                   | 2                                    | 90                     | 90%                    | 300s                          |         |                |
| 3      | C    | 10                 | 100                   | 2                                    | 88                     | 88%                    | 309s                          |         |                |
| 4      | D    | 5                  | 100                   | 2                                    | 85                     | 85%                    | 330s                          |         |                |
| 5      | E    | 3                  | 100                   | 2                                    | 70                     | 70%                    | 400s                          |         |                |
| 6      | F    | 3                  | 100                   | 2                                    | 76                     | 76%                    | 380s                          |         |                |
| 7      | G    | 1                  | 100                   | 2                                    | 50                     | 50%                    | 450s                          |         |                |

Remarks: This experiment stipulates that the cable length is 2cm each time, and the stripping error is between -15% and +15% for correct stripping. (This error range is established according to the actual production standard of the secondary work)

From the test data analysis in Table 2, 7 people with different work experience when using traditional wire stripping pliers for stripping, the per capita correct stripping rate is only 77.7%, and the time is 355s. Obviously, traditional wire strippers are lacking in the correct rate of stripping and work efficiency, and need to be improved.

3. New combination tool principle and structure

3.1. Improved wallpaper knife structure

See Figures 1, 2, and 3. The components are as follows: 1: lifting ring, 2: counting wheel, 3: display, 4: blade, 5: magnet, 6: probe, 7: magnetoelectric sensor, 8: wire, 9: Tool holder.

As shown in Figures 1 and 2, the modified stripped cable wallpaper knife comprises a shank 9, a blade 4 on the front side of the shank 9, and an open sling 1 (for cable penetration) at the lower end of the front side of the shank 9. A counting wheel 2 (counter) is provided at the upper inner side of sling 1, and a display 3 is provided on the shank 9.

When performing the stripping work, thread the cable from the eye 1 and adjust the size of the ring to fit the thickness of the cable. When the work of stripping the cable sheath is carried out, the hand of the worker is held behind the loop, so that the cutter head is separated from the hand by the loop, thereby avoiding the possibility of hurting the hand. The counting wheel 2 which is close to the cable sheath during the peeling work will roll as the stripping progresses, and the rolling data is transmitted to the processor through the sensor 7, and the display on the wallpaper knife will display the accurate stripping length after the processor calculates. [6]
3.2. Improved wire stripper structure

See Figures 3 and 4. The parts names are as follows: 1: stripper body, 2: slide, 3: scale, 4: sliding scale baffle, 5: dial hole, 6: shaft.

The improved wire stripper comprises a hinged opening and closing wire stripper body 1, and a slide rail 2 is fixed on one side of the wire stripper body 1, and a scale 3 is hinged on the slide track 2, and the scale 3 can rotate around the slide track and move along the slide. The scale 3 has a sliding scale baffle 4, and the setting of the scale baffle 4 can control the length of the dial. [7]

4. Analysis of experimental data after using a new combination tool

In order to verify the improved tool usage, the same experiment was performed using the same combination of tools and the same personnel used in the first part of the experiment, while the other conditions were unchanged. The improved data is shown in Table 3 and Table 4. Table 3 shows the experimental data of the improved wallpaper knife, and Table 4 shows the experimental data of the improved wire stripper.
Table 3. Traditional wallpaper knife stripping experimental data

| Number | Name | Experience (year) | Total number of times | Cable length (m) | Number of injured hands | Hand injury probability | Per capita hand injury probability | Average time (s) | Per capita time (s) | Number of errors | Number of errors per capita |
|--------|------|-------------------|-----------------------|-----------------|-------------------------|------------------------|----------------------------------|----------------|-------------------|----------------|--------------------------|
| 1      | A    | 9                 | 100                   | 50              | 0                       | 0%                     | 0%                               | 33s            | 33.33s            | 0              | 0                        |
| 2      | B    | 13                | 100                   | 50              | 0                       | 0%                     | 0%                               | 32s            | 33.33s            | 0              | 0                        |
| 3      | C    | 10                | 100                   | 50              | 0                       | 0%                     | 0%                               | 30s            | 33.33s            | 0              | 0                        |
| 4      | D    | 5                 | 100                   | 50              | 0                       | 0%                     | 0%                               | 31s            | 33.33s            | 0              | 0                        |
| 5      | E    | 3                 | 100                   | 50              | 0                       | 0%                     | 0%                               | 38s            | 33.33s            | 0              | 0                        |
| 6      | F    | 3                 | 100                   | 50              | 0                       | 0%                     | 0%                               | 36s            | 33.33s            | 0              | 0                        |

Table 4. Traditional wire stripper experimental data

| Number | Name | Experience (year) | Total number of times | Standard stripping cable length (cm) | Correct stripping times | Stripping correct rate | Per capita stripping accuracy | Time (s) | Average time(s) |
|--------|------|-------------------|-----------------------|-------------------------------------|-------------------------|------------------------|--------------------------------|----------|-----------------|
| 1      | A    | 9                 | 100                   | 2                                   | 100                     | 100%                   | 100%                           | 290s     | 295s            |
| 2      | B    | 13                | 100                   | 2                                   | 100                     | 100%                   | 100%                           | 280s     | 283s            |
| 3      | C    | 10                | 100                   | 2                                   | 100                     | 100%                   | 100%                           | 288s     | 290s            |
| 4      | D    | 5                 | 100                   | 2                                   | 100                     | 100%                   | 100%                           | 295s     | 295s            |
| 5      | E    | 3                 | 100                   | 2                                   | 100                     | 100%                   | 100%                           | 305s     | 305s            |
| 6      | F    | 3                 | 100                   | 2                                   | 100                     | 100%                   | 100%                           | 310s     | 310s            |
| 7      | G    | 1                 | 100                   | 2                                   | 100                     | 100%                   | 100%                           | 290s     | 290s            |

Comparing Tables 1 and 3, it can be clearly seen that after using the improved wallpaper knife, the probability of per capita injury under the same conditions is reduced to 0%, which fully guarantees the safety of the staff. The average per capita time has dropped from the original 47s to 33.33s, and the work efficiency has improved significantly.

Comparing Table 2 and Table 4, it can be clearly seen that after using the improved wire stripper, the stripping accuracy rate is 100% under the same conditions, and the per capita time of stripping 100 times is from 355s to 295s. The quality of work and work efficiency have been greatly improved.

5. Conclusion
Aiming at the problems of low safety, low efficiency and low economy of the current substation secondary cable breaking and stripping, this paper proposes a special combination tool. From the working principle and structure of the third part of this paper, as well as the data analysis and comparison of the second part and the fourth part, it can be seen that the use of the combination tool can effectively improve the safety, efficiency and economy of the secondary work of the substation.

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