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Development of a portable retractable tower naming plate paster

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Abstract. Due to the use of the new line and the new station area, the existing tower naming plate has not met the requirements of the latest specification, and it is urgent to replace it in batches, but the traditional naming plate pasting work must be carried out manually throughout the whole process, which is time-consuming and laborious, and the efficiency is low. In order to solve the above problems, a portable retractable tower naming plate pasting device was developed to improve the on-site pasting working mode, and the device integrates a fixed fixture, a cleaning brush, and a retractable insulating rod in one, and has the characteristics of portability and high efficiency. It has been proved in practice that the developed device can effectively reduce the unqualified rate of pasting and improve work efficiency, and effectively improve quality and efficiency.

1 Introduction

The tower naming board is a working board of the power line, which not only displays the name and direction of the line, but also plays the role of publicity and warning[1]. In recent years, with the rapid economic and social development, the continuous expansion of urban boundaries, and the use of a large number of new lines and new stations, how to strengthen the management of distribution network has become a key task that must be paid attention to for a long time[2-3]. The pole number plate is the working card of the power line, which not only shows the name and direction of the line, but also plays the role of publicizing power knowledge and providing safety warnings. Some of the newly put into operation line pole number plate is missing, some line pole number plate in the natural environment to fall off, missing, blurred and other problems to the distribution network line operation and maintenance and daily maintenance leave a large safety hazard. In addition, due to historical reasons, there are a large number of pole number plates named on the site to not meet the requirements of the latest specifications, and need to be replaced in large quantities, and the workload of pole number plate pasting is getting larger and larger, which consumes a lot of human resources at the same time, and also greatly increases the work pressure of the owner of the distribution network equipment. How to improve the efficiency of pole number plate pasting has become an urgent problem to be solved. At present, most of the existing literature on the research on tower naming plates is from the perspectives of improving the material of the naming plate itself and reducing the cost [4-10]. However, there are few studies on the problem of low efficiency of naming plate pasting in the actual work of distribution network operation and maintenance personnel.

In order to improve the efficiency of on-site pasting of tower naming plates, a portable retractable tower naming plate pasting device was developed based on the actual production requirements. The developed device has been applied in the actual production work of the team, and it has been proved in practice that the device can effectively reduce the error of pasting work and improve work efficiency.

2 Traditional tower naming tag on-site pasting workflow

The traditional on-site pasting of tower name plates requires at least three people to complete: one person is responsible for safety supervision, one person climbs the ladder to carry out the pasting work, and one driver. The on-site pasting workflow of the naming plate can be divided into: on-site investigation, on-site preparation, on-site operation, on-site cleaning, and the time consumption of each work link is different. Figure 1 shows the specific process.

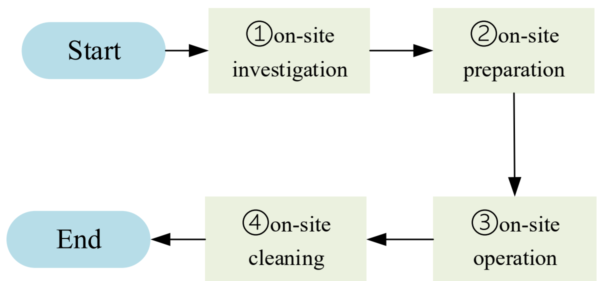

Fig 1. The traditional on-site pasting workflow of tower naming plates

First of all, the staff conducts on-site investigation, determines the work content and checks the work task object, and conducts on-site preparation after confirming the site; Then the staff will carry the electrician ladder

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from the engineering vehicle to the work site and carry out the relevant security arrangement, and the escalator will be climbed by one person to carry out the pasting work, and then the ladder will be carried back to the engineering vehicle and placed safely after the work is completed; Finally, the site is cleaned up after the pasting work is completed.

That is, the on-site pasting work is time-consuming:

$$T_{\text{sum}} = T_{on-site\ investigation} + T_{on-site\ preparation} + T_{on-site\ operation} + T_{on-site\ cleaning} \tag{1}$$

According to the survey statistics, the average time spent on on-site pasting work and the proportion of time spent in each link are shown in Table 1.

Tab 1. Statistics of the average time consumption of each link

Tache	Average pasting time (s)	Proportion (%)	Cumulative proportion (%)
on-site operation	90.5	75.04	75.04
on-site investigation	15.2	12.6	87.64
on-site preparation	8.1	6.72	94.36
on-site cleaning	6.8	5.64	100.0

Time-consuming diagram of on-site pasting of tower naming plates is shown in Figure 2.

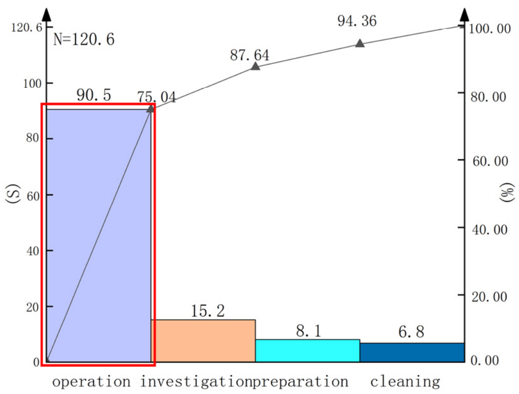

Fig 2. Time-consuming diagram of on-site pasting of tower naming plates

It can be seen from Figure 2 that the overall pasting work of the traditional tower naming plate in the field pasting work takes an average of 120.6 seconds, where in the on-site investigation takes seconds, accounting for 12.6%, the on-site preparation takes seconds, accounts for 6.72%, the on-site operation takes seconds, accounts for 75.04%, and the on-site cleaning takes seconds, accounting for 5.64%.

Since the on-site operation process occupies most of the time of the overall pasting work, this paper further studies the on-site operation link by using hierarchical analysis, and the specific process is shown in Figure 3.

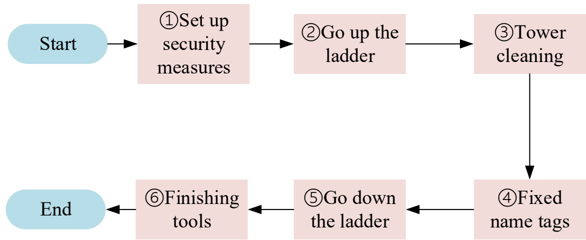

Fig 3. Flow chart of on-site operation

First of all, the staff carried out on-site security arrangement, then climbed the ladder to clean the tower, then fixed the naming plate, went down the ladder after the work on the tower was completed, and finally sorted out the tools. The specific time-consuming proportion of each process is shown in Figure 4, and it can be seen from the figure that the fixed time-consuming time of the ladder process and the naming plate accounts for 85.51%, that is, the above-mentioned process is the main cause that causes the tower naming plate to paste the work on site for a long time.

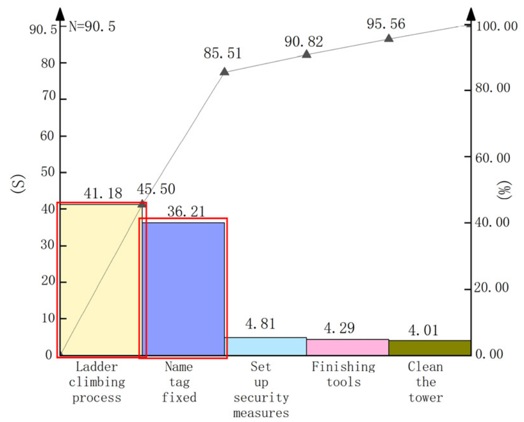

Fig.4 Time-consuming diagram of each process of on-site operation

In actual on-site work, due to the different heights of the naming plates, it is necessary to judge according to the specific conditions of the site, resulting in the need to adjust the placement angle of the ladder many times or even replace the more suitable ladder; Due to the entry of air when manually pasting the naming plate, it is easy to appear bubbles, wrinkles and other phenomena after the naming plate is pasted, and it needs to be adjusted artificially many times.

Through the above analysis, it can be seen that there are two defects in the on-site pasting of traditional tower naming plates:

(1) The manual handling and placement process of the ladder is cumbersome, resulting in the ladder process taking too long;

(2) Manually pasting the naming plate is prone to bubbles and wrinkles, and it needs to be adjusted artificially many times, resulting in the fixing time of the naming tag taking too long.

Solving the above two defects can greatly shorten the working time of on-site pasting of tower naming plates, reduce the work pressure of distribution network operation and maintenance personnel, and improve the work efficiency of distribution network operation and maintenance personnel.

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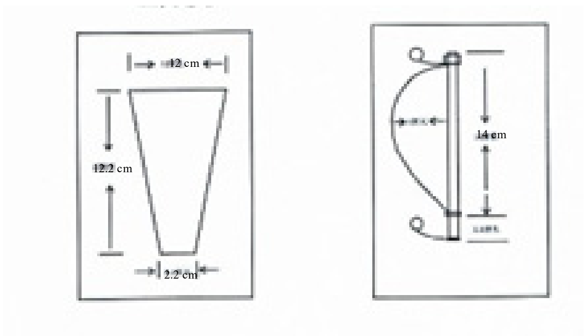
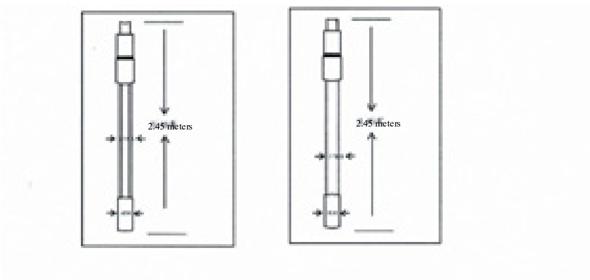
3 Design of portable retractable tower naming plate pasting device

Based on the defects existing in the traditional tower naming plate pasting work, this paper designs a portable retractable tower naming plate pasting device according to the actual production requirements, and the design schematic diagram is shown in Figure 5.



(a) fixed clamp



(b) retractable insulating rod

Fig 5. Schematic diagram of device design

The overall unit can be divided into two parts: a fixed clamp (Fig 5a) and a retractable insulating rod(Fig 5b) . Among them, the main part of the fixing fixture is made of cast steel material, including the upper and lower fixing clips, the main body pressing plate, and the wooden cleaning brush; The main part of the retractable insulating rod is made of mixed insulating materials, and the height can be freely adjusted in two sections.

When using the developed pasting device to carry out on-site pasting work, first use the fixed fixture to fix the upper and lower ends of the naming plate, and then use the retractable insulating rod to raise the device to the working height to carry out the pasting work, and then use the cleaning brush on the device to flatten the naming plate after the naming plate is pasted, and then complete the on-site pasting work. The specific use of the tool is shown in Figure 6.

Fig 6. Field usage diagram

When using the tool developed in this paper to carry out the naming plate pasting work, the working procedure becomes: take out the device from the engineering vehicle - carry out the pasting work - put the device back on the engineering vehicle, and the specific flow chart is shown in Figure 7.

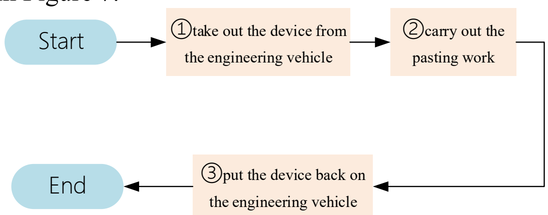


Fig 7. Improved pasting workflow

Compared with the traditional tower naming plate on-site pasting work, the retractable insulating rod replaces the traditional ladder climbing process when using the device to work, and the fixed fixture replaces the manual pasting of the naming plate. It not only simplifies the steps of the ladder climbing process, reduces the burden on the staff, but also improves the success rate of naming plate pasting.

4 Experimental validation

Certified by the relevant departments of the company, the equipment of this achievement has no negative impact on safety, quality, cost, etc., and it is agreed that the device developed in this paper will be put into use in the daily tower naming plate pasting work. In order to test the actual pasting effect of the developed device, the team has put into use the portable retractable tower naming plate pasting device since January 2023. It is also compared with the time taken by the staff to paste the original method from January to October 2022. After being put into use for a period of time, the traditional pasting method and the developed device pasting were continuously tracked and statistically compared, and the naming plate pasting situation under different working modes was obtained, as shown in Table 2.

Table 2. Pasting of naming plates in different ways

Date	Odds of success (%)	Average pasting time (s)	Pasting method
2022.01	95.4	109.3	
2022.02	94.5	130.4	

2022.03	96.4	122.1	artificial
…	…	…	
2022.01~2022.10	95.4	120.6	
2023.01	100	50.5	assistive devices
2022.02	99.5	50.1	
2022.03	100	50.1	
…	…	…	
2023.01~2023.10	99.8	49.6	

From the above table, it can be seen that from 2022.01 to October 2022, the average success rate of the tower naming plate was 95.4% and the average time was 120.6 seconds. Since January 2023, when the developed device is used for pasting work, the success rate of naming plate pasting is 99.8%, and the average time is 49.6 seconds, and the comparison of pasting time before and after the use of the device is shown in Figure 8.

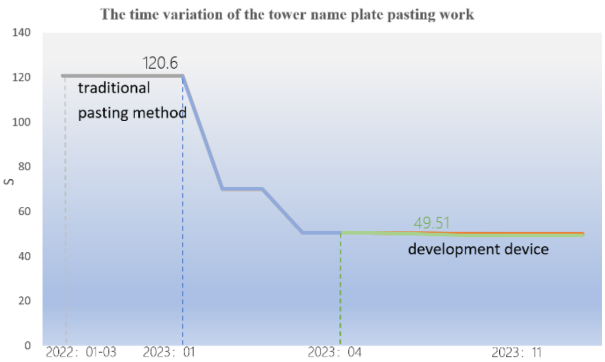


Fig 8. Comparison curve of pasting time between the traditional pasting method and the development device

It can be seen from the above figure that when the developed device is used for on-site pasting work, the time taken is significantly reduced compared with the traditional working method. The device developed in this paper can effectively improve the success rate of tower naming plate pasting, reduce the time consumption of pasting work, and effectively improve quality and efficiency.

5 Conclusion

By using the device developed in this paper, the on-site pasting time of the tower naming plate is shortened, and the on-site pasting work can be completed by only 2 people at most, which greatly improves the work efficiency and saves a lot of manpower and material resources. The timely update of the tower naming plate helps to strengthen the management of the distribution network, facilitates the daily maintenance operation of the operation and maintenance personnel of the distribution network, and prevents the staff from confusing the equipment during the inspection and operation of the power equipment, resulting in personal injuries and equipment damage, which brings considerable social benefits. In view of the problems of small success rate and low work efficiency caused by cumbersome manual operation mode and geographical environment restrictions in the pasting of tower naming plates by distribution network operation and maintenance personnel, a portable retractable tower naming plate pasting device has been developed and has been put into actual production and use.

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