The influence factors on optical cable's water seepage and corresponding solutions

Bin Zhang, Zhenhua Liu, Yijun Zhang, Yangzhu Zhang, Zhenggang Wang, Shaofen Liu,Haiyan Song

Xi'an Xigu Fiber Optica Communication Co., Ltd,

No.18 Information Road, Hi-tech Industrial development Zone, Xi'an, shaanxi, P.R China

+86-029-85691220 zhangbin@fxoc.com.cn

Abstract

This paper has discussed the reasons for optical cable's water seepage from such aspects as the optical cable's structure, the material property and jelly filling methods of the water-resistant cable jelly as well as the molding of laminated metal plastic strip. At first, we have offered the reasonable design scheme of cable structure, analyzed the relation between the material and the section's water seepage, chosen a reasonable jelly filling method to improve the optical cable's water-resistance. Then compared with the existing moldings of laminated metal plastic strip, it is necessary to design a new kind of optical cable with higher production speed, lower broken belt rate and better water-resistance. At last, we have summarized the questions mentioned above, and provided the complete scheme to solve the optical cable's water seepage problem, and the experimental results have shown that the scheme is highly effective in water-resistance.

Keywords: water seepage; structure; material; filling methods; molding

1. Introduction

During its long-term use process, the optical cable will be inevitably affected by water invasion from the surrounding environment, which will influence its service life and transmission performance. So seeping water of the optical cable is always a difficult problem in its use. Therefore, it is quite important to reasonably control the manufacturing technology to enhance the cable's water-resistance. And water-resistance was influenced by many different kinds of factors. Take the fully filled optical fiber cable as an example. We have offered the reasonable design scheme of cable structure, made comparative analysis on the performance of different cable jelly by experiment, and analyzed the relation between the material and the section's water seepage. Compare with the influence of two different kinds of jelly filing methods on the optical cable's water seepage, we have chosen a reasonable one from the perspective to improve the optical cable's water-resistance. Compare with the existing moldings of laminated metal plastic strip to design a new kind of optical cable with higher production speed, lower broken belt rate and better water-resistance.

We have summarized the questions mentioned above, and provided the complete scheme to solve the optical cable's water seepage problem, and the experimental results have shown that the scheme is highly effective in water-resistance.

2. The influence factors on optical cable's water seepage

We have statistical a large number of cables after the water seepage experiment, the results shown that water seepage is always found in cable core and the overlaps of the laminated metal plastic strip. There are nearly 94% water seepage appeared in the overlaps of the laminated metal plastic strip and cable core, about 6% appeared in other part[1]. So how to solve the water seepage in the overlaps of the laminated metal plastic strip and cable core is very important. This paper has discussed for cable's structure, material property, jelly filling methods and laminated metal plastic strip which are shown in Figure1.

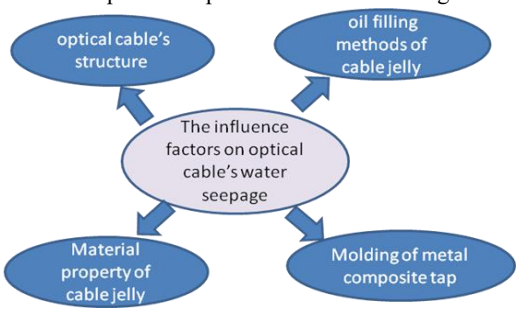


Figure 1. Influence factors on optical cable's water seepage

The experiment and conclusion are based on fully filled optical fiber cable which the structure is shown in Figure 2.

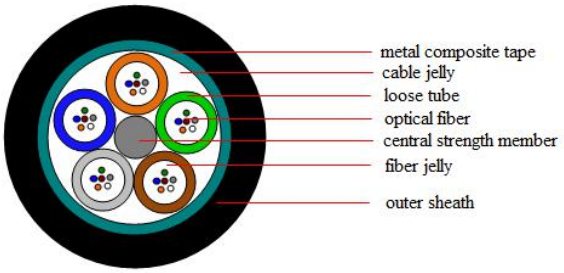


Figure 2. Structure of fully filled optical fiber cable

2.1 Structure of optical cable

In order to improve the cable's mechanical properties and protect the transmission performance of optical fiber, so the loose tubes were also used SZ stranding and then consist of cable core. In the cable core whether cable jelly can fully filled was decided by shell clearance, therefore we must consider the shell clearance when designing the structure of the cable. We often calculated the cross section of the loose tube as an ideal circle, but actually the cross section of the loose tube which vertical with the strength member is an ellipse by using the SZ stranding. The side view of the cable core is shown in Figure 3.

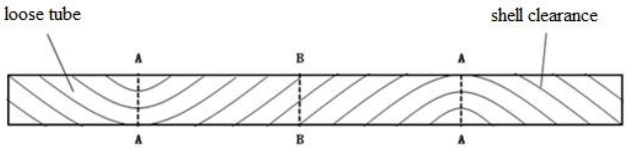
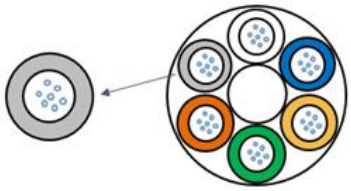
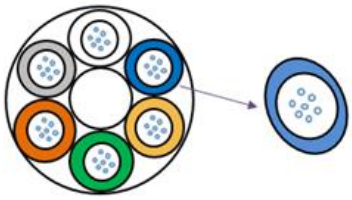


Figure 3. The side view of the cable core after SZ stranding

The cross section in different parts of the cable core is shown in Figure 4. Figure 4(a) shows A-A cross section, which is a circle. Figure 4(b) shows B-B cross section, which is an ellipse. We can see that A-A cross section is a special part between S stranding and Z stranding, B-B cross section is in the same stranding way.



（a）A-A cross section



（b）B-B cross section

Figure 4. Cross section in different parts of the cable core

Based on circle and ellipse cross section, the clearance of the loose tube is calculated respectively, we draw a conclusion that the clearance of circle cross section is larger than the ellipse one. And the shell clearance was influenced by the diameter of the loose tube and strength member, the number of loose tube and stranding intercept. That we can see from Table1.

Table 1. Clearance of the loose tube with different structure

structure	Strength member	Stranding intercept	clearance of the loose tube		Difference（mm）
			Circle cross section（mm）	Ellipse cross section(mm)	
1+5-Φ2.05	1.6	60	0.0954	0.0583	0.0371
1+6-Φ2.05	2.2	85	0.075	0.0499	0.0251
1+8-Φ2.05	3.5	90	0.0739	0.0358	0.0381
1+10-Φ2.05	4.9	100	0.0977	0.0494	0.0483
1+12-Φ2.05	6.3	110	0.1111	0.0537	0.0574

The clearance of the loose tube is large which is shown in Figure 5, and the clearance of the loose tube is small which is shown in Figure 6.Both pictures are the real picture of the cable core. The clearance of the loose tube also decided the cable jelly whether can fully fill the cable core. The cable jelly can easily fill the large clearance of the loose tube, but it is hard to fully fill the small clearance of the loose tube. So the A-A section it has a better water-resistance than B-B section.

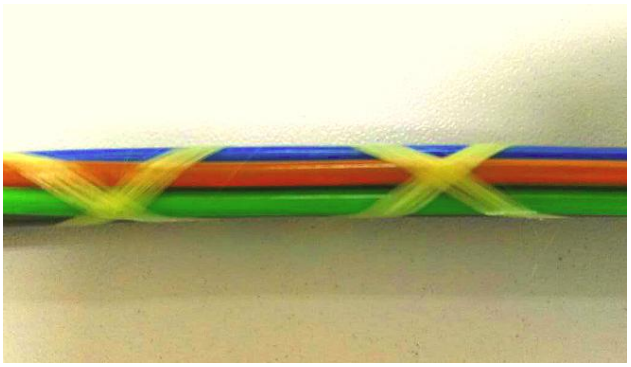


Figure 5. The cross section is a circle

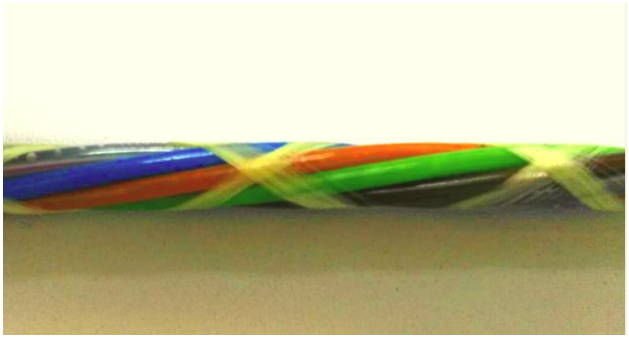


Figure 6. The cross section is an ellipse

2.2 Material property and filling method

The cable jelly is an important material to fully fill the optical fiber cable, it is also filled between loose tube, between cable core and laminated metal plastic strip that can easily prevent the water seepage and protect the loose tube [2]. In the end, optical cable's service life and transmission performance are highly protected.

According to the water blocking mechanism, cable jelly mainly fall into two categories which is water proof type and water absorption swelling. And the water absorption swelling is widely used in the fully filled optical cable. In the experiment, we choose different kinds of cable jelly from different companies and have different parameters. The different parameters are shown in Table 2.

Table 2. Parameter of different cable jelly

parameter	sample 1	sample 2	sample 3	sample 4
viscosity (mpa.s)	10000	12000 ±3000	11000 ±3000	7000± 2000
Density（g/cm3）	0.58	0.93± 0.02	0.6± 0.02	0.93± 0.03
penetration25℃(1/10mm)	445	380± 10	420± 20	440±30
penetration-40℃(1/10mm)	150	>100	>100	>100
water adsorption time 15g(sample) +10g(water)（min）	1	<2	<3	<1

The water seepage is not only decided by material property, but also the method of filling. Cable jelly has two kinds of filling patterns, one is pressure filling and the other is spraying. The pressure filling method can make the cable jelly full of the cable core, but the jelly can't fill overlaps of the laminated metal plastic strip. So it may lead to water seepage. Although the spraying method can fill overlaps, but it needs to fill the cable

jelly in the core when is stranding. Different cable jelly have different advantages and disadvantages, hence it is necessary to choose a suitable method. The spraying and pressure filling equipment are shown in Figure 7 and Figure 8.

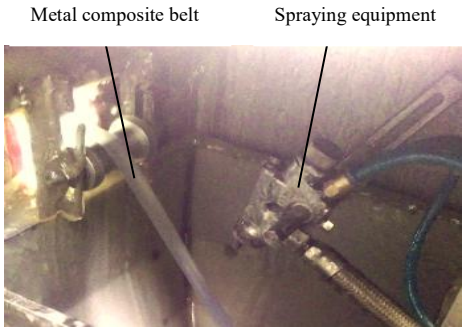


Figure 7. Spraying equipment

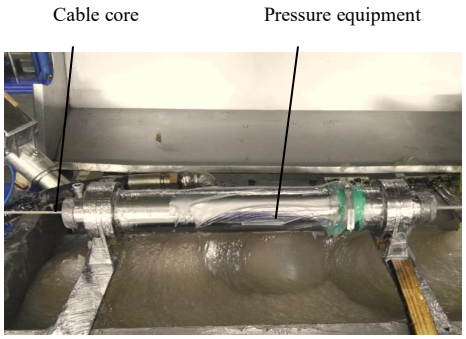


Figure 8. Pressure filling equipment

In this paper, we choose four kinds of cable jelly and use two kinds of different filling method, introduce 8 group compare experiment, each group have 10 cable samples which is 1 meter water column for 3 meters cable and keep 24 hours, based on the same environment. The water seepage experiment equipment is shown in Figure 9.

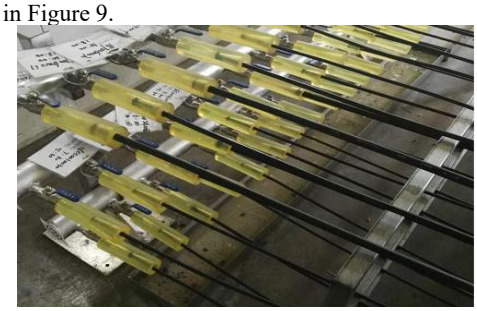


Figure 9. Water seepage experiment equipment

With pressure filling method, the cable jelly 4 is the best one for water-resistance, the cable jelly 1 and cable jelly 3 is the second and third, the cable jelly 2 is the worst one. This phenomenon is proved that the shorter water adsorption time it has, the better water-resistance it is. With the same cable jelly, pressing method is better than spraying.

With spraying method, the cable jelly 4 is the best one too, the cable jelly 1 and cable jelly 2 is the second and third, the cable jelly 3 is the worst one, it proved that the viscosity is an important parameter, the lower viscosity, the better it is. The result is shown in Figure10.

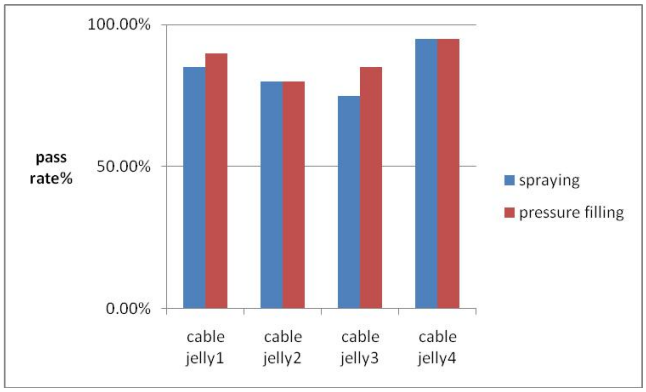


Figure 10. Result of the experiment

2.3 Molding of laminated metal plastic strip

Laminated metal plastic strip is longitudinal wrapped by mold, it can make the composite belt have overlaps and protect the fiber in the cable. But the gap between the cable core and laminated metal plastic strip, which in the overlaps and the side of the laminated metal plastic strip is upwarp .Those phenomenon will result water seepage. So how to choose a suitable mould is necessary for laminated metal plastic strip. There are three kinds of problems which are shown in Figure 11.

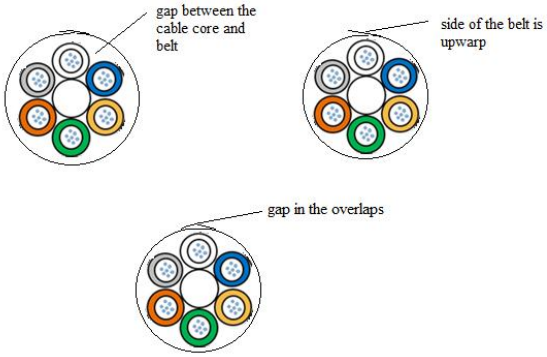


Figure 11. Three kinds of problems are resulted by mould

When the water invade optical cable, the gap between the cable core and laminated metal plastic strip is large, there are not enough cable jelly to fill the gap, it may result water seepage. If there is a gap in the overlaps of the laminated metal plastic strip, the water will invade optical cable easily. And the upwarp side of the laminated metal plastic strip will also result water seepage. It is not effective to solve those problems by using the existing molding of the laminated metal plastic strip. It also caused the problem of water seepage after experiment. The Figure12 is the real picture of the optical cable. So we design a new molding of laminated metal plastic strip in next section with a higher production speed, lower broken belt and better water-resistance.

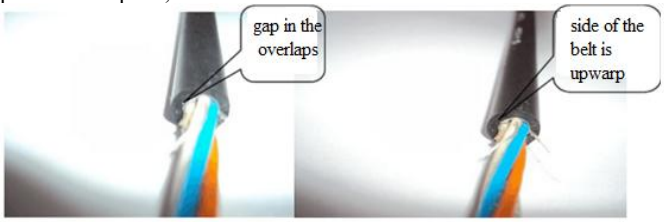


Figure 12. The problem of the laminated metal plastic strip

3. The solution of optical cable's water seepage

Cable's water seepage was decided by many factors mentioned above. Aiming at those problems, we have provided the complete scheme to solve the optical cable's water seepage problems. The solution is shown in Figure 13.

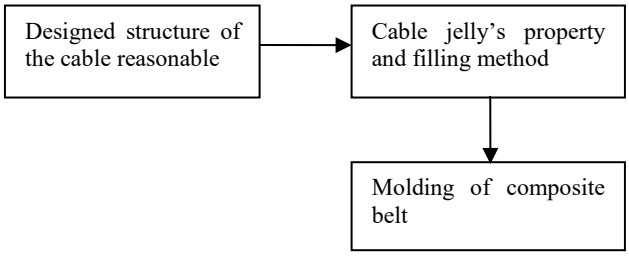


Figure 13. Solution of optical cable's water seepage

3.1 Structure of the optical cable

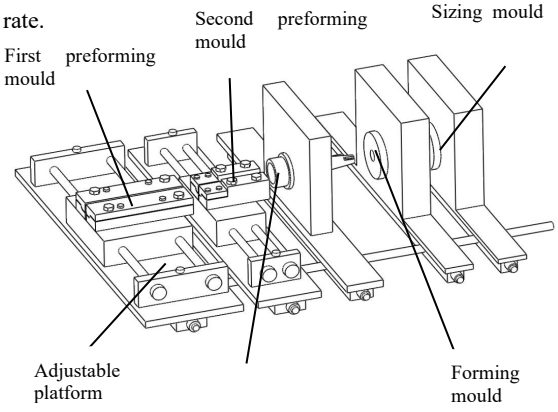
We should consider the difference between theoretical calculation and actual production and give a reasonable shell clearance. The clearance was decided by the numbers and the diameter of the loose tube, the size of the strength member, we should control the stranding length in the process of production.

3.2 Cable jelly's property and filling method

In production, different fill methods have different kinds of cable jelly. For example, cable jelly which has low viscosity only coating in the laminated metal plastic strip when we use spraying method, because the lower viscosity the cable jelly has, the more easier cable jelly spraying. And cable jelly which has short water adsorption time filled in the cable core when we use the pressure method. But in production, spraying method is more complex than pressure method, and it influences the efficiency. So we suggest that use pressure method to fill the cable core, and the new molding for laminated metal plastic strip. By using this method, it is not only resistance water in the cable core, but also resistance water in the overlaps.

3.3 Molding of laminated metal plastic strip

We design a new kind of molding is shown in Figure14. The molding of composite belt including first preforming mould, second preforming mould, overlapping mould, forming mould, sizing mould, adjustable platform. Using this new kind of molding can make the overlaps of the composite belt become tight. It can easily solve the problems which are mentioned above. It is avoided the water seepage in the overlaps of the composite belt. This mould is not only preventing water seepage, but also have a higher production speed belt rate.



Overlapping mould

Figure 14. Molding of laminated metal plastic strip

When laminated metal plastic strip though this new kind of mould, it is gradually longitudinal wrapped by this mould. After every mould, we can see the position of laminated metal plastic strip with the cable core which is shown in Figure 15.

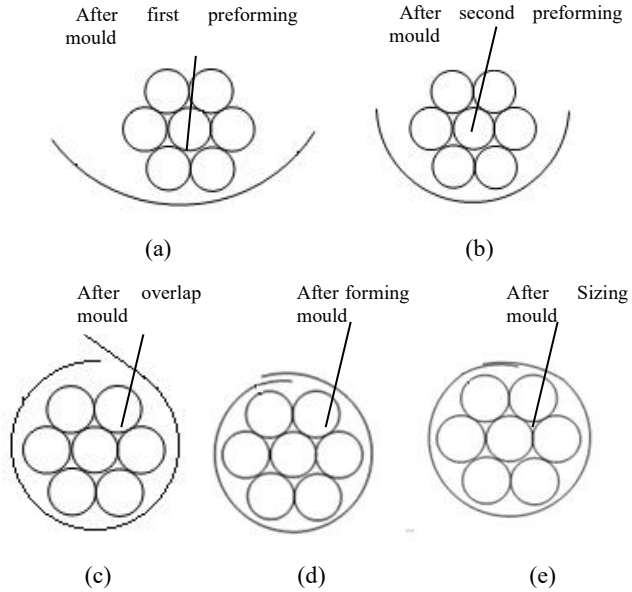


Figure 15. Longitudinal wrap picture after each mould

4. Conclusion

In this paper, we designed cable's structure, chosen a suitable cable jelly and jelly filling method, and designed a new molding of laminated metal plastic strip. It can solve the problems of cable's water seepage easily. In the water seepage experiment, we used 1 meter water column for 3 meters cable and kept 24 hours, the pass rate of the water seepage is 100%. After using the new molding of laminated metal plastic strip, we split the cable and found that the overlaps of the laminated metal plastic strip is very tight and have no clearance without cable jelly. So the molding of laminated metal plastic strip is very effective to the water seepage. This kind of mould is not only apply to fully filled optical fiber cable, but also apply to the dry and semi-dry optical fiber cable.

5. References

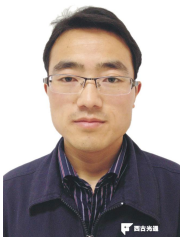
[1] Zhang Lei, Ye Yongqun. Some suggestions and solutions about cable's waterproof. Optical fiber cable academic proceedings. *P*387-392 (2009).

[2] Ai Tao, Li Tao, Zhang Hua. Analysis cable's water seepage. Modern transmission, P72-75 (2015).

6. Pictures of Authors

Bin Zhang

Bin Zhang received his master degree of science in Xi'an technological university in 2014. He joined Xi'an Xigu Fiber Optica Communication Co., Ltd in 2014. Now he has been engaged in the technology R&D dept.



Zhenhua Liu

Zhenhua Liu got a bachelor degree from Xi'an University of Architecture and technology in 2002. He joined Xi'an Xigu Fiber Optica Communication Co., Ltd in 2002.Now he is the CMO in furukawa electric Xi'an Optical communication Co.,Ltd.

Yijun Zhang

Yijun Zhang got a bachelor degree from Xi'an Technological university in 2005. He joined Xi'an Xigu Fiber Optica Communication Co., Ltd in 2008.Now he is a minister of Technology R&D Dept.

Shaofen Liu

s born in 1971. He received his bachelor's Electronic Technology from Xi'an University 1993. He joined Xi'an Xigu Fiber Optica o., Ltd in 2002, now he works as equipment

Haiyan Song

Haiyan Song is the General Manager in Xi'an Xigu Fiber Optica Communication Co., Ltd. He received his PhD degree in Electromagnetic Fields and Microwave Techniques from Beijing University of Post and Telecommunications in 1996.

Yangzhu Zhang

Yangzhu Zhang got a bachelor degree from Changchun University of Science and Technology in 1990. He joined Xi'an Xigu Fiber Optica Communication Co., Ltd in 1990. Now he is an engineer in Technology R&D Dept.

Zhengang Wang

Zhenggang Wang was born in 1986. He received his M.S.degree in Material Physics and Chemical from Hebei University of Technology in 2013. He joined Xi'an Xigu Fiber Optica Communication Co., Ltd after graduated. Now he works as manager in Quality and Assurance department.