Amelioration of Cone-shaped Optical Fiber Equipment*

WEI Shan-cheng[1], CHAO Jun-feng[2], LAI Zhen-jiang[1]
(1 *College of Physics and Information Engineering, Henan Normal University, Xinxiang, Henan* 453007, *China*)
(2 *Department of Physical and Information, Yulin Normal University, Yulin, Guangxi* 537000, *China*)

Abstract: Based on the complexity of fabricating the taper fiber and the performance in transmission of the image bundles, through applying the technology of combining step motor and computer, controlling the usual optical fiber double crucibles drawbench out-nozzle diameter and tub wheel′s rotating speed at the same time, of a way fabricating the taper fiber with numerical control, whose length can reach to 1m, is realized. Two image taper fiber bundles with the different ratio of radius are made. Compared with the ususl way that enlarging the volume of the tub wheel, this technique is smaller in the volume, easier to manipulate, easier to control the ratio of radius, more endurable to strain. At last we analyses the mode wastage of the taper fiber.

Key words: Taper fiber; Drawing fiber with drawbench; Step motor; Double crucibles drawbench; Multi-component glass fiber
CLCN: TN253 **Document Code**: A **Article ID**: 1004-4213(2008)04-0822-3

0 Introduction

In the non-communication optical fiber technology field, taper fiber is becoming more and more important with its predominant capability. In the market, there are two kinds of taper fiber: one is a taper with one end drawn cone-shaped, which is a little shorter and often applied in coupling of fiber to fiber, fiber to lamp-house and fiber to optical element, such as the splitter and the combiner of different kinds[1-2], the optical fiber probe of scanning tunneling microscopy[3] and taper coupling to CCD[4-7] et al. The fabrication of taper fiber is processing again on the foundation of fiber, which is much shorter. We can use drawing and eroding[8] to do it. The other is a longer taper, which can be used in coupling[9] sometimes, but hasn't appeared in the newspaper in other ways. With the drawbench, according to the data, tub wheels circled with fiber will have huge bulk when the ratio of radius of the fibers′ two ends is 3:1, and which should be affected by surroundings, leading to much loss in taper fiber. Through the experiment in optical fiber bundle image transmitter, we'll find that the longer fiber have great advantages and wide application foreground.

Based on the circumstances above, through the technology of combining the step motor and the computer, while controlling the usual optical fiber double crucibles drawbench out-nozzle diameter and the tub wheel′s rotating speed, the radius ratio can reach to 3.54:1, and the length can reach to 1m, which makes amplificatory image transmission come true after experimenting over and over.

* Supported by the Henan Science and Technology Office (00111022) and Patent of China (02278998.7)
Email: wsc@henannu.edu.cn
Received date: 2006-09-22

1 Experiments

The double crucibles drawbench facility is usually used in drawing multi-component glass fiber. We can put fiber core glass (refractive index is 1.446) and envelope glass (refractive index is 1.452) into the double crucibles made from platina or other metal with high melting point. Below 1 000℃, melted glass droops due to gravity, getting taper fiber in shape with running flat tub wheel. As the temperature in drawing is not well-proportioned, and the tub wheel's rotating speed can't be controlled easily, the taper fiber will have low transmission quality and high attenuation. Therefore, we use computer to control the step motor in used drawbench facility. The sketch map of system shows in Fig. 1.

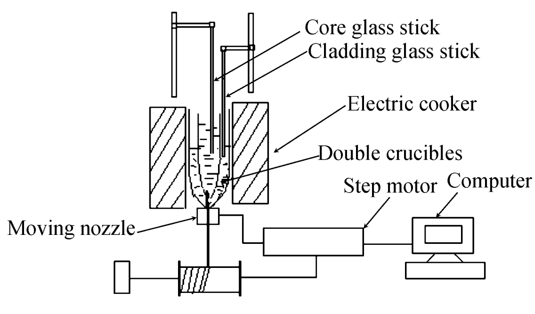


Fig. 1 Computer controlling the step motor sketch map

Under the calefaction stove, we install equipment to change the out-nozzle diameter, which is connected to the multiphase step motor. The multiphase step motor is an element which can switch the electricity pulse signal into angle displacement or line displacement. Single phase pulse signal is switched into multiphase pulse signal through the pulse distributor, and is sent into every phase of electromotor after it was magnified with power amplifier. Once inputting a pulse signal of a certain frequency, the electriferous state of every phase of the electromotor will change, and the rotor will turn to a certain angle. When we input a certain frequency pulse continuously, the rotating speed of the electromotor will keep corresponding relation with the frequency of pulse input, which will not be influenced by the wave of voltage and changes of the load. The controlling sketch map of typical step motor[10] indicates in Fig. 2.

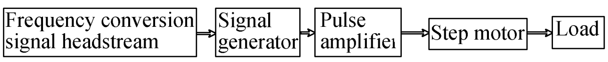


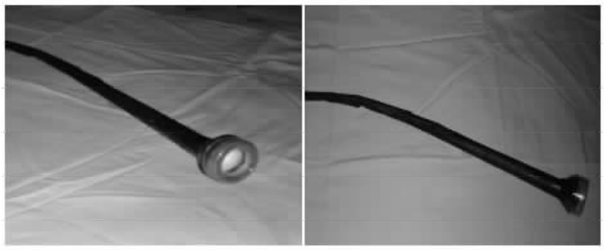
Fig. 2 Controlling sketch map of the classical step motor

The frequency conversion signal headstream is a signal generator whose pulse frequency is from a few hertz to some ten kilohertz and can vary continuously, which provides pulse distributor with pulse sequence. The pulse distributor inputs pulse signal into the pulse amplifier with a certain logical relation to magnify it, so as to drive the step motor to rotate.

During the drawing process, we adjust rotating speed of the step motor along with the time changing to make the fiber diameter change at a certain speed. Controlling the rotating speed of tub wheel at the same time, we can fabricate taper fibers with different ratio of radius.

2 Discussions

The technology of combining the step motor and the computer, not only controlls the nozzle diameter and tub wheel′s rotating speed automatically, but also reduces the influence of artificial factor. We must control temperature strictly for the variety of environment temperature should affect the quality of optical fiber immediately. We designed that the original diameter of the crucible nozzle is (55.0±1.0) μm, the original diameter of the core is (50.0±1.0) μm. The numerical aperture is 0.58. Without changing the thickness of the envelope, we get two kinds of taper fiber: the first, the final diameter is (125.6±1.0) μm, the ratio of radius is 2.41:1, and the length of the taper fiber is (1.00±0.01) m; the second, the final diameter is (182.0±1.0) μm, the ratio of radius is 3.54:1, and the length of the taper fiber is (1.00±0.01) m. (see Fig. 3)



(a) The final dimeter is (125.6+1.0)μm, the radio of radius is 2.41:1 (b) The final dimeter is (182.0+1.0)μm, the radio of radius is 3.54:1

Fig. 3 Two image taper fiber bundles with the different ratio of radius. The length of the taper fiber is (1.00±0.01) m

With the two kinds of taper fiber, when the rays of light transmit from the big port to the little port, the ratio of wastage[11] is

$$\frac{\Delta M}{M_1} = 1 - \left(\frac{D_1}{D_2}\right)^2 = 0.83; 0.92$$

For the taper fiber, here D_1 is the diameter of the little port and D_2 is the diameter of the big port.

The large wastage of the transmission mode is avoidless to taper fiber. While, increasing the length of fiber will be in favor of image transmission as with the same light energy.

Through the new double crucibles drawbench facility with the technology of combining step motor and computer, not only controls the out-nozzle diameter and tub wheel's rotating speed with numerical control, but also avoids the influence of the artificiality. We have drawn 1m taper fiber for image transmission with the reconstructive double crucibles drawbench equipment, which not only makes up for the limitation of fabricating long taper fiber with drawing and eroding, but also overcomes the disadvantage of the tub wheel volume being too big and so much instable factors. The new way realizes automatic control, which can satisfy the need of volume-produce, especially, drawing the taper fiber with big ratio radius.

3 Conclusions

Though in this way we can get taper fiber with high quality, it will be influenced by the lubricating property and the changing of the nozzle temperature and so on. As there are many aspects to be improved, we should make great efforts to explore it.

References

[1] ZHAO F Y, ZHANG Q, TANG H Q. The coupling between butt fiber and spherical lensed fiber [J]. *Acta Photonica Sinica*, 2003, **32**(2): 218-221.

[2] YOU Shan-hong, HAO Su-jun, YIN Zong-min, *et al*. Analysis and test of bend loss in single mode fiber[J]. *Acta Photonica Sinica*, 2003, **32**(4): 409-411.

[3] YANG Xiu-wen, XIE Hong, ZHU Sheng-xiang, *et al*. Fabrication of a new optical fiber probe for atomic force microscopy[J]. *Photoelectron Technology*, 2002, **22**(3): 33-35.

[4] WANG Yao-xiang, TIAN Wei-jian, HUANG Kun, *et al*. Theoretical analysis of the coupling efficient between fiber taper and CCD[J]. *Acta Photonica Sinica*, 2004, **33**(3): 318-321.

[5] XIA Ke-yu, YU Rong-jin, MENG Hua-mao. 1 ×7 Tapered Mixing-rod POF Coupler[J]. *Acta Photonica Sinica*, 2004, **33**(8): 908-911.

[6] XUE Chun-rong, ZHU Sheng-xiang, XIAO Zhi-gang. Coupling properties between two tapered fiber [J]. *Acta Photonica Sinica*, 2004, **33**(7): 803-805.

[7] LI Bao-hong, LIU Xue-feng, HUANG De-xiu. Coupling characteristics of tapered fiber microlenses[J]. *Semiconductor Photoelectricity*, 1996, **17**(2): 121-125.

[8] ZHANG Yao-ming. Research & application of non - communication optical fibers[J]. *Fiber Glass*, 2003, **5**(11): 3-11.

[9] AN H L. Theoretical investigation on the effective coupling from laser diode to tapered lensed single-mode optical fiber[J]. *Opt Commun*, 2000, 181(1): 89-95.

[10] YANG Jian-hua. Designing the control system of fiber optic coil[D]. Hangzhou: Zhejiang University, 2003: 49-51.

[11] WANG Yao-xiang, TIAN Wei-jian, ZHANG Xing-long. Theoretical analysis of the effective transmission about fiber taper[J]. *Acta Photonica Sinica*, 2005, **34**(4): 529-533

锥形光纤装置研究

魏山城[1], 晁军峰[2], 赖振讲[1]

(1 河南师范大学 物理与信息工程学院,河南 新乡 453007)

(2 玉林师范学院 物理与信息科学系,广西 玉林 537000)

收稿日期:2006-09-22

摘 要:基于锥形光纤制造过程的复杂性及其传像束的传输性能,利用微机与步进电机相结合,同时控制常用的双坩埚光纤拉丝机出丝管口的直径大小和鼓轮转速快慢,实现了数控拉制1 m长锥形光纤的新方法,并且集束制作出了两种两端不同半径比的锥形光纤传像束.与常用的增大鼓轮体积的方法相比,该装置具有体积小,便于操作,两端半径比可自由控制,断丝率低等特点.分析了这两种锥形光纤传像束的模式损耗。

关键词:锥形光纤;光纤拉制;步进电机;双坩埚拉丝机;多组分玻璃光纤

WEI Shan-cheng was born in 1952. He graduated from Henan Normal University with the B. S. degree, and received M. S. degree from Shanxi Normal University in 1983. Now he is an professor at Henan Normal University. His research interests include nonlinear optics, optical fiber sensors and related topics.