New Mass Fusion Splicer FSM-50R Series

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Fixed V-groove fusion splicers are commonly used in the installation of fiber optic cables, including FTTx applications, in Japan and rest of the world. Splicer users, especially those deploying new FTTx applications, are increasingly requiring splicers to be light and have a compact form factor, in addition to being fast and easy to use. Fujikura has introduced several new fixed V-groove splicers to meet these requirements. The FSM-50R is used to splice up to 12-fiber ribbons, the FSM-17R is used for splicing up to 4-fiber ribbons, and the FSM-17S is used for single fiber splices. Each of these splicers includes multiple advanced features to meet the requirements of customers in Japan and rest of the world.

1. Introduction

In recent years, the core of the optical network communications infrastructure has been installed in Asia, especially in China. In Japan and the United States, FTTP applications that connect homes and offices to the network are increasing.

The diverse conditions for installing optical fiber networks require optical fiber fusion splicers not only to be small and light but also to have short splicing and protection sleeve shrinking times.

In order to meet these requirements, we have developed the fixed V-groove fusion splicer series that consists of the FSM-50R for up to 12-fiber ribbons, the FSM-17R for up to 4-fiber ribbons and the FSM-17S for single fiber splicing. This lineup is shown in Table 1.

Significant characteristics of the FSM-50R series are:

(1) Shortest splicing time: 20 s for 12-fiber ribbons. This is the fastest splicing time of all 12-fiber ribbon splicers in the world.
(2) Lightest weight: 2.65 kg (including the standard battery). This is the lightest weight of all 12-fiber ribbon splicers in the world.
(3) Easy operation: equipped with automatic fiber arrangement guide.
(4) Reduced number of steps to make a splice
(5) Real-time arc power control

Table 1. New Splicer Lineup

Model name	Applicable fiber count
FSM-50R	1 to 12
FSM-17R	1 to 4
FSM-17S	1 (Sheath clamp type)
FSM-17S-FH	1 (Fiber holder type)

Arc power is controlled according to the brightness of the fiber at the time of arc discharge in auto mode.

2. Product Overview

The FSM-50R is shown in Fig.1.

A comparison of specifications between the old models and the new models is shown in Table 2.

3. Details

3.1 Reducing Splicing and Heating Times

3.1.1 Reducing Splicing Time

In the FSM-50R splicer, motors controlling the fiber movements (advancing and receding) have been innovated so that the time required to set the fiber ends face to face is much shorter than that with older models. Software and hardware were designed

Fig. 1. Appearance of New Fusion Splicer.

Table 2. Comparison of Specifications

Item	New model FSM-50R	Old model FSM-30R
1. Appearance		
Dimensions	150×150×150 mm	150×150×150 mm
Weight (with AC adapter)	2.65 kg	3.1 kg
2. Splicing performance		
Average splice loss	0.05 dB (SMF)	0.05dB (SMF)
Splice time	20 seconds	30 seconds
Protection sleeve shrinkage time	45 seconds	100 seconds
Number of splices & shrinks with charged battery	140 splices (When using Battery-L*)	30 splices
3. Performances and functions related to operations		
Steps to make a splice	11	22
Time to make a splice	93 sec/splice	178 sec/splice
Assistance of operation	Protection sleeve position adjustment function	–
Dual monitor position (front/rear)	Possible	Impossible
Monitor size	5.6 inches	5.0 inches
4. Functions for certain splices		
Arc power calibration	Automatic	Manual
Fiber arrangement	Automatic	Manual
Fiber arrangement in tube heater	Automatic	Manual

* Option

to increase the calculation speed for splice loss estimation. The result is the time required to splice has been reduced to 20 s on average.

3.1.2 Reducing Protection Sleeve Shrinking Time

In order to avoid bubbles remaining inside of the protection sleeve during shrinking, it is necessary for the center of the sleeve to shrink before the sleeve ends. The tube heater in the older splicer models has only one heat source at the center of the tube heater such that there is a heat gradient that enables the sleeve center to shrink before the ends. The tube heater built in the new model has a strong heat source at the center of the heater and rather weak heat sources at both the ends of the heater. The structure realizes an ideal heat gradient and provides much more heat to the sleeves than the old model.

The result is that it takes only 40 s to shrink 40 mm sleeves applicable for up to 12-fiber ribbons, and only 45 s to shrink sleeves applicable for up to 4-fiber ribbons or 8-fiber ribbons.

3.2 Reducing Weight

Fixed V-groove fusion splicers are commonly used in the installation of the fiber optic cables. This situation requires the splicers to be not only a precision instrument but also a durable one. It is also important that the splicers are portable because the splicers are frequently used at the top of a utility pole and inside of a manhole, which means the splicers need to be small and light.

In order to meet these requirements, magnesium die-castings have been used with the main parts and the components of the new model are optimized to be durable and light. As a result, FSM-50R is the lightest 12-fiber ribbon splicer in the world (2.65 kg, including an AC adapter).

3.3 Enhancing Easy and Simple Operation

3.3.1 Structure Around V-grooves

When splicing fibers in aerial FTTP installations, it was difficult for the operators to set fibers in the narrow-pitched V-grooves of mass fusion splicers when the operators were not in a comfortable working position.

In addition, when splicing fibers in underground trunk cables, operators needed additional light if it was too dark to see the V-grooves and set the fibers in them.

The FSM-50R significantly improves the operability of the splicer under these conditions by making the fiber-setting process very easy using the improvements described below:

1. The widths of fiber catcher grooves on fiber holders are optimized for each applicable fiber ribbon width.
2. The play between fiber holders and the z-stage is optimized.
3. An automatic fiber arrangement guide has been developed. The guide arranges fibers on the V-groove automatically so that operators do not have to arrange fibers manually when fibers are set on the splicers.

The outline of fiber arrangement guide is shown in Fig. 2.

3.3.2 Reducing Operations Needed to Make a Splice

In the FSM-50R, the required operation count has been reduced to 11 and the time spent at the splicer to make a splice is 93 s. This is 85 s shorter than that of the older model, as shown in Table 3. Total operation time, including fiber preparation, has been reduced to approximately 3 min.

The single fiber splicer FSM-50S has a special device that assists operators to bring both the splice point and protection sleeve to the center of the tube heater. The same function is also installed in the FSM-50R. In addition, the tube heater unit has a function to tension fibers in order to arrange them auto-

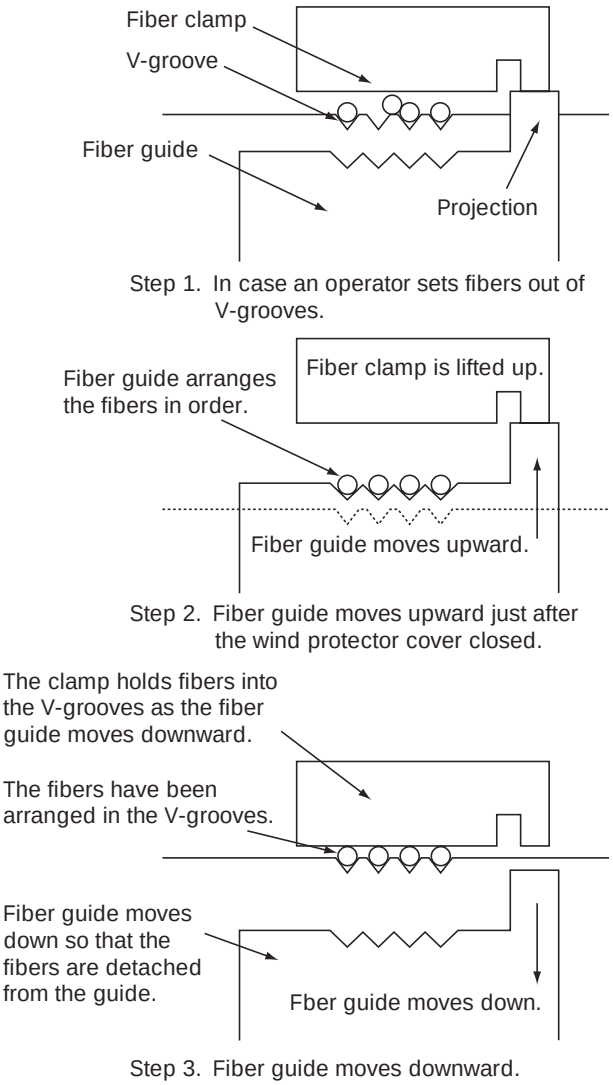

Fig. 2. New Fiber Guide System.

matically just after starting the heating process. Operational capabilities of the tube heater have significantly improved with these functions.

3.3.3 Flexible Direction

The optimum placement of the splicer relative to the operator changes depending on the surplus length of fibers to be spliced, relative position between the splicer and closures, and so forth. The FSM-50R has keyboards not only in the front side but also in the backside. The image on the monitor can be displayed upside down by the software setting when the monitor is tilted up. These functions allow the operators to use the splicers from various directions as needed.

3.4 Preventing Faulty Splice

3.4.1 Real-time Automatic Arc Calibration

In order to make stable low loss ribbon splices, it is important that the heat to the fibers is distributed adequately.

Table 3. Comparison of Splice Operation

	FSM-50R (New model)	FSM-30R (Old model)	
	11 operations to make a splice 93 seconds	22 operations to make a splice 178 seconds	
5 sec	1. Place the left fiber holder. 2. Place the right fiber holder. 3. Close the wind protector cover.	1. Set the left fiber holder, close the holder clamp. 2. Set the right fiber holder, close the holder clamp. 3. Set the left fiber clamp. 4. Set the right fiber clamp. 5. Close the wind protector cover. 6. Press the SET key.	15 sec
20 sec	Splicing	Splicing	30 sec
20 sec	4. Open the wind protector cover. 5. Open the left fiber holder cover. 6. Open the right fiber holder cover. 7. Remove the fiber from the holders. 8. Adjust the position of the protection sleeve. 9. Set the fiber in the tube heater. 10. Press HEAT key.	7. Open the wind protector cover. 8. Remove the left fiber clamp. 9. Remove the right fiber clamp. 10.Open the cover-1 of the left fiber holder. 11.Open the cover-1 of the right fiber holder. 12.Open the cover-2 of the left fiber holder. 13.Open the cover-2 of the right fiber holder. 14.Remove the fiber from the holders. 15.Adjust the position of the protection sleeve. 16.Set the fiber in the tube heater. 17.Adjust the position of the splice point. 18.Close the cover of the tube heater. 19.Press HEAT key.	30 sec
45 sec	Heating the sleeve	Heating the sleeve	100 sec
3 sec	11.Remove the fiber from the splicer.	20.Remove the fiber from the splicer. 21.Open the left holder clamp, remove the fiber holder. 22.Open the right holder clamp, remove the fiber holder.	3 sec

However, the heat applied to the fibers is not stable even if the discharge current and discharge voltage are kept constant because the environmental conditions are always different, such as air pressure, temperature, humidity and wear of electrodes.

Splice loss increases when the heat applied to the fiber goes out of the acceptable range due to this instability.

Older splicers had sensors that measured the environmental conditions and the splicers adjusted arc discharge power according to the measured results. However, the old splicers were still required to calibrate the arc discharge power with a special function before splicing because the condition of electrodes

was not referenced yet.

The special arc calibration function measured melt-back amount of fibers after arc discharge, so the splicers estimated the distributed heat and calibrate the arc power setting. The function consumed time because operators needed to prepare a pair of cleaned and cleaved fibers to perform this function. The splicers could not ensure low splicing loss when the function was not performed.

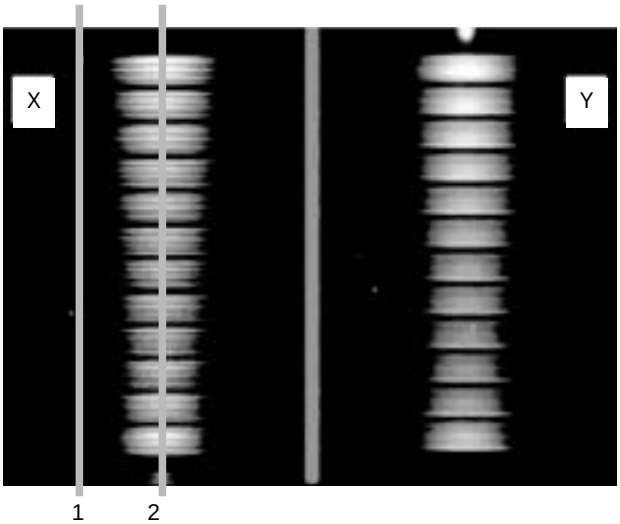

Fig. 3. Thermal Luminescence of Optical Fiber.

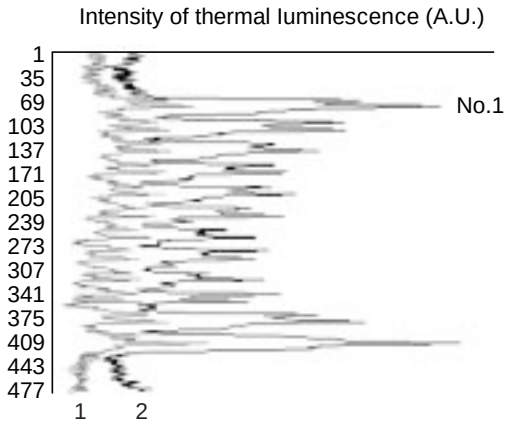

Fig. 4. Analyzed Fiber Luminescence.

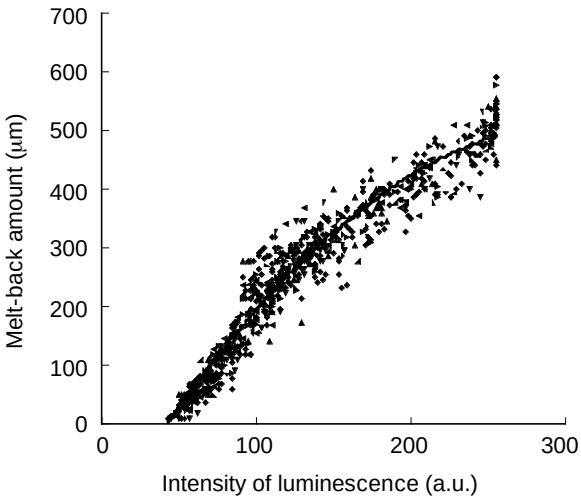

Fig. 5. Relation between Melt-back Amount and Thermal Luminescence.

In order to resolve these problems, automatic real-time arc calibrating function similar to the function of the FSM-50S has been installed in the FSM-50R series. The splicers observe the thermal luminescence of the optical fibers and adjust arc discharge power automatically according to the amount of luminescence.

Figure 3 shows an example of thermal luminescence during a splice. The distributed heat can be calculated from the sum of the brightness data that are picked up by vertical scan from the image. For example, Figure 4 illustrates the brightness data under vertical scan lines 1 and 2.

The melt-back amount provides a consistent relation to the distributed heat for the fibers. Figure 5 shows the example of the relation between melt-back amount and thermal luminescence.

Figure 6 shows the relation between arc discharge current and thermal luminescence. Though the degree of thermal luminescence depends on the fiber number, fiber position and environmental conditions, the correlation between the luminescence and the arc discharge current is always stable when the conditions are the same. Therefore, the required discharge current compensation can be calculated from the difference between the measured luminescence and the luminescence under the referenced adequate heat condition.

Otherwise, adequate heat quantity can be distributed to the fibers by compensating discharge time instead of compensating discharge current. Required discharge time compensation is also calculated from the difference of luminescence. This discharge time

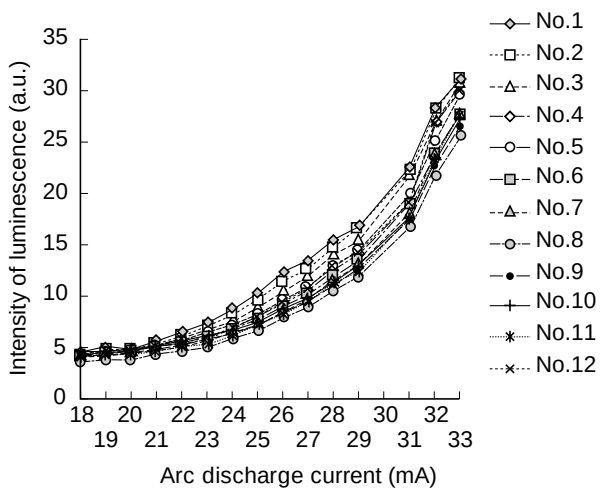

Fig. 6. Relation between Arc Discharge Current and Thermal Luminescence.

compensation method can be applied when discharge current should be constant or its range is limited.

As mentioned above, real-time arc calibration is performed using feedback loop, using the difference between the measured luminescence and the adequate luminescence to the arc discharge time.

Therefore, the function provides stable low splicing loss under any environmental condition without measuring the melt-back amount.

4. Conclusion

A new mass fusion splicer series has achieved the fastest splicing time and lightest weight, and provides easy and simple operation and consistent low splicing loss without the performance of any special function by the operators. These advantages decrease the operation time and cost and increase the reliability of splices under any environmental conditions.