The Effect of the Grain Size Distribution on Viscosity and Fluidity of Fluid Resin

by

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1. Introduction

Fluid resin, from the necessity of giving preferable fluidity to the powder-liquid mixture, requires a large amount of monomer, as compared with heat curing resin. But in reality it is said that because the viscosity increase of the resin mixture occurs considerably quick, the pouring operation becomes shortened, it becomes difficult to pour the resin mixture sufficiently into the details of molds[1,2]. So, a fluid resin having preferable fluidity and a wide range of operation time is being desired.

As the fluidity of resin mixture is varied in accordance with the swelling and solubility of polymer into monomer, it is naturally under the influence of the properties of both polymer and monomer.

In order to find a composition having preferable fluidity and a wide range of operation time, the authors considering it necessary to reexamine the grain size distribution of polymer which is closely related to the fluidity, examine the effect of the grain size distribution change on viscosity and fluidity.

2. Materials and Methods

1. Materials

The polymer used in the present experiments is Mitsubishi Rayon’s methacrylate resin (Acrycon, $79 \times 10^4$ in molecular weight), which is classified in four groups, (A), (B), (C) and (D) by using the auto sieving machine with sieves, 100, 150, 200 and 250 mesh, attached severally, to be used as specimens. Furthermore, by mixing these four groups at the same weight percent, six groups of specimens, (A)-(B), (A)-(C), (A)-(D), (B)-(C), (B)-(D) and (C)-(D), are also prepared. Of these specimens, the grain size distribution is measured to confirm the grain size distributing condition (Figs. 1, 2, 3).

As monomer, methyl methacrylate on the market is used after being distilled under reduced pressure.

2. Methods

1) Powder-liquid ratio

The polymer-monomer mixing ratio (L/P) is fixed at 1.75:1 (weight percent), and the temperature of monomer, 21~22°C.
Fig. 1. Grain size distribution of polymer

Fig. 2. Grain size distribution of polymer

Fig. 3. Grain size distribution of polymer
2) Measurement of viscosity rising

Each specimen, mixed at the powder-liquid ratio above-mentioned, is stirred for 30 seconds, and of the resin mixture, the viscosity rising with the passage of time is measured by the rotary viscosimeter.

3) Measurement of fluidity

Of the resin mixture, mixed and stirred in the same way shown in 2), the change of fluidity is measured by use of a measurement apparatus for the rate of fluidity of fluid resin[2].

The above-shown experiments are carried out under the condition of room temperature, 21±1°C, and humidity, 50±1%.

3. Results and Discussion

The viscosity rising corresponding to the grain size of polymer (Fig. 4) shows that the smaller the grain size is, the faster becomes the viscosity rising. This is presumably because the smaller the grain size is, the larger becomes the specific surface, and consequently the rate of solubility increasing, the concentration of polymer in monomer becomes high.

It is generally considered that the fluidity of resin mixture early disappears when its viscosity rises abruptly with the passage of time, and the pouring operation becomes difficult. Contrarily, in case the viscosity rising is slow, there is the possibility of the sedimentation of polymer, separated from monomer, and the concentration becoming
non-homogeneous, causes uneven curing. That is, the large grain polymer is liable to make the viscosity rising too slow, while the small grain one is liable to make it too rapid. So, preferable results cannot presumably be expected as fluid resin, if they are respectively used alone.

On the other hand, the change of the velocity of fluidity (Fig. 5) shows that the large grain polymer, as compared with the small grain one, is quick in the velocity of fluidity, having a wide range of time in which the mixture shows preferable fluidity. But in the case of the mixture of large grain polymer, the separation of polymer from monomer is observed during the measurement, though such a phenomenon is not observed in the case of the mixture of small grain polymer. From this fact, too, it can be presumed that to use the polymer of a single grain size is not preferable.

From the results shown above, the authors consider it a method for maintaining the homogeneity of mixture while suppressing its viscosity rising to some degree, to mix polymers of different grain sizes, prepare six kinds of mixed polymer groups by mixing four kinds of groups at the same weight percent, and examine their viscosity and fluidity. The results show that their viscosity rising curves (Fig. 6) as compared with those of single polymer groups, become slow-rising, showing a resemblance to the curve of the large grain polymer. The reason is presumably that in case two polymers, respectively quick and slow in solubility to MMA, coexist, the swelling and solubility of the former occur first and then follow those of the latter more slowly to the already decreased MMA, and consequently the viscosity rising is retarded to a great degree.

![Fig. 5. Chronological relationships between rate of fluidity and grain size](image-url)
Fig. 6. Chronological relationships between viscosity and grain size distribution

Fig. 7. Chronological relationships between rate of fluidity and grain size distribution
Regarding the relationship between the grain size distributing condition and viscosity rising, it is made out that in the case of the group of M-character type distribution containing a great deal of polymers, smaller than 60 µ and larger than 120 x in grain size, the viscosity is low in the initial stage, but it rises comparatively quickly as time goes on. While, the group of symmetrical type distribution containing a great deal of polymers, 80～100 µ and smaller than 60 µ, shows high initial viscosity and abrupt rising, but another group containing polymers, 80～100 µ and larger than 100 µ shows comparatively slow-rising.

Again, regarding the relationship between the grain size distributing condition and fluidity (Fig. 7), it is made out that the mixed polymer groups, as compared with the single polymer ones, have not only wide ranges of time in which the fluidity is preferable, but also the velocity of fluidity showing a tendency to quicken.

From the results shown above, it can be presumed that the polymer of fluid resin becomes effective when used by mixing those of different grain sizes adequately.

4. Conclusion

As the results of the present experiments, it is proved that the grain size distribution of polymer showing preferable fluidity and a wide range of operation time is M-character type distribution with large and small grains adequately mixed.

References
