Basic Studies on Condensability of Amalgam Mix

by

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Introduction

The purpose of the condensation of amalgam is to force the remaining alloy particles as closely together as possible and into all parts of the prepared cavity, and, at the same time, to remove as much mercury from the mass as is consistent with good practice[1]. In other words, the amalgam should be condensed into the prepared cavity so that the greatest possible density is attained, with sufficient mercury present to insure a complete continuity of the matrix phase between the remaining particles of alloy.

Amalgam condensation is generally carried out as follows: a small piece of amalgam mix, immediately after being mixed, is carried into the cavity to be condensed, and when it is judged to be sufficiently condensed, another small piece is added to be condensed again. There are some studies on the condensation degree of hardened amalgam[2-8]. However, with regard to the condensability of the amalgam mix, when it is judged to be sufficiently condensed, few reports have hitherto been published.

Again, when condensation is done with the same filling force, the smaller the plugger is in diameter, the larger the condensation pressure that is obtainable, but the plugger is so small that it is liable to get into the amalgam mix and often fails to give effective pressure. Clinical experience tells us that this tendency is remarkable especially in the case of spherical type alloy amalgam having larger pre-setting flow as compared with lathe-cut type alloy amalgam. This is obviously due to the differences in condensability, of which, too, no reports have ever been published.

The present study purposed to clarify the condensability of the amalgam mix, examine the effects on condensability exerted by various manipulative conditions, the important factors such as mercury-alloy ratio, mixing time, size of amalgam mix (number of pieces of amalgam mix measured by the carrier), delayed condensation, condensation pressure and diameters of cavity and plugger, and at the same time, examine the relationship between the cavity-plugger’s area ratio and condensability.

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Experimental Methods

In the present experiments, one kind each of spherical amalgam alloy (Shofu Spherical Amalgam Alloy 8, Batch number: 393) and lathe-cut amalgam alloy (Shofu Micro Amalgam Alloy, Batch number: 43) were used. For ease of reference, these are referred to as SS8 and SM respectively. 0.4 g of alloy was triturated by a Shofu Amalgam Mixer “DELUXE” for 10 seconds, at the mercury-ratio, 0.84 in the former case and 1.0 in the latter as stated in the directions.

Fig. 1 Amalgam carrier used

Fig. 2. Apparatus for measuring condensability of amalgam mix
To measure a fixed amount of amalgam mix, the conventional amalgam carrier shown in Fig. 1 was used. By using this carrier with a little practice, one can measure a fixed weight or volume of amalgam mix easily.

For condensation, a contrived, improved type of the NON condensation apparatus[9] shown in Fig. 2 was used. The apparatus with a plunger of adequate diameter and with suitable condensation pressure, makes it possible to condense the amalgam mix and to measure its condensed height at every thrust by the attached dial gauge.

The mix measured by the amalgam carrier was condensed in the metal mold[10] (hereinafter referred to as cavity) as evenly as possible by the above-mentioned condensation apparatus for measuring condensability of amalgam mix, and as shown in Fig. 3, the height (Hn) between the upper surface of the plunger in the cavity and the surface of the plugger was measured by the dial gauge, and from the height of effectively condensed amalgam mix, the volume of amalgam mix condensed in the cavity was calculated.

Condensability was determined by the following formula:

$$C = \frac{V_n}{V_0} \times \frac{\pi D^2 H_n}{4} \times 100 \%$$

Where

- $C$ = Condensability
- $V_n$ = Condensed volume in the cavity at n times thrust (mm$^3$)
- $V_0$ = Volume measured by the carrier (mm$^3$)
- $D$ = Inside diameter of the cavity (mm)
- $H_n$ = Condensed height in the cavity at n times thrust (mm)
- $d$ = Inside diameter of measuring part of the carrier (mm)
- $l$ = Length of measuring part of the carrier (mm)
- $N$ = Number of pieces measured by the carrier

Fig. 3 Measurement of height of amalgam mix condensed by the apparatus.
It was reported as a percentage of the volume of the amalgam mix corresponding to the effectively condensed height in the cavity to its original fixed volume measured by the amalgam carrier.

**Results and Discussion**

Fig. 4, regarding SS8, shows the results of examination on the relationship between the number of thrusts and condensability at various mercury-alloy ratios, when the amalgam mix was condensed with 2.0 MPa condensation pressure in a cavity, 4.0 mm in diameter, by a plugger, 2.5 mm in diameter. The results prove that condensability varies to a greater degree when the number of thrusts is smaller, and it becomes almost constant with thrusts repeated more than 75 times.

Fig. 5 is concerned with SM condensed with 6.0 MPa condensation pressure. The change in condensability when the number of thrusts is smaller, though not so remarkable as compared with that of SS8, gradually decreases, and condensability becomes almost constant with thrusts repeated more than 100 times.

Other experimental results obtained under various experimental conditions also made out that constant condensability was obtainable with thrusts repeated more than 75–100 times. So, in the following experiments, condensability obtained with thrusts repeated 100 times was examined.

Fig. 6, regarding condensability obtained with thrusts repeated 100 times, shows the results obtained by changing the mercury-alloy ratios. In the case of SS8, condensability decreased in accordance with an increase in ratio, especially remarkable when the ratio exceeded the specified value (0.84). SM decreased in condensability almost linearly between 1.0 and 1.6 in the mercury ratio, but not so remarkably as compared with SS8. To be small in condensability means that the plugger is liable

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**Fig. 4** Effect of mercury-alloy ratio on condensability of amalgam mix.

**Fig. 5** Effect of mercury-alloy ratio on condensability of amalgam mix.
to thrust into the amalgam mix itself, and thrust, however repeated, does not work effectively in condensation, the amalgam mix being merely stirred, and a well-condensed restoration is not achieved.

Fig. 7 shows the results of examination of the effect on condensability exerted by the number of pieces of amalgam mix measured and carried into the cavity by the amalgam carrier, that is, the size or volume of the amalgam mix at the beginning of condensation. The results prove that in both the SS8 and SM cases, the amount of amalgam mix had little effect on condensability.

Fig. 6 Effect of mercury-alloy ratio on condensability of amalgam mix.

Fig. 7 Effect of size of amalgam mix on its condensability.

Fig. 8 Effect of mixing time on condensability of amalgam mix.

Fig. 9 Effect of delayed condensation on condensability of amalgam mix.
Fig. 8, regarding the mixing time, proves that in either case, the mixing time, 5–30 seconds, had little effect on condensability, though a 5-second mixing is obviously insufficient.

Fig. 9, regarding the delayed condensation, proves that in the SS8 case, a 1 minute delayed condensation caused approximately a 7% increase in condensability, while in the SM case, the increase was only 2%. The increase in condensability in this case was considered due to an equal amount of increase in matrix or bubbles. Skinner recommends that condensation should be done as quickly as possible, and if it takes more than 3.5 minutes, new amalgam should be mixed. Though an increase in condensability differs according to the kinds of alloys, our studies made out that a 3-minute delayed condensation caused a 12–13% decrease in strength. So, it is undesirable to mix a large amount of amalgam at one time.

Fig. 10, regarding the condensation pressure, proves that in either case condensability decreased in accordance with the increase in condensation pressure. SS8 was larger than SM in decrease.

Fig. 11 shows the results of examination on the effect of the diameters of the cavity and plugger on condensability. It proves that in the cavity, the smaller the plugger is in diameter, the more condensability decreases under the same condensation pressure. Especially, SS8 was remarkable in the decreasing tendency. The results coincide with clinical experience: the plugger was liable to thrust into the amalgam mix. When the amalgam mix was condensed with a plugger whose diameter was the same as that of the cavity, condensability became approximately 95% in SS8 and 88% in SM, nearly 100% of the original volume in either case. This is presumably due to the fact that under the thrust, alloy particles become close to one another and excess mercury and bubbles in the matrix part are removed. As to the fact that SS8 is larger than SM in condensability, it is considered that SS8, a spherical alloy,
is higher than SM, a lathe-cut alloy, in repletion of alloy particles. The fact that SS8 contrarily becomes small in condensability when the plugger is smaller than the cavity in diameter is also considered due to the properties of spherical alloy.

Figs. 12 and 13 show the results, previously obtained from the differences in diameter of the cavity and plugger, rewritten in the form of the relationship between cavity-plugger area ratio and condensability of SS8 and SM. In either case, the nearer the area ratio was to 1.0, that is, the nearer the plugger was to the cavity in diameter,
the larger condensability became, which decreased as the area ratio became large, and gradually the decreasing tendency slowed. Again, under the same condensation pressure, it proved that as shown here, the relationship between condensability and cavity-plugger area ratio drew a curve of secondary degree, a suggestive result. The curve, varying in accordance with the condensation pressure, became lower as the pressure became larger. This tendency was remarkable in the SS8 curve as compared with the SM curve.

Conclusions

The conclusions drawn from the results shown above are as follows:
1. Mercury-alloy ratio, delayed condensation, diameters of cavity and plugger and their area ratio were factors affecting condensability.
2. The size of the amalgam mix and mixing time had little effect on condensability.
3. Under the same condensation pressure, there was a constant relationship between condensability and the cavity-plugger's area ratio. Condensability became maximum at 1.0 in ratio, decreased as the area ratio became larger, and gradually settled. Again, the higher the condensation pressure was, the lower the constant relationship became. This tendency was especially remarkable in SS8.

References