Effects of Size of Mix and Trituration Time on Physical Properties of Amalgam

by

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1. Introduction

It is well known that the mercury-alloy ratio and trituration time greatly influence the physical properties of the amalgam, and there are a great number of studies about this. Nowadays, the standard approach to this problem is that the optimum trituration time varies according to the size of the mix, and trituration time should be extended as the size of mix increases. Reference books [1-2] and manufacturer's instructions on the use of alloys also advise the same approach. However, few studies have been made to check the validity of this approach.

Recently, attention has been called to the fact that the trituration sound suddenly changes during mechanical trituration of an amalgam. The following report has appeared opposing the previously described established theory [3]: The time to sound change between the start of trituration and the point of sound change is shortened with the increase in the size of mix, indicating that the trituration time should be shortened as the volume increases. This report was also confirmed by a visual observation in the amalgam mix just after the point of sound change and was in contradiction with the generally accepted theory.

In order to explicate which theory is true, the generally accepted theory or the new opposing theory, concerning correlation between size of mix and trituration time, the authors investigated this problem from the aspect of the physical properties of the amalgam. That is, for the purpose of reaching a correct conclusion, the experimental order was arranged at random statistically so that the relation between the size of mix and trituration time could be analyzed in detail.

2. Experimental Method

Shofu Spherical alloys (Batch No. 234) were employed for this experiment as alloys, and triturated by Shofu mixer in a mercury-alloy ratio of 0.85. For the trituration times, four different times, 5, 10, 20 and 30 seconds were chosen. The size of mix made from the 0.30 g minimum quantity of alloy and a fixed amount of mercury

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was taken as 1. In this study four different sizes of mix, 3, 4, 5 and 6 were adopted. The amount of triturated amalgam mix used for filling was always the same size as that of mix 3 and was filled in a mold with a diameter of 4.0 mm following the new "NON" filling method [4]. The length of the specimen was 8.0 mm. Tensile and compressive strengths were determined after the elapse of 24 hours. The determination of tensile strength was based on the Diametral Compressive Test [5-6], and dimensional change was determined by ADA specification [7].

3. Experimental Results

3.1 Tensile strength

Table 1 illustrates analysis of variance, and Fig. 1 the factorial effect of the size of mix and trituration time. In the table and figure, * and ** indicate a significant difference of 5 % and 1 %, respectively, in the level of significance. No significant difference concerning the size of mix was recognized. However concerning the trituration time a significant difference was observed, and its percentage of contribution was 60.8 %. Upon examining the difference in tensile strength between

Table 1. Analysis of variance for tensile strength

Source of variation	S	ϕ	V	Fo	ρ (%)
A: Size of mix	2463	3	821		
B: Trituration time	72513	3	24171	17.0**	60.8
A $\times$ B	5012	9	557		
e: Error	32200	16	2012		
(e): Pooled error	(39675)	(28)	(1417)		39.2
T: Total	112188	31			100.0

Fig. 1 Factorial effect on tensile strength

amalgam mixes made at each level of trituration time, no significant difference in the trituration times between 20 and 30 seconds was recognized, however between the other combinations of times, a significant difference was noticed as illustrated in Fig. 1.

3.2 Compressive strength

Table 2 shows the analysis of variance and Fig. 2 the factorial effect of size of mix and trituration time. No significant difference in the size of mix was recognized. In trituration time, however, a significant difference of 1 % was recognized in the level of significance and its percentage of contribution was 81.2 %. No significant difference was recognized in trituration time between 20 and 30 seconds; however, among the other combinations of times a significant difference was noticed.

Table 2. Analysis of variance for compressive strength

Source of variation	S	ϕ	V	Fo	ρ (%)
A: Size of mix	18900	3	6300		
B: Trituration time	1276300	3	425433	45.4**	81.2
A $\times$ B	49600	9	5511		
e: Error	194000	16	12125		
(e): Pooled error	(262500)	(28)	(9375)		18.8
T: Total	1538800	31			100.0

Fig. 2 Factorial effect on compressive strength of SS8

3.3 Dimensional change

Table 3 indicates analysis of variance and Fig. 3 the factorial effect of the size of mix and trituration time. Here too, no significant difference concerning the size of mix was recognized; the same as in the previously described tensile and compressive strength tests. In trituration time, however, significant difference of 1 % was observed in the level of significance and its percentage of contribution was 73.4 %. No significant difference was noticed in trituration time between 5 and 10 seconds; however,

among the other combinations of times, a significant difference was recognized. In the case of 10 seconds or over, shrinkage increased significantly as trituration time was prolonged.

Table 3. Analysis of variance for dimensional change

Source of variation	S	ϕ	V	Fo	ρ (%)
A: Size of mix	110	3	37		
B: Trituration time	3367	3	1122	31.1**	73.4
A $\times$ B	91	9	10		
e: Error	811	16	51		
(e): Pooled error	(1012)	(28)	(36)		26.6
T: Total	4379	31			100.0

Fig. 3 Factorial effect on dimensional change of SS8

3.4 The effect of the number of triturations

In 3.1, 3.2 and 3.3 the effects of triturating different sizes of mix at a time was compared. In practice, however, when filling in large cavities, triturating the mix in separate smaller batches may be necessary. Therefore in this experiment, a fixed quantity of amalgam alloy (0.90 g) was mixed, separated into the following portions each of which was triturated for the indicated length of time, and its effect on tensile strength was compared:

- A1 = 0.90 g for 20 seconds (one trituration)
- A2 = 0.45 g for 20 seconds each (2 triturations)
- A3 = 0.30 g for 20 seconds each (3 triturations)
- A4 = 0.45 g for 10 seconds each (2 triturations)
- A5 = 0.30 g for 7 seconds each (3 triturations)

Table 4 shows the analysis of variance and Fig. 4 the factorial effect of the number of triturations. Significant effect of the number of triturations was recognized and the level of significance was 5 %. Among the levels, a significant difference was observed only in the combination between A5 and the other A1, A2 and A3, however, among

the other combinations no significant difference was noticed. The tensile strength of A5 was the lowest of all the tests.

Table 4. Analysis of variance for effect of number of mix on tensile strength

Source of variation	S	ϕ	V	Fo
A: Number of mix	20440	4	5110	2.9*
e: Error	35360	20	1768	
T: Total	55800	24

Fig. 4 Effect of number of mix on tensile strength

4. Discussion

The experimental results show that the size of mix has little effect on tensile and compressive strength, and dimensional change. But trituration time influences the above physical properties to a large extent; insufficient trituration time reduces the strength and too much trituration time increases shrinkage in dimensional change. This tendency agrees with many other reports [8–11]. That is, regardless of the size of the mix, only the amalgam which is mixed at the optimum trituration time comes out best.

It is generally considered that the more the size of the mix increases, the more the trituration time should be extended. And manuals of manufacturers give such instructions. However, it is clear from this investigation that the generally accepted theory is in the wrong.

Amalgam mix, when mixed in large sizes at a time, is left in the air for a long time before being used in filling and its strength declines [3, 8, 12]. It is generally believed, therefore, that an amalgam mix which is exposed to the air for three to three and half minutes or more after trituration, should be discarded, and a new

amalgam mix should be triturated [1]. In such a case, therefore, the results of the experiment indicate that the amalgam should not be triturated all at once but separated into smaller batches to be triturated as needed. And variation in the trituration time is not necessary.

5. Conclusion

As a result of this comparative investigation on the relation between the size of mix and trituration time of the amalgam from the aspect of its physical properties using a statistical analysis, the following conclusion was obtained:

- 1) Change of trituration time has a considerable effect on the physical properties of amalgam. However, little influence was recognized by the change of the size of mix.
- 2) There is no need to change the optimum trituration time regardless of the size of mix or the number of trituration.

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