STUDIES ON RUBBER BASE IMPRESSION MATERIALS

[PART XVIII] REPRODUCIBILITY CORRESPONDING TO THE CHANGE OF STUFFING TIME

BY

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INTRODUCTION

In order to determine the reproducibility or the ability to reappear the original model by impression taking, several methods are considerable.

One of the most convenient and reliable methods would be the investigation of the reproducibility by means of fine lines engraved on the pattern surface.

As the engraving of the fine lines on the pattern with desired dimensions is very difficult, the author has exerted a great effort to get the above mentioned object, and thus various lines of different fineness have been worked out on the pattern surface.

Then the fineness of each line was determined by the microscopy as accurate as could be done.

The engraving of the fine lines of the micron order was worked out with the steel blade that is commonly used for the shaving.

The author has succeeded to get the fineness of up to 0.39 \( \mu \), that was so fine as could not be found by our eyes.

EXPERIMENT I

**Determination of the reproducibility by means of the fine lines corresponding to the change of stuffing time**

1. Method of the Experiment

i) A pair of bronze metallic pattern that has fine chromium coating was employed to take impression of 100\( \times \)10\( \times \)10 mm test pieces. On one side of the pattern surface of 100\( \times \)10, 26 lines of different fineness were engraved by a steel blade in order to investigate the reproducibility of those fine lines being reappeared on the polysulfide rubber impressions.

The fineness of each line on the pattern was determined by the microscopy, as shown on the Table 22.

ii) Material of the following composition was employed in the investigation of reproducibility.

*Appendix: Dept. of Dental Technology, (Chief. Prof. Y. Kanzawa) School of Dentistry.
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Table 22. Reproducibility of fine lines corresponding to the change of stuffing time

<table>
<thead>
<tr>
<th>Pattern fineness</th>
<th>No.</th>
<th>75 sec</th>
<th>90 sec</th>
<th>110 sec</th>
<th>Pattern fineness</th>
<th>No.</th>
<th>75 sec</th>
<th>90 sec</th>
<th>110 sec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>270.80</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>14</td>
<td>12.48</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>177.84</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>15</td>
<td>9.36</td>
<td>O</td>
<td>O</td>
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<tr>
<td></td>
<td>3</td>
<td>174.72</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>16</td>
<td>7.80</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>165.36</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>17</td>
<td>7.69</td>
<td>O</td>
<td>O</td>
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<tr>
<td></td>
<td>5</td>
<td>160.68</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>18</td>
<td>6.92</td>
<td>O</td>
<td>O</td>
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<tr>
<td></td>
<td>6</td>
<td>156.00</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>19</td>
<td>6.34</td>
<td>O</td>
<td>O</td>
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<tr>
<td></td>
<td>7</td>
<td>143.52</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>20</td>
<td>6.24</td>
<td>O</td>
<td>O</td>
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<tr>
<td></td>
<td>8</td>
<td>109.20</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>21</td>
<td>5.30</td>
<td>O</td>
<td>O</td>
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<td></td>
<td>9</td>
<td>62.40</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>22</td>
<td>3.85</td>
<td>O</td>
<td>O</td>
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<td></td>
<td>10</td>
<td>43.68</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>23</td>
<td>3.46</td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>11</td>
<td>24.96</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>24</td>
<td>2.31</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>21.84</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>25</td>
<td>1.15</td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>13</td>
<td>15.60</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>26</td>
<td>0.39</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

O -- Reproduced  X -- Not Reproduced

A-agent: polysulfide liquid polymers (about 4.000 in molecular weight) 77%, CaSO₄·1/2H₂O 10%, sulfur (S) 3%, SiO₂(B) 10%

B-agent: PbO₂ 13%, MnO₂ 39%, SiO₂(B) 28%, castor oil 20%

iii) The reproducibility of the fine lines about the above mentioned material was determined corresponding to the stuffing time of each 75 seconds, 90 seconds and 110 seconds.

2. Results of the Experiment

The results of the experiment are shown on the Table 22 simultaneously with the list of all lines of different fineness on the pattern. On the table, O marks show the completely reproduced and X marks not reproduced.

Refering to the results, following items have been understood.

i) Inspite of the incomplete procedures of the manufacturing processes, the reproducibility by this material was so good as to be able to reproduce up to 3.85 μ line at the stuffing time of 75 seconds.

ii) Despite the results obtained by this experiment was exercised by compressing the material into the pattern by the increasing force in order to flow out the excess amount of the material through two outlets of each 0.5 mm diameter drilled onto the upper lid of the pattern, the reproducibility, devalued corresponding to the increase of the stuffing time.

It may readily be supposed from this result that the reproducibility functions direct proportionally to the fluidity of the material at that time.

**EXPERIMENT II**

_Investigations on the change of fluidity after mixing of A and B-agents_
1. Method of the Experiment

i) A pair of bronze metallic pattern that has fine chromium coating was employed to take cylindrical impressions of 35 mm diameter and 12.5 mm height. On the upper lid of the pattern, 0.5 mm diameter outlet was drilled by which the excess amount of the fluidal impression material would be flown out of the pattern when pressed by the pressing apparatus.

ii) Three kinds of composition were employed in this case of experiment as follows.

**Material I:**
- **A-agent:** polysulfide liquid polymers (about 4,000 in molecular weight) 77%, CaSO₄·½H₂O 10%, sulfur (S) 3%, SiO₂(B) 10%
- **B-agent:** PbO₂ 13%, MnO₂ 39%, SiO₂(B) 28%, castor oil 20%

**Material II**
- **A-agent:** polysulfide liquid polymers (about 4,000 in molecular weight) 72%, CaSO₄·½H₂O 10%, sulfur (S) 3%, SiO₂(B) 15%
- **B-agent:** PbO₂ 14%, MnO₂ 42%, SiO₂(B) 25%, castor oil 19%

**Material III**
- **A-agent:** polysulfide liquid polymers (about 4,000 in molecular weight) 62%, CaSO₄·½H₂O 10%, sulfur (S) 3%, SiO₂(B) 25%
- **B-agent:** PbO₂ 12.5%, MnO₂ 37.5%, SiO₂(B) 31%, castor oil 19%

iii) The flow out compression testings were exercised about those materials by means of the Shopper's type compression tester and the pattern of previously described.

The time used for the mixing operation was each 50 seconds.

2. Results of the Experiment

Fig. 85 illustrates the results of the flow out compression testing corresponding to the change of stuffing time. The stuffing times were adjusted at 70, 80, 90 and 100 seconds.

In the figure, each number of the diagram shows the result about the material of the corresponding number.

Referring to the figure, following items have been reached the comprehension.

i) In those cases, the flow out compression could not be recorded owing to the scaling out at the stuffing time of 100 seconds.

ii) Any diagram has showed sudden uprising almost about at 85 seconds stuffing time.

iii) The curvature of diagram became larger corresponding to the increase of the fillers in their compositions.

iv) The reproducibility of each material corresponding to the change of the stuffing time would certainly be caused proportionally to the fluidity, namely along the diagram shown on the figure, so thus these diagrams may
be called the "reproducibility diagram" of each material.

DISCUSSION AND SUMMARY

It is a common sense to think that the reproducibility of this sort of impression materials depends chiefly upon the fluidity of the material when they were stuffed onto the patterns. Correspondingly the time lag of the stuffing operation would result the bad effect on the reproducibility by such materials.

Thus the equation of representing the reproducibility may certainly be given by the following equation;

$$R = K\phi = K\left(\frac{1}{\eta}\right) \quad \text{(1)}$$

where $R$ . . . reproducibility  
$\phi$ . . . fluidity  
$\eta$ . . . viscosity  
$K$ . . . constant

As was introduced in the former articles, if a liquid with a coefficient of viscosity $\eta$ flows with a uniform velocity, at a rate of $v$ cm in $t$ sec, through
a narrow tube of radius \( r \) cm and length \( l \) cm, under a driving pressure \( p \) dynes per square cm, then

\[
\eta = \frac{\pi r^4 p t}{8 \nu l} \tag{2}
\]

This equation is the mathematical expression of the Poiseullie's law,\(^2\) by which the rate of flow is inversely proportional to the fourth power of the radius of the tube: it is the basis of methods for determining coefficient of viscosity of liquids. In the derivation of (2), the assumption is made that the flow takes place slowly, and that the liquid leaves the tube with a negligible velocity.

In the case of the experiment of this report, \( r, l, t \) and \( \nu \) are assumed to be constant, so the equation (2) becomes,

\[
\eta = kP \tag{3}
\]

where \( P \) is compression load per unit area, and \( k \) is a constant.

Then from (1) and (3),

\[
R = K_0 \eta = K \left( \frac{1}{\eta} \right) = K_0 \frac{1}{P} \tag{4}
\]

where \( K_0 \) is also a constant.

On the occasion of the Experiment I, the reproducibility was caught by not continuous change of the fineness of the fine lines, so thus it is not adequate to make the actual "reproducibility diagram" in the strict meaning.

The author has examined the above mentioned procedure in order to compare the results of the Experiment I and II approximately: Fig. 87 shows the diagram that was obtained by such a contemplation.

Refering to the diagram of No. 1 in the Fig. 86 and that of Fig. 87, it may readily be nodded that the theory of the reproducibility founded on the fluidity was not wrong.

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**References**

2) S. Glasstone: Physical Chemistry (1940).