

**To compare the dimensional accuracy of dies obtained by using different tray materials – An in vitro study**

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**Abstract**

**Introduction:** This in-vitro study was undertaken to compare the dimensional accuracy of dies obtained by using different tray materials and pouring casts at different time intervals.

**Objectives**

1. To compare the dimensional accuracy of dies obtained from auto polymerizing acrylic resin custom tray from the metal die model.

2. To compare the dimensional accuracy of dies obtained from light cure acrylic resin custom tray from the metal die model.

3. To compare the dimensional accuracy of dies obtained from metal stock tray from the metal die model.

4. To compare the dimensional accuracy of dies obtained from plastic stock tray from the metal die model.

5. To compare dimensional accuracy of dies obtained from all tray materials poured at different time intervals that is at immediate pouring, 24 hours and 72 hours amongst each other.

**Materials and Methods:** Vinyl polysiloxane in putty and light body consistency were used for making impressions. A stainless steel die with specific dimensions was used for making the samples. Two indentations were made on the top and lateral side of the die. Total 12 groups were made using each type of tray at immediate, 24 hrs and 72 hrs time interval. 120 samples were fabricated ten per group. Three readings were recorded for each sample and average of the three were compared amongst themselves. Linear measurements were done using profile projector. Data was collected and analysed statistically.

**Results:** Based on the study it can be concluded that dimensional accuracy was comparable at immediate pouring with different tray materials as the horizontal and vertical distance was found to be statistically non-significant. However, on comparison of horizontal and vertical distance at 24 hr and 72 hr it was found that result of dimensional accuracy was best for light cure tray followed by custom tray, stock metal tray and stock plastic tray.

**Keywords:** Tray Materials, Time Intervals, Profile Projector, Stainless Steel Die.

### **Introduction**

Prosthetic dentistry makes it possible to duplicate oral conditions & tooth morphology by making impressions. There are many reports concerning how to improve the accuracy of impression techniques, including controlling the room temperature, using single or double impression techniques, using individual or custom trays etc<sup>1</sup>. Transfer of an accurate replication of the patient's hard and soft tissue to the dental laboratory is important. Most

dental surgeons have experienced the consequence of making a poor impression.

The ability to identify and analyze inaccurate impressions and to understand how to avoid them is key to successful restoration<sup>2</sup>. Since impressions reproduce both the oral conditions and tooth morphology, success is dependent on understanding the anatomy of the periodontium, creating a precise and accurate preparation (especially at the finish line) by employing the correct impression technique and appropriate impression material. However, none of these alone will ensure an accurate impression. Many studies on impression accuracy have been published. Many in-vitro studies in which it was assumed that the evaluated impressions were acceptable, meaning no visible errors were observed<sup>2</sup>.

Another factor affecting the success of dental prosthesis is the accurate and passive fit. Mis-fitting prosthesis can possibly induce some tension on the components, consequently resulting in mechanical and biological complications. Accurately and passively fitting prosthesis are essential for maintaining the oral tissue health and proper bio mechanical functioning of the restoration. This fit of prosthesis depends upon the selection of dimensionally stable tray and technique of the impression making which as a result would give a detailed recording of the oral tissues<sup>3</sup>. In majority of the cases, there is need of renewing the cast which is due to problems in the first cast or due to the laboratory steps. Under these conditions, a good material can pour the impression prepared and made several casts; and the accuracy of the primary cast is required<sup>4</sup>.

Thickness of impression material and undercut of the standard die have been shown to affect the dimension of stone dies. The increase in thickness of the impression material from 1 to 4 mm caused a greater distortion than

the height increase of the undercut from 1 to 3 mm. It should be remembered that an increase in bulk of impression material under the experimental conditions specified by thermal contraction inevitable results in a greater inaccuracy of the impression. Pouring the dies at 37°C significantly reduces the effect of material bulk on the accuracy of president impressions<sup>5</sup>. Tray accuracy plays a significant role in making a precise impression as it provides sufficient amount of space for impression material to flow. Tray spacer of optimal thickness is essential for achieving the acceptable thickness of impression material<sup>3</sup>.

Impression making and cast making are the two steps necessary to make a well fitting restoration. Fit refers to the placement of a restoration made from an accurate impression technique that requires minimal insertion adjustments. Impression accuracy is dependent on die material used to make the cast<sup>6</sup>. This in-vitro study was carried out to compare the dimensional accuracy of die by using different tray materials and pouring casts at different time intervals.

### **Materials and Method**

This in vitro study was conducted in Department of Prosthodontics, Bhojia Dental College and Hospital (Bhud) Baddi.

120 samples were made using each type of tray and the samples were poured immediately, at 24 hrs and at 72 hrs respectively in Type IV dental stone.

### **Materials**

To conduct this study following materials were used

1. Condensation silicone (Coltene Speedex Putty 9450 Alstatten, Switzerland) (Fig.1a)
2. Polyethylene Separating sheets (DPI, Mumbai, India)
3. Autopolymeirizing acrylic resin material (DPI, Rudrapur, Utrakhand, India) (Fig. 1b)

4. Light cure tray material (Delta Labs No.323, Chennai, India) (Fig. 1c)
5. Tray adhesive (Coltene Adhesive Polysiloxane, 9450 Alstatten, Switzerland)
6. Type IV Dental stone (Kalabhai Karson Pvt. Ltd. Kalabhai House 43/44, L.B.S Marg, Viknroli, Mumbai, 400 079 Maharashtra) (Fig. 1d)
7. Aluminium Foil
8. Separating media – Cold Mould Seal (DPI, Khasra no. 161B, Rudrapur, 263153, Utrakhand)

### **Armamentarium**

1. Stainless steel die (Fig. 2a)
2. Perforated metal stock trays (Fig.3a)
3. Perforated autopolymerising resin custom trays (Fig. 3b)
4. Perforated plastic stock tray (Fig. 3c)
5. Perforated light cure custom tray (Fig. 3d)
6. Spacer sheets (Fig. 4a)
7. Dispensing gun (Dentsply)
8. Glass slab
9. Mixing tips
10. Rubber bowl
11. Mixing spatula (stainless steel straight, metal cement)
12. Water measuring jar
13. Bard Parker handle no.4 and blade no. 20
14. Finishing stones, mandrel and sand paper
15. Lacron carver
16. Camel hair brush
17. Spacer sheet

### **Equipments**

1. Vibrator
2. Lathe
3. Profile Projector (Sipcon Instrument Industries, Ambala Cantt, India) (Fig. 5a)
4. Dental Vaccuforming machine (Fig. 5b)

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## **Method**

### **1. Preparation of master model**

A stainless steel die (Fig. 2a) resembling single prepared posterior tooth was used as a master model for the impression techniques used in this study. The die was fabricated to simulate full - crown preparation. A horizontal indentation was marked on top of the die (Fig. 2a & 2b) and a vertical indentation was marked above the shoulder finish line and below the top on lateral surfaces of the die (Fig. 2a & 2b).

### **2. Fabrication of tray**

The perforated metal (Fig. 3a) and plastic stock trays (Fig. 3c) were prefabricated with the help of a milling machine. For both autopolymerizing perforated custom tray (Fig. 3b) and light cure perforated custom tray (Fig. 3d) a spacer sheet of 3.5 mm thickness (Fig. 4a) was adapted over the master die using vacuum forming machine (Fig. 5b) onto which aluminum foil was adapted as separating medium onto spacer and cold mould seal was applied to metal part of die and the autopolymerizing acrylic resin material (Fig. 1b.) was then mixed and adapted onto the die in dough stage and allowed to set on die for 24hours. The light cure custom tray was fabricated by adapting the light cure cake onto the adapted spacer and the tray was cured in the light curing unit. Both the custom trays were retrieved after achieving the final set and were then trimmed and polished prior to impression making.

### **3. Grouping of samples**

Total Twelve groups were made.

- a. Group I- samples obtained by making impression with Metal stock tray and poured immediately (Fig. 6a).
- b. Group II- samples obtained by making impression with Metal stock tray and poured after 24 hours (Fig. 6a).

- c. Group III- samples obtained by making impression with Metal stock tray and poured after 72 hours (Fig. 6a).

- d. Group IV- samples obtained by making impression with Plastic stock tray and poured immediately (Fig. 6b).

- e. Group V- samples obtained by making impression with Plastic stock tray and poured after 24 hours (Fig. 6b).

- f. Group VI- samples obtained by making impression with Plastic stock tray and poured after 72 hours (Fig. 6b).

- g. Group VII- samples obtained by making impression with Light cure custom tray and poured immediately (Fig.6c).

- h. Group VIII - samples obtained by making impression with Light cure custom tray and poured after 24 hours (Fig. 6c).

- i. Group IX- samples obtained by making impression with Light cure custom tray and poured after 72 hours (Fig.6c).

- j. Group X- samples obtained by making impression with Autopolymerizing resin custom tray and poured immediately (Fig.6d).

- k. Group XI- samples obtained by making impression with Autopolymerizing resin custom tray and poured after 24 hours (Fig.6d).

- l. Group XII - samples obtained by making impression with Autopolymerizing resin custom tray and poured after 72 hours (Fig.6d).

### **Preparation of samples**

A total of 120 specimens were fabricated 10 per group. Each tray (custom/stock) was painted on with tray adhesive and allowed to dry as per manufacturer's instructions. A putty impression using polyethylene spacer sheet was made individually with metal stock tray, plastic stock tray, light cure custom tray and

autopolymerizing resin custom tray at three time intervals i.e immediately, 24 hours and 72 hours respectively. For each tray, tray adhesive was applied and then air dried. Using this tray a putty impression was made with polyethylene spacer and after the putty was set the tray was retrieved. Polyethylene spacer sheet was removed to provide space for the light body. The light body was then injected into the set putty material and the final impression was made. The impression was then poured in type- IV dental stone

### Measurement of samples

The testing of the samples were done using profile projector (Fig. 5a & 5b) For dimensional accuracy the horizontal and vertical distance on the die were measured. Three readings were recorded for each sample and average of the three readings was compared amongst themselves for the final results.

### Statistical analysis

Data collected was subjected to statistical analysis using one-way ANOVA and post hoc test.

### Results

Table 1 and fig. 1-6 depicts comparison of dimensional accuracy of dies obtained from all tray materials poured at different time intervals. The mean and standard deviation values of horizontal distance and vertical distance at immediate pouring, 24 hr and 72 hr were compiled. The mean value of horizontal distance at immediate pouring for Master die, Custom tray, Stock metal tray, Light cure tray and Stock plastic tray was found to be 8.49600, 8.47380, 8.46580, 8.48950 and 8.46400 respectively. The mean value of horizontal distance at 24 hr for Master die, Custom tray, Stock metal tray, Light cure tray and Stock plastic tray was found to be 8.49600, 8.48840, 8.43510, 8.49240 and 8.40000 respectively. The mean value of horizontal distance at 72 hr for Master die, Custom tray, Stock

metal tray, Light cure tray and Stock plastic tray was found to be 8.49600, 8.45110, 8.43280, 8.47190 and 8.42280 respectively. The mean value of vertical distance at immediate pouring for Master die, Custom tray, Stock metal tray, Light cure tray and Stock plastic tray was found to be 9.30900, 9.29270, 9.29050, 9.30470 and 9.28810 be respectively. The mean value of vertical distance at 24 hr for Master die, Custom tray, Stock metal tray, Light cure tray and Stock plastic tray was found to be 9.30900, 9.25480, 9.20480, 9.28870 and 9.16990 respectively. The mean value of vertical distance at 72 hr for Master die, Custom tray, Stock metal tray, Light cure tray and Stock plastic tray was found to be 9.30900, 9.24690, 9.21580, 9.26850 and 9.14730 respectively. Further, comparison had been made using ANOVA test which revealed statistically significant difference in horizontal distance and vertical distance at 24 hr and 72 hr. (P-value <0.05)

Table 2 and figure 7 depict intragroup comparison of dimensional accuracy of Custom tray. The mean difference of values obtained on comparing different time interval had been presented in table. Further, comparison was made using paired sample t test which revealed statistically significant difference between Horizontal Immediate - Horizontal 72 hr (Mean diff= .022700), Horizontal 24 hr - Horizontal 72 hr (Mean diff= .037300) and Vertical Immediate - Vertical 72 hr (Mean diff= .045800). (P-value <0.05)

Table 3 and figure 8 depict intragroup comparison of dimensional accuracy of stock metal tray. The mean difference of values obtained on comparing different time interval had been presented in table. Further, comparison was made using paired sample t test which revealed statistically significant difference between Vertical Immediate - Vertical 24 hr (Mean diff=

.085700) and Vertical Immediate - Vertical 72 hr (Mean diff= .074700). (P-value <0.05)

Table 4 and figure 9 depict intragroup comparison of dimensional accuracy of light cure tray. The mean difference of values obtained on comparing different time interval had been presented in table. Further, comparison was made using paired sample t test which revealed statistically significant difference between Horizontal 24 hr - Horizontal 72 hr (Mean diff= .020500) and Vertical Immediate - Vertical 72 hr (Mean diff= .036200). (P-value <0.05)

Table 5 and figure 10 depict intragroup comparison of dimensional accuracy of stock plastic tray. The mean difference of values obtained on comparing different time interval had been presented in table. Further, comparison was made using paired sample t test which revealed statistically significant difference between Horizontal Immediate - Horizontal 24 hr (Mean diff= .064000), Horizontal Immediate - Horizontal 72 hr (Mean diff= .041200), Vertical Immediate - Vertical 24 hr (Mean diff= .118200), Vertical Immediate - Vertical 72 hr (Mean diff= .140800) and Vertical 24 hr - Vertical 72 hr (Mean diff= .022600). (P-value <0.05).

### Discussion

Dentists face numerous clinical challenges and evaluating self-performance for quality assurance can be demanding. Now a day's rubber base impression materials are highly accurate and are widely used for making impressions in fixed prosthodontics. Making an impression represents a crucial step in processing and fitting dental prosthesis. The use of appropriate trays, sufficient retention of the impression material to the tray, complete polymerization of the materials with proper adherence to each other, and the absence of bubbles, voids, or tears along the finish line. For that reason, the quality of the impression is decisive for final fitting

accuracy, and consequently for the success of the dental reconstruction. In case of inaccuracy, the impression should be repeated, spending costs and time. Therefore, selecting the best and most accurate impression material, technique along with the tray is essential for successful treatment. In the present in-vitro study, a metal die was made to compare the dimensional accuracy of the dies obtained using different tray materials. Impression were made on the die by using condensation silicone impression material with different tray materials and were poured at three different time intervals i.e. immediate pouring, 24 hours after making the impression and 72 hours after making the impression. The dimensional stability of an impression material reflects its ability to maintain the accuracy of the impression over time. Several studies exist in the literature on comparison of dimensional stability of elastomeric impression materials. Kumar et.al<sup>7</sup> in his study reported that condensation silicone showed a generally unchanged diameter or a bigger diameter at the time of initial pour but as the time elapsed, shorter dies in diameter than the standard ones were obtained. The reason behind this was, condensation silicones are understood to undergo considerable polymerization shrinkage, they showed stress relaxation as a function of time causing the material to come toward the imaginary center of the impression, leading to production of dies which were shorter in both horizontal and vertical dimensions. The results of this study are in line with the results that we obtained in our study when the impressions were poured after 24 hours and 72 hours of making the impression which resulted in shorter diameter of stone dies.

The most common dimensional changes that occur with the silicone-based impression materials are related to the material's polymerization shrinkage and to temperature

differences between the oral environment along with the room and the incomplete elastic recovery is another important factor<sup>8</sup>. In a study conducted by Paginano et.al<sup>9</sup> it has been shown that the greater the period of time a cold-curing acrylic resin custom tray is stored prior to use, the more stable it becomes. Ideally, waiting at least 9 hours after fabrication of a custom tray allows the materials tested to become comparatively stable. If it is necessary to use a tray soon after fabrication, following hardening, it should be placed in boiling water for 5 minutes and then cooled to room temperature. In one of the study, linear dimensional change of twelve commercially available autopolymerizing acrylic resin tray materials was evaluated for over a 24-hour period and it was recommended that the construction of autopolymerizing custom tray should be done 24 hours prior to impression making so as to achieve maximum set of the resin material as after that the polymerization shrinkage is insignificant. This recommendation was adhered to in our present study, the perforated autopolymerizing custom tray was allowed to set on metal die for 24 hours after which the finishing and polishing was done and then the impressions were made<sup>10</sup>.

Huey-Yuan Wang et.al<sup>11</sup> in his study concluded that condensation silicone was more accurate in custom tray impressions as compared to stock trays. In present study also custom trays depicted better results in comparison to stock trays when impressions were poured at 24 hour and 72 hour time interval.

Bomberg et.al<sup>12</sup> advocated that the custom acrylic resin impression tray is necessary to obtain a successful elastomeric impression. This advocacy has been based on research that indicated least dimensional change when the impression material was uniformly thin. The material thickness in the tray is affected by the way in which the tray is made as well as the manner in which it

is used. Variables in making the custom tray include thickness and uniformity of the spacer, occlusal stops, and extension. When custom tray is used, complete seating of the tray and orientation and centering of the tray during placement must be considered. Bomberg et.al<sup>12</sup> also stated that the dimensional change of the impression during storage is a characteristic of the material, a reduction in its bulk should lead to a desired amount of dimensional change. Dimensional changes that occur during the setting of elastomeric impression materials (polysulfides, conventional silicones, and polysiloxanes) are proportional to the thickness of the material. They are minimized when the thickness is a consistent 2 to 3 mm. In a study by Kumar et.al<sup>13</sup> the author recommends 2 to 4 mm spaced trays to produce more accurate die stone casts.

Lacy et.al<sup>14</sup> studied time-dependent accuracy of condensation silicones and recommended that for maximum accuracy, the condensation silicone systems should be poured as soon as possible after making the impression. Which supports the results obtained in the present novel study where no relevant significant changes have been observed on pouring the impressions immediately after impression making. The dimensional stability in this study was the result not only of the dimensional stability of the impression materials themselves, but was also due to the bonding adhesive, type of tray, material of the tray and spacer thickness used for impression material.

Figure Legends



Fig.1a: Condensation silicone



Fig.1b: Autopolymerising acrylic resin material

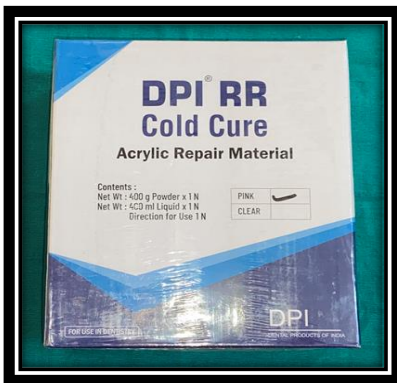


Fig. 1c: Light cure tray material



Fig.1d: Type IV dental stone



Fig. 2a Stainless steel die,

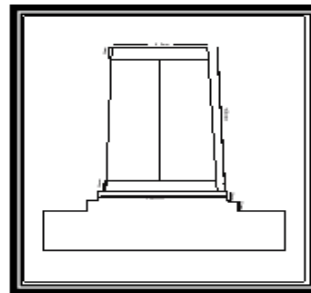


Fig. 2b: Stainless steel die with dimensions (frontal and top view)



Fig. 3a: Metal stock tray placed over the master die



Fig. 3b: Perforated autopolymerizing resin custom tray,



Fig. 3c: Perforated plastic stock tray



Fig. 3d: Perforated light cure custom tray

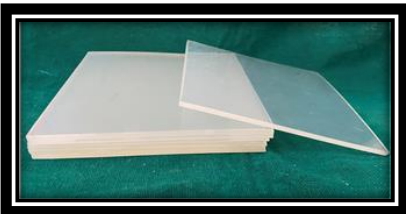


Fig. 4a: Spacer sheets (thickness 3.5 mm)



Fig. 4b: Adapted spacer sheet over the die



Fig. 5a: Profile Projector,



Fig. 5b: Vaccumforming Machine with master die in place

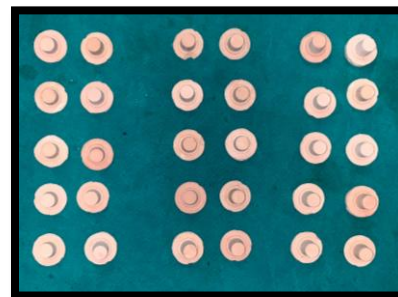


Fig. 6a: Samples from Group I, Group II, Group III

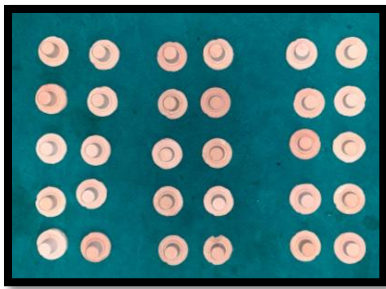


Fig. 6b: Samples from Group IV, Group V, Group VI

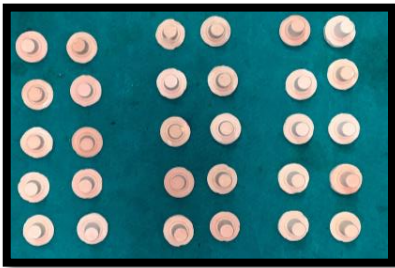


Fig. 6c; Samples from Group VII, Group VIII, Group IX

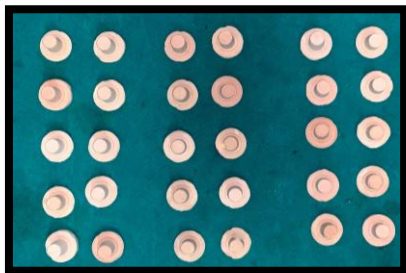


Fig. 6d: Samples from Group X, Group XI, Group XII

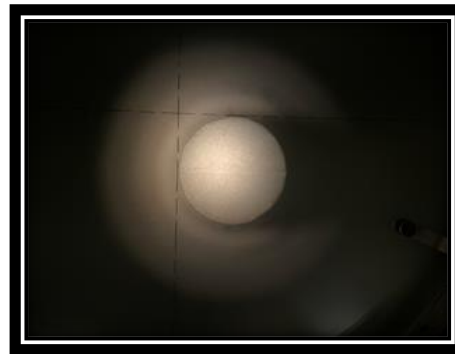


Fig. 7b: Top view of the die on the profile projector

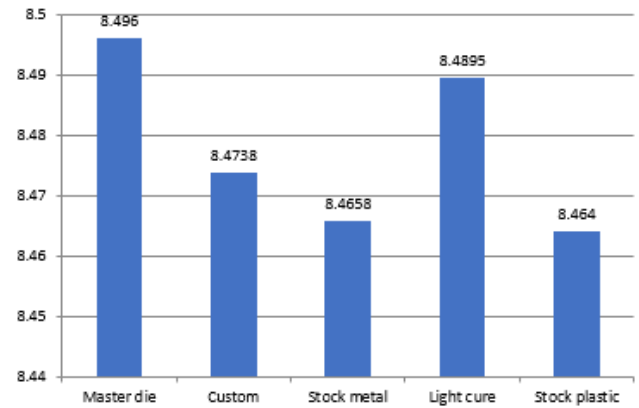


Fig. 8a: Intergroup comparison of horizontal distance at immediate pouring.

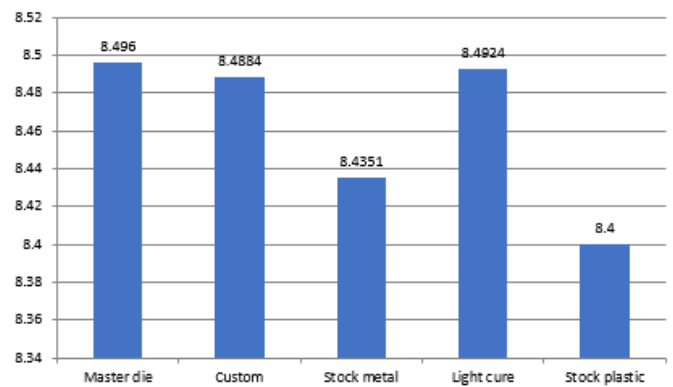


Fig.8b: Intergroup comparison of horizontal distance at 24 hrs.

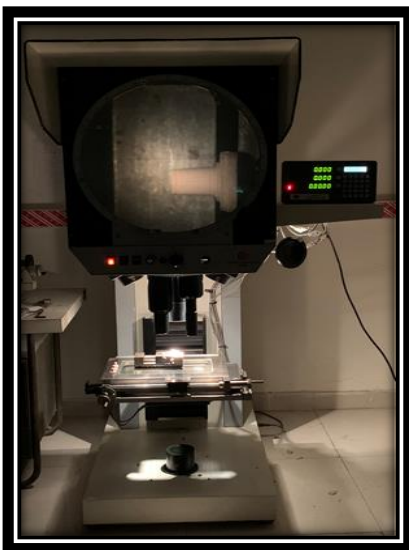


Fig. 7a: Die placed on the profile projector and its view on the profile projector(laterally)

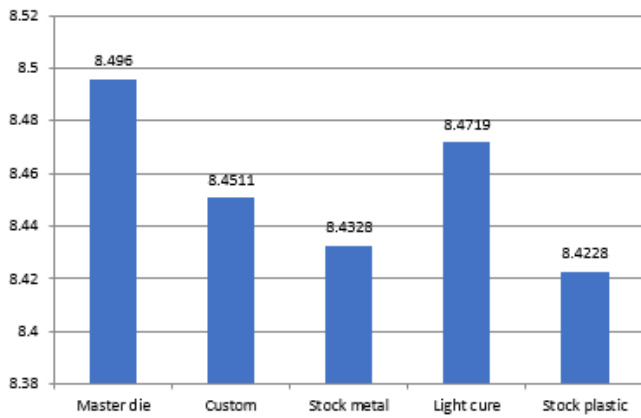


Fig. 8c: Intergroup comparison of horizontal distance at 72 hrs.

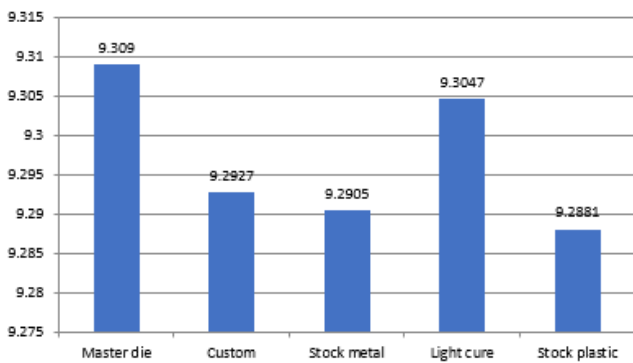


Fig. 8d: Intergroup Comparison of vertical distance at immediate pouring

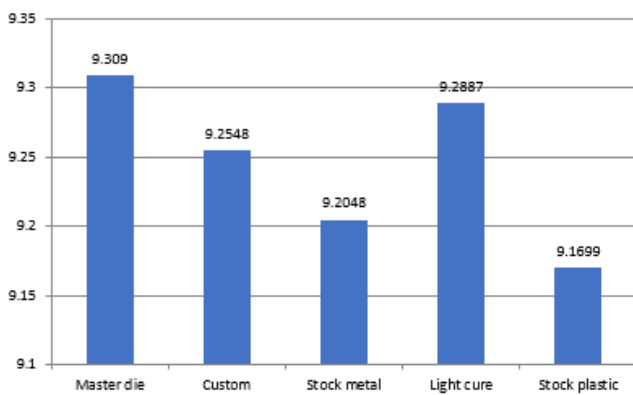


Fig. 9a: Intergroup comparison of vertical distance at 24 hours

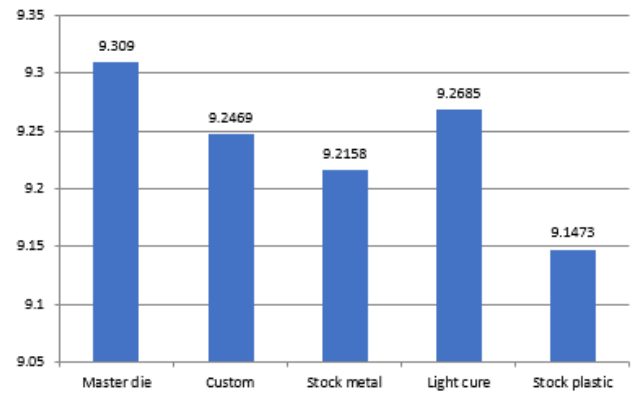


Fig. 9b: Intergroup Comparison of vertical distance at 72 hours

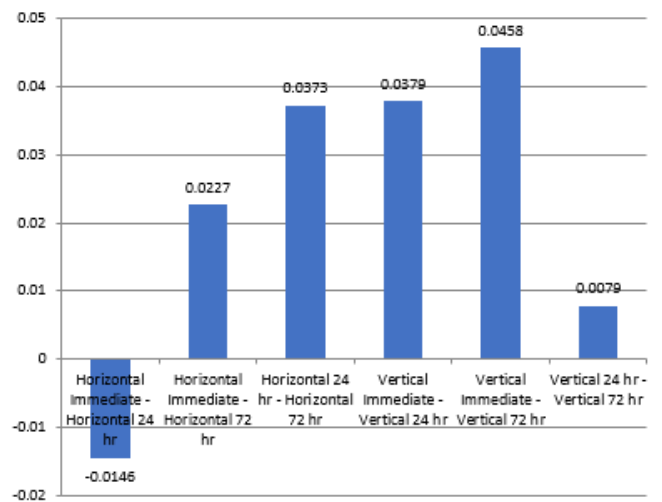


Fig. 9c: Intragroup comparison of custom tray

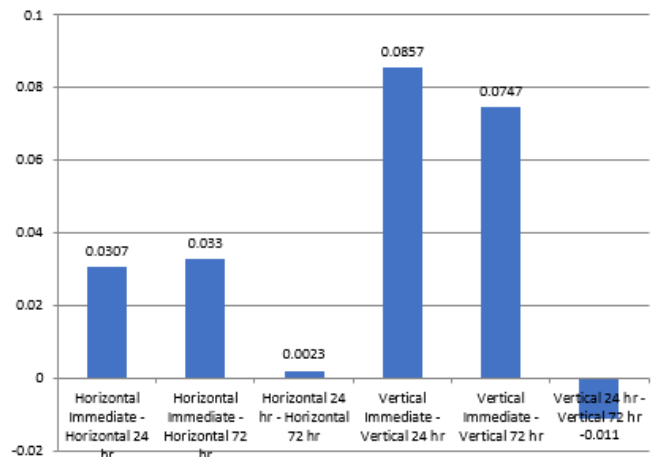


Fig. 9d: Intragroup comparison of stock metal tray

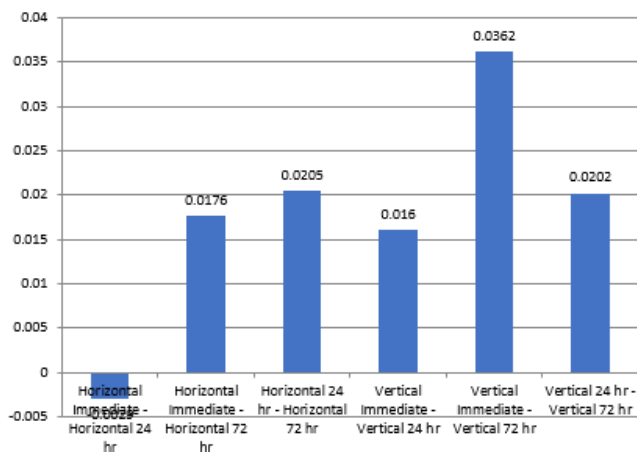


Fig. 10a: Intragroup comparison of light cure tray

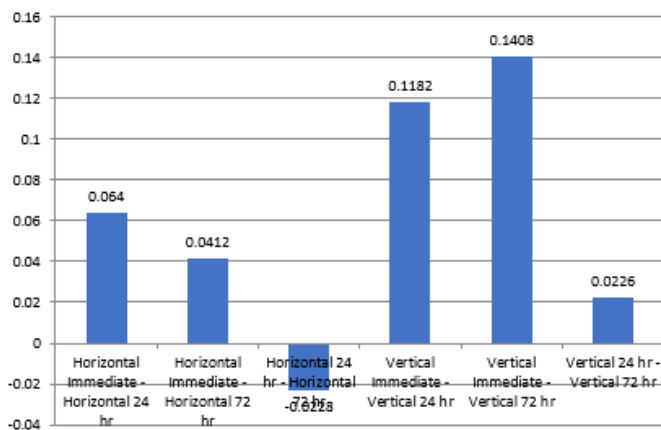


Fig. 10b: Intragroup comparison of stock plastic tray

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