Lost Wax Casting Conditions with Tourmaline in-situ

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Abstract. The technique of stone in place casting had established in jewelry production for three decades. However, the process did not widely used since it was limited to precious stones with high hardness and high stability at high temperature. This experiment tested on tourmaline which is semi-precious gemstone having less hardness and less stability comparing to precious stones. The objective of this experiment was to achieve the conditions of a lost-wax casting process with tourmaline placing in waxes of the casting process. The experiment was designed into two parts. The first part is to understand the phenomena of tourmaline under the heating conditions. Natural tourmaline stones were investigated and compared inclusions tested at a temperature of 700 ^{o}C. Tourmaline with ion-implantation was also heated at 700 ^{o}C to compare. The second part is to test tourmaline in place casting with three conditions of flask casting at 550°C, 625°C, and 700 °C. The results showed that stones were able to tolerate as much as at 700 ^{o}C. The inclusion growth of ion-implantation under heating at 700 ^{o}C also observed the growth of inclusion in the same way of untreated tourmaline. The casting condition at 550°C showed the better results of changes. High probability of breaking stones after casting was bazel.

Introduction

Stone in place casting has known in jewelry manufacturing for three decades. The concept of this technique allows an economic production due to the faster process time and cheaper labor costs [1]. The technical reports had focused on jewelry manufacturers with casting products of cubic zircon in-situ silver alloys [2]. The technique requires workers with comprehending understand of traditional investment casting; therefore, they can apply techniques of stones in place casting. Precious stone types such as diamond and sapphire used for jewelry casters due to stability at high temperature and high hardness. Careful procedures and technical knowledge needed to be considered to avoid the stones breaking after casting**.**

Casters need to consider two criteria for stones in place casting techniques. The first criterion is to understand stone tolerances at highest temperatures of investment flasks in casting processes. The flask temperature effects to stone deteriorations during holding times at the highest temperature of investment flasks. Casters need to decrease highest temperatures of investment flasks to prevent stone degradations whereas the reduction of flask temperature might effect to the strength of investment bonds. The casters need to consider the traded off between the strength of flask bonds and probabilities of stone deteriorations. The second criterion of stone in place casting is to make sure that all stones were in places and unbreaking after casting. Various kinds of stone settings effects to the final products of stone in place casting since different types of settings have various contact areas of metal with stones. High probabilities of breaking of stones after casting were the setting with bigger areas of metal contacting to the stones. The metals with high contact areas to stones could be shrunk and pressed stones, whereas lesser contacts of stones had fewer probabilities of breaking stones.

Therefore, there are two main concerns to use for stone in place casting. Firstly, one is to understand how stones can yield the temperature without any changes in inclusions or deteriorations.

The second concerns are how hard the stones could be tolerate from pressing of metals during solidification processes. In this experiment, there were two sets of observations varied by temperature and holding times of stones in place casting for jewelry productions.

Methodology

The objective of the experiment was to understand the tourmaline temperature endurance under flask conditions and use as a guideline of using temperature for the next step of the experiment. The second experiment is to test on the real condition of stone in place casting for commercial jewelry processes. The experiment designed into two parts as following

1. Endurance of Tourmaline under flask casting conditions

Natural tourmaline stones with inclusions around 20% were selected. All samples were investigated and labeled the areas of inclusions. The areas of inclusions were counted as Pixel using ImageJ software. All stones were embedded in gypsum-bonded investment and heated at a temperature of 700 °C for various times. Tourmaline with ion-implantation were also selected temperature at 700 °C to compare the results. The stones at different heating times were observed the growth of inclusions and counted pixels. The data were plotted to compare the results of all stones with various temperature conditions.

1. Casting condition of tourmaline in situ casting

There were three steps of casting conditions of tourmaline as shown in Figure 1 . It showed the regular cycle of gypsum-bonded investment for jewelry casting production. The highest flask temperature conditions were changed to use at 550°C, 625°C, and 700 °C . All samples were then cast at 550 °C.

Natural tourmaline with the diameter sizes of 2-3 mm was placed in the waxes of pave setting and bazel setting. Wax samples were assembled in the flask trees with stones in the wax as shown in Figure 2. Wax trees were filled as molds in investment flasks. The trees were continued the lost wax process with flask temperature cycles as indicated in Figure 1 .Then ,metals were poured into trees with the stone in place. The metal casting with vacuum casting was at 1020 °C with three different flask temperatures. After casting, the sample held in the chamber for 3 minutes to allow metal solidify preventing oxidation. The flask trees were air cooling for 2 hours then removing the gypsum investment molds. All stones were investigated the inclusions and stone breaking results

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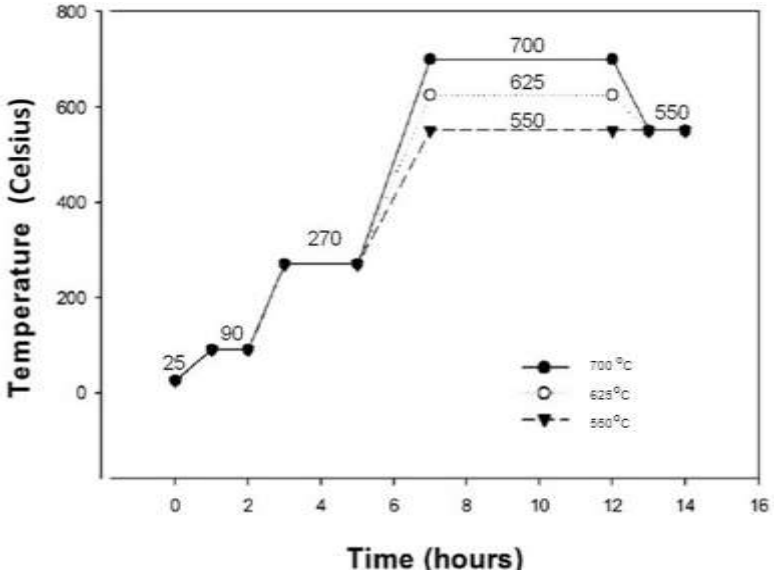
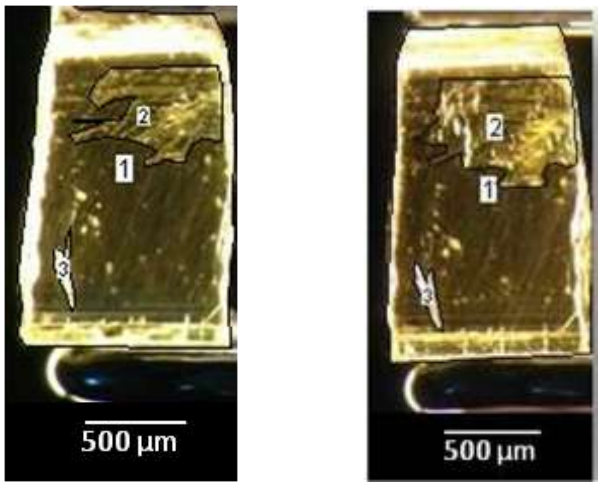


Figure 1 Casting temperature of tourmaline at three different highest flask temperature.

Figure. 2 Flask tree with stones in wax

Results and discussion

The area expansions of inclusions were observed after heating showed in Figure 3. A logarithm plot of inclusion expansions with time at 700 °C was shown in Figure 4. The main idea was to present the exponential increment of inclusion expansions. It means that inclusions were a little change at this temperature corresponding to the stone in place casting time. Another word, the temperature at 700 °C might be safe to the stones. Therefore, the casting experiment at highest flask temperatures for 3-4 hours could use. The ion-implantation also behaved like natural tourmaline. The results showed that inclusions of both treat and natural tourmaline with stones in place casting were slightly changed. Therefore, there was no advantage of using the heat treatment tourmaline.



a) b)

Figure 3 Inclusions in tourmaline after heat treat at 700 °C for 4 hours a) before heating b) after heat

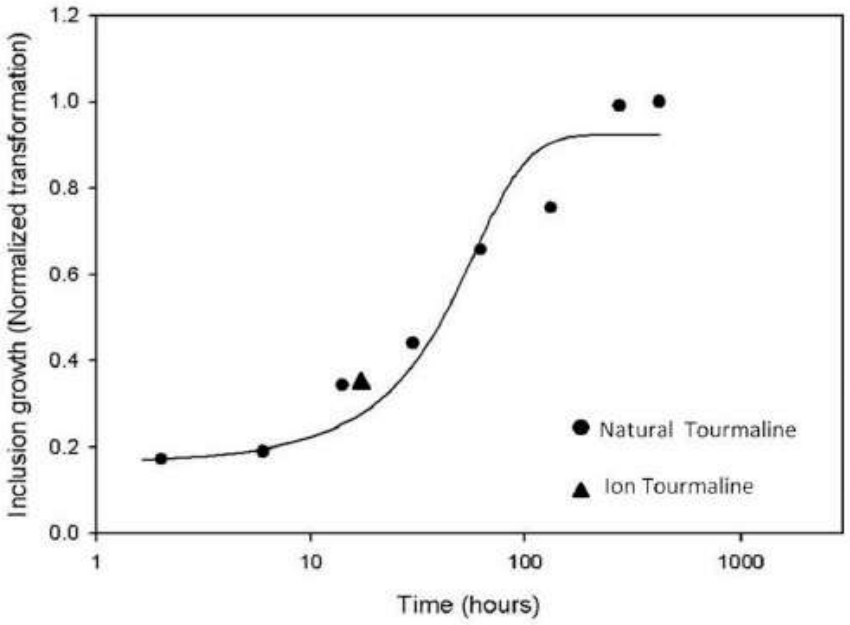
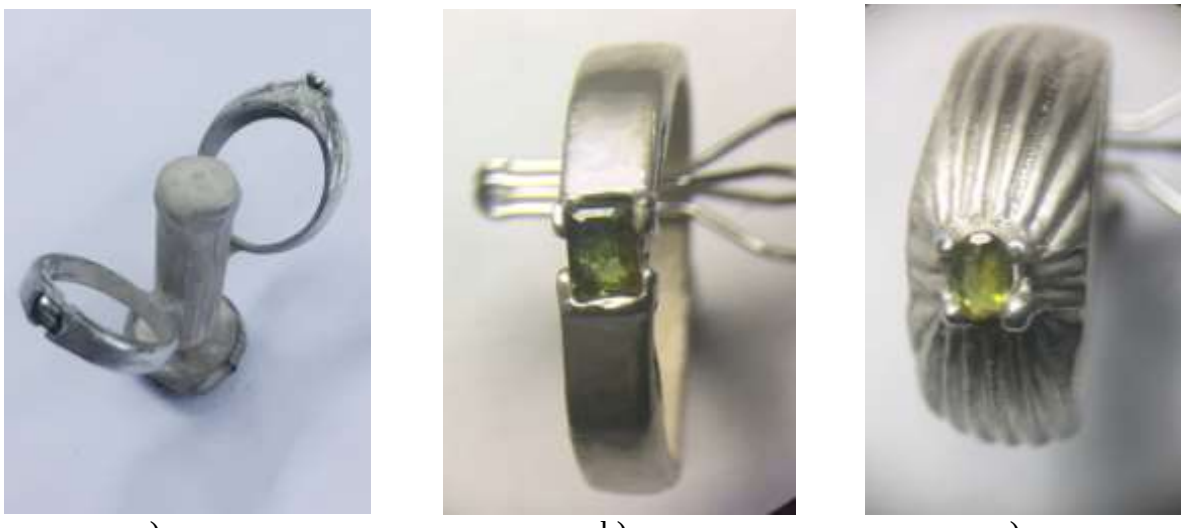


Figure 4 Transformation of tourmaline inclusions at 700 °C.

The second step was to show the tolerance of samples at various flask temperature as designed at three temperatures. Tourmaline with lower flask temperature at 550 °C showed better results as indicated in Figure 5. The color and inclusions had no changes at 550 °C whereas 700 °C showed some changes in color results. The bazel setting showed some minor nicks at the corner of edges whereas pave setting showed no changes. The shapes of the stones with edges contacting to metals might risk for stone in place casting techniques.



a) b) c)

Figure 5 Samples of stone in place casting a) tree after casting at 550 °C b) tourmaline with bazel setting c) tourmaline with pave setting

Conclusions

Tourmaline in situ casting was tested at highest flask temperature at 700 °C at different times. The fraction transformation shows sluggish changes in inclusion. The transformation curves were used to predict the temperature at casting. The natural and ion-implantation tourmaline in place casting was tested the transformation changes. It shows no different stages of inclusion transformation. The test of tourmaline in place casting succeed at 550°C. It showed no changes in results of stones after casting. The different types of stone setting show that bezel setting was higher risk than pave setting. It was due to bigger areas of metal contacting to tourmaline.

Acknowledgment

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