# Surface Roughness Modification Experiments of Quartz Mold by Sandblasting Method for Metal Fuel Rod Fabrication

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## 1. Introduction

In general, a quartz tube is used as a mold for manufacturing a fuel rod, which is applied in a metal fuel fabrication [1,2]. In order to prevent the reaction with the metal melt, the yttria (or zirconia) slurry solution is brushed on the inner surface of the quartz tube to form an appropriate-thickness protection layer to prevent reaction of the quartz tube and melt [3,4]. Since the inner surface of the quartz tube is very slippery due to the nature of the glass, it is difficult to form a protection layer using the slurry solution.

In order to overcome these disadvantages, this study artificially modified the surface characteristics of the quartz tube to improve the surface properties of the quartz tube, so as to maintain the adhesive strength when the slurry solution is adhesive on the quartz surface.

Chemical method and physical method can be considered as methods for modifying quartz tube surfaces. In the first study, chemical surface modification studies have been carried out. However, it was changed with physical handling method because of the need to handle toxic chemicals with high risks in the chemical method. As a physical modification method, we tried to modify the surface characteristics of the quartz surface by using sandblasting technique.

## 2. Experiments

The sandblasting is a method widely used for cleaning and treating the surface of a contaminated common metal. When a specified fine powder maintained at a high pressure is ejected using a nozzle of an appropriate size, this ejected-powder is striking the surface of the relative medium so the surface was treated. In this study, the inner surface of a smooth quartz tube was treated by applying this method, so that the irregularly defects on surface were forcibly formed. The powder used in this test was alumina of 37 mesh size.

In order to characterize the applied pressure, the sandblasting operation was performed while varying the pressure in the range of 2.5 to 3.5 kg/cm$^2$. The time of sandblasting was maintained at a constant level for about 10 seconds, considering the initial state of the study.

Before experiments to modify the inner surface on the quartz tube, the preliminary experiments were conducted to investigate the surface characteristics of the quartz plate under operating-pressure changes. The used quartz plate is a square plate of 30x30x5 mm thickness (made of fused quartz glass by GE maximum working temperature:1200℃) and the conditions of sandblasting are as shown in Table 1. Surface roughness was measured using a SJ-411 (Mitutoyo) surface roughness meter to confirm the roughness of the surface-modified quartz plate.

Table 1. Surface Roughness Measurement of Quartz Plate and Quartz Tube after Sandblasting Operations.

| Quartz plate | Ra(㎛) | Rz(㎛) | Remarks |
|---|---|---|---|
| 2.0 Kg/cm$^2$ | 5.337 | 27.669 | manual |
| | 7.369 | 39.121 | |
| 2.5 Kg/cm$^2$ | 7.404 | 40.859 | |
| | 7.191 | 38.681 | |
| 3.5 Kg/cm$^2$ | 6.903 | 36.928 | |
| | 6.456 | 34.456 | |
| | | | |
| * Reference | 0.009 | 0.085 | original |
| | | | |
| Quartz tube | | | |
| 20 sec | 3.014 | 19.080 | manual |
| 30 sec | 7.977 | 37.208 | |
| 30 sec (R) | 7.523 | 35.272 | |
| 40 sec | 2.719 | 15.515 | |

Ra : average roughness value:

## 3. Results and Discussions

In Fig.1, the value of Ra, which represents the average of the roughness measurement values of the surface of the quartz plate according to the sandblasting pressure, is briefly shown. To obtain the Ra value, the surface roughness according to the pressure change was measured twice and the average value was taken.

When sandblasting was performed for the same period of time, the surface roughness values did not increase in proportion to the pressure even when the pressure to be blasted was increased, and it tended to fall after having the maximum value. That is, when the ejecting pressure exceeds a certain limit value, the magnitude of the surface roughness tends to decrease.

This is similar to the experiment in which the blasting pressure is kept constant and the working time is increased. The right side of Fig.1 shows the result of measuring the roughness of the tube surface after increasing the blasting time at a constant pressure using a quartz tube. Even if the same pressure is applied, the roughness is not increased proportionally when the time is increased and the roughness value tends to decrease after some time passes and the average roughness value show the maximum value.

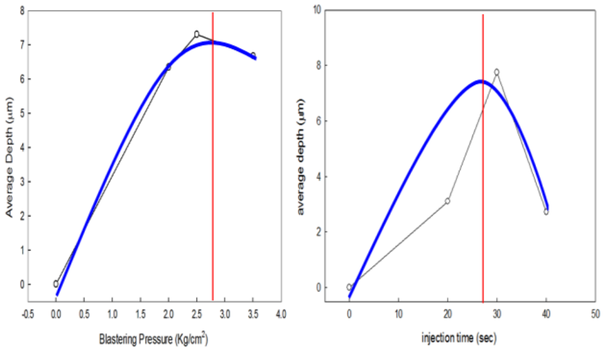


Fig. 1. Roughness value changes of quartz plates (left) and quartz tubes (right) according to blasting pressures and blasting time.

As a result, it is important to find an operating zone where the roughness of the quartz tube is maximized by the appropriate blasting time and pressure in order to maximize the roughness value of the quartz tube using the sandblasting method. In the present study, it was predicted that good results would be obtained when the blasting pressure of about 2.8 kg/cm$^2$ was applied for about 27 to 28 seconds.

In order to observe the shape of the surface roughness of the quartz plate, an SEM photograph of the specimen was observed and is shown in Fig. 2.

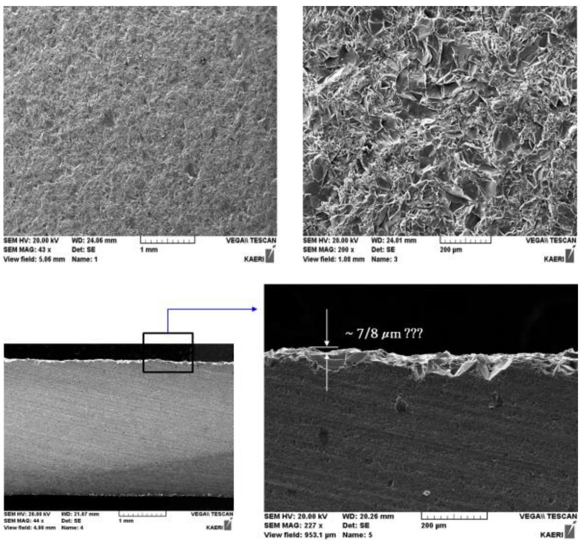


Fig. 2. SEM photographs of quartz plate after sandblasting work during 10 sec at 2.5 kg/cm$^2$.

Fig. 2 shows a specimen sandblasted for 10 seconds at an ejecting pressure of 2.5 kg/cm$^2$, showing how the entire surface was defected and how thick it was damaged in the thickness direction. It can be seen that the surface shape(roughness) is deformed to a fairly uniform extent over the entire surface, and the surface is worn to a depth of about 7-8㎛ on the original surface. The defected shape is irregularly unevenness. Therefore, when the slurry solution is brushed on the surface, the rough surface is expected to serve as an anchoring function to improve the adhesion of the slurry solution.

Fig. 3 shows the result of brushing the slurry solution using a quartz tube with sandblasting and without sandblasting. It can be indirectly confirmed that the brushing result of the slurry solution after surface deformation is much better than that of the left side, which is a smooth surface. In order to confirm the sandblasting effect, adhesion force analyses on both samples will be performed later.

Fig. 3. Slurry brushing photos of quartz tubes obtained after sandblasting (left: without sandblasting, right: with sandblasting).

## 4. Conclusions

In order to improve the slurry adhesion of quartz tube used in the process of manufacturing metal fuel rod, surface roughness was changed by sandblasting method. The average value of surface roughness did not increase with increasing work pressure or work time, but it showed a tendency to decrease after having maximum value. In this study, it was predicted that the appropriate pressure and time for the surface treatment of quartz tube would require a working time of about 2.8 kg/cm$^2$ and about 27 seconds. The results of the preliminary experiment with the brushing of the slurry solution using the specimens with surface roughening and the specimens with no working surface showed that the adhesion characteristics were improved to such an extent that they could be clearly distinguished.

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