An Investigation on Improving Dispersion Homogeneity of Large Particle U-Mo and Al powders by a Sieving Through Method

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1. Introduction

In KAERI a large U-Mo particle dispersion fuel has been under development due to a smaller specific interface area and more inter-particle space in connection with solving an interaction problem in high low enrichment U-density research reactor fuel [1]. Some of the above fuel specimens were irradiated in the KOMO-3 and the PIE results were revealed to be very promising [2]. However, it is very difficult to obtain a homogeneous dispersion of large particle U-Mo particles in the Al matrix of a fuel meat by some of the common blending methods. Previously more than 5 repetitive extrusions were used in order to obtain a homogeneous dispersion in fabricating fuel meats of the large U-Mo particles dispersions in the Al matrix for some irradiation tests. For auniform dispersion of large U-Mo particles, a regular arrangement of U-Mo large particles by placing the particles into the openings of asieve has been applied. An apparatus was designed and manufactured by implanting the above idea. Some experiments have been carried out. In this paper, the obtained results are described and discussed.

2. Experiments

As a basic concept of a regular arrangement of U-Mo large particles by placing the particles into the openings of a sieve screening net for homogeneous dispersion, a jig was designed and manufactured as shown in figure 1. The bottom of the sieve screening net was assembled with a moving plate for blocking the regularly situated U-Mo particles. The loaded powers were designed to be available for pressing and sintering under pressure. A proper quantity of U-Mo powder was loaded and spread the U-Mo particles on all of the sieve screen openings. An equivalent quantity of Al powder to U-Mo powder was charged over the U-Mo particles. A flat leveling work is then done with a blade. The U-Mo power and Al powder with a uniform layer are charged in to the container. This kind of charge was repeated until the purposed height was achieved. The container was closed with a plug and pressure-sintered for 4 hours at 480 C with about 440 kg/cm^2. After a sintering, the sample was cut into several pieces and then observed using an optical microscope. Some density measurements by immersion methods were done for examining the homogeneity.

Additionally the alternatively stacked powder of U-Mo and Al powders was pressured to compact and then hot-extruded to a rod like fuel meat. The rod was cut onto many pieces and a density measurement was done for the pieces in order to examine the homogeneity. Also an optical observation was made.

Fig. 1 A jig for dispersing U-Mo large particles

3. Results and Discussion

The stacked powder through a sieve appeared to be sintered soundly without no pores. The shell of the pressure-sintering jig was strongly bonded with the sintered material. Therefore the sample with the jig was cut into 9 pieces for 9 sample parts. An observation for particles dispersion was done as shown in Fig.5.

Fig. 6 represents a typical large U-Mo particle dispersion in the fuel meat fabricated by 5 extrusions in the KOMO-4. From the observation there is not much difference from the dispersion point of view for the two photos.

The results in Table 1 are density measurements for the 9 obtained parts. The variations of the 9 measured values are less than 6 %. The limit of the U-235 homogeneity for the fuel meat rod of the HANARO fuel is +/- 8.5 %. The dispersion degree of the mixed powder is considered to be acceptable. When the mixed powder is extruded, it is expected that the homogeneity of the extruded fuel meat rod would be improved.

The target volume fraction of the U-Mo powder for this dispersion experiment was 30 %. The average value of the measured densities for the sintered sample is 6.59 g/cc, which corresponds to 94.3% of the theoretical density. The density obtained by the pressure-sintering is considered to be acceptable for forming the fuel meat. The standard deviation was calculated to be 0.16 g/cc, which seems to be enough small.

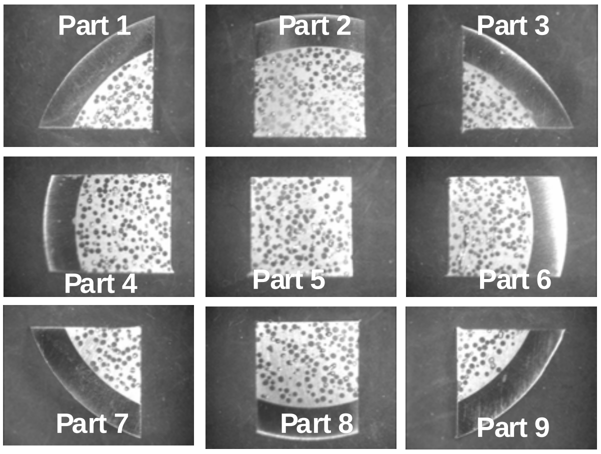

Fig. 5 Cross section of a pressure-sintered sample

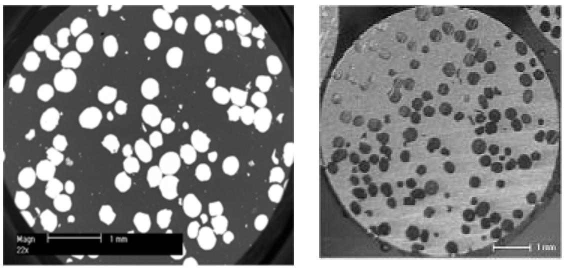

Fig. 6 Cross section of a fuel meat fabricated by 5 repeating extrusions

Table 1. Measured densities of the cut parts for pressure sintered sample.

Part	1	2	3	4	5	6	7	8	9
Density g/cc	**6.99**	6.42	6.55	6.49	6.69	6.42	6.59	6.57	6.56
Variation (%)	**+6.0**	-2.5	-0.6	-1.5	+1.6	-2.5	+ 0.04	-0.3	-0.4
Deviation g/cc	**+ 0.40**	-0.17	-0.04	-0.1	+0.1	- 0.17	0	-0.02	-0.03

Table 2. Measured densities of the cut pieces for an extruded rod

Piece	1	2	3	4	5	6	7	8
Density g/cc	6.65	6.75	6.63	6.76	6.77	6.87	6.74	6.95
Variation (%)	-2.8	-1.3	-3.1	-1.2	-1.0	+0.4	-1.5	+1.6
Piece	9	10	11	12	13	14	15	16
Density g/cc	6.65	6.95	6.94	6.49	7.31	6.89	7.10	6.93
Variation (%)	-2.8	+1.6	+1.5	-5.1	+6.9	+0.7	+3.8	+1.3

Additionally the alternatively repeated stacked powder was pressed to compact. The compact was hot-extruded to rod which is same dimension with the real fuel meat. The rod was cut to 18 pieces.

The measured densities for the pieces presented as shown in table 2. All densities ranged within the acceptable variation of +/- 8.5 %. Only one piece showed an exceeding value of +6.9%. This peaking phenomenon could be avoided by more precisely controlling the process conditions. The standard deviation was calculated to be 0.19 g/cc. The density range having 95% possibility would be from 6.456 to 7.2 g/cc. Accordingly this stacking method using sieve could be applicable. Fig. 7 is a typical observed micrograph for the cross-section of the extruded rod. The homogeneity of U-Mo particle dispersion seems to be almost same as that of the real fuel meat used for the irradiation test.

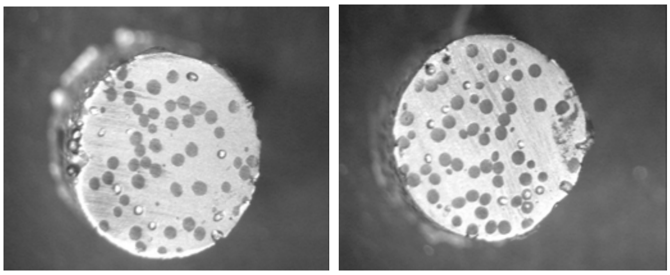

Fig. 7. Typical observed micrographs for the cross-section of the extruded rod

4. Conclusion

An apparatus was manufactured with a concept of a regular arrangement of U-Mo large particles by placing the particles into the openings of a sieve. The alternatively stacked powder was pressure-sintered successfully. The densities measured for 9 parts of the specimen were varied with less than 6 %. The average density was 6.59 g/cc, which corresponds to 94.3% of the theoretical density. The measured densities for the pieces of the hot-extruded rod appeared to be generally good within the acceptable variation of +/- 8.5 %. Only one piece showed an exceeding value of +6.9%. The standard deviation was calculated to be relatively small as 0.19 g/cc. The developed method is very simple in workability. The new dispersion fuel meat fabrication method by placing the particles into the openings of a sieve screening net would be favorable in obtaining a good dispersion from the viewpoint of a fabrication economy.

5. Reference

1. Y.S. Lee, et. al., RRFM 2005
2. J.M. Park, et. al., RRFM 2008
3. C.K. Kim. et. al., RERTR 1998