

FUEL FABRICATION OF U_3Si_2/Al AND R & D CURRENT STATUS OF RESEARCH REACTOR AT BATAN

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INTRODUCTION



- Fuel element production installation, are designed for the dispersion fuel plate-type production in the form of $\text{U}_3\text{O}_8/\text{Al}$ dan UAl_x/Al using low enrichment uranium ($< 20 \% {}^{235}\text{U}$).
- In 1987, BATAN began of $\text{U}_3\text{O}_8/\text{Al}$ fuel producing with $2,96 \text{ gU/cm}^3$ uranium density to meet of the RSG – GAS fuel needs.
- In 1996, ownership of fuel element production installation was transferred from BATAN to PT. INUKI (persero) which is a State-Owned Enterprises for commercial purposes, while R & D of fuel still being done by BATAN .
- R & D of $\text{U}_3\text{Si}_2/\text{Al}$ fuel began in 1989, and in 1997 the $\text{U}_3\text{Si}_2/\text{Al}$ fuel with $2,96 \text{ gU/cm}^3$ uranium density being produced by PT INUKI (persero) for RSG - GAS .

FABRICATION PROCESS of U_3Si_2 / Al FUEL PLATE TYPE

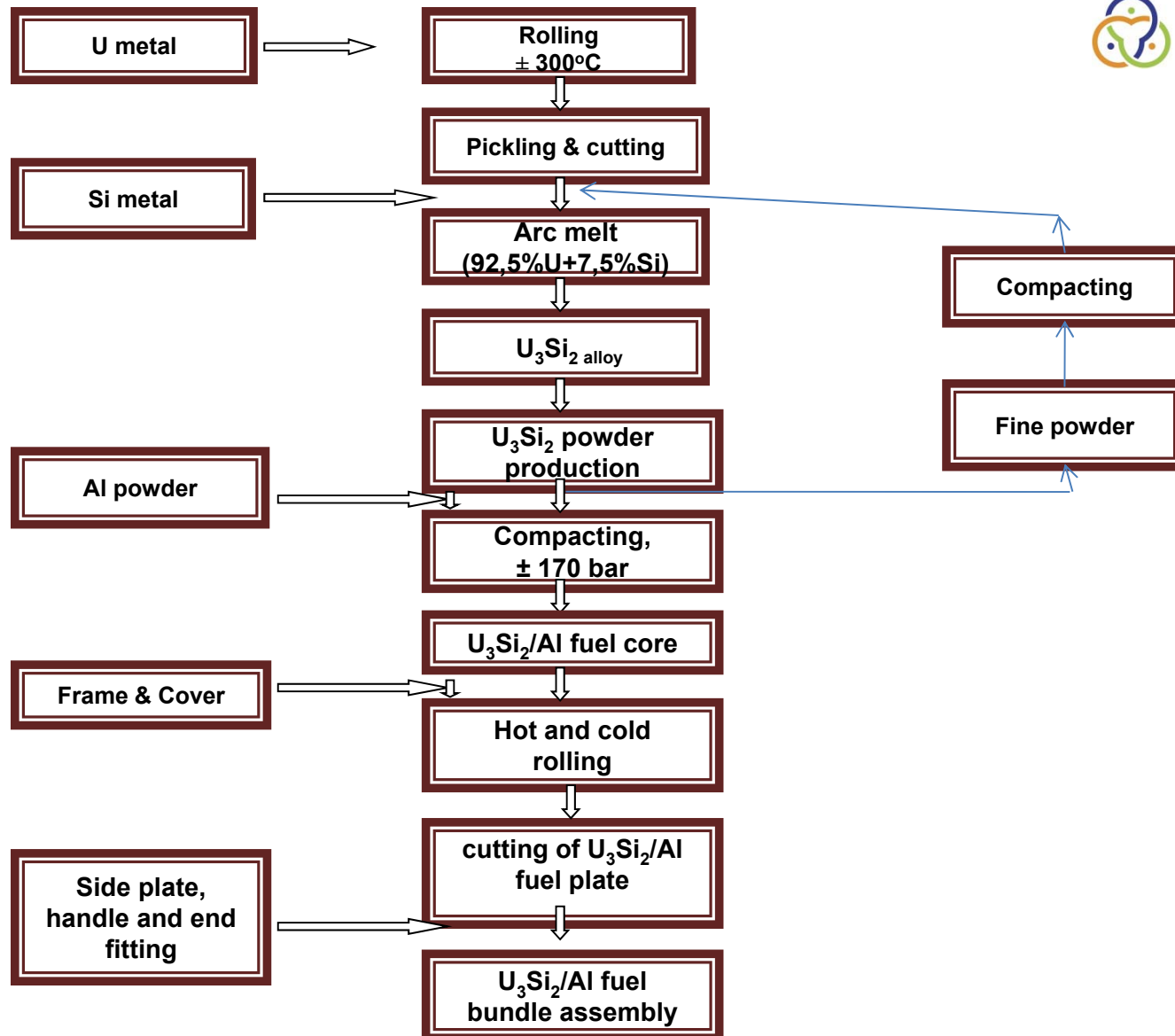




Fig. U metal



Fig. Si metal



Fig . Smelting process



Fig. U₃Si₂ ingot



Fig. Grinding mill process



Fig. U₃Si₂ powder

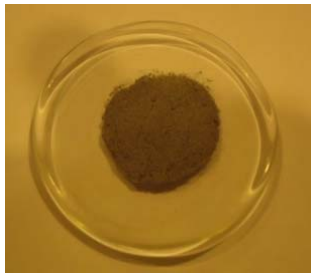


Fig. Al matrix powder



Fig. U_3Si_2 powder



Fig. Compacting process



dimensions of $100 \times 60 \times 3.15^{+0.05}$ mm



Fig. Fuel core of U_3Si_2/Al



Fig. Frame, cover and fuel core of U_3Si_2/Al



Fig. Composite assembly



Fig. Welding process



Fig. Weld plate

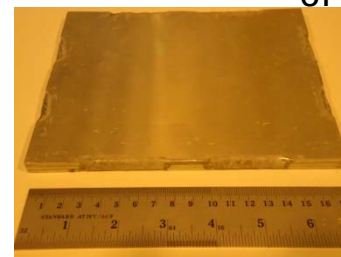




Fig. annealing process



Fig. hot rolling process



Fig. measuring



Fig. roll plate



dimensions of $625^{\pm 0,2} \times 70,75^{\pm 0,15} \times 1,3^{\pm 0,07}$ mm



Fig. fuel plate



Fig. $\text{U}_3\text{Si}_2/\text{Al}$ fuel element and control element

R & D OF RESEARCH REACTOR FUEL IS BEING DONE

1. R & D of U_3Si_2/Al fuel with $4,8 \text{ gU/cm}^3$ uranium density:

- **The samples test of U_3Si_2/Al fuel plate, with 4.8 gU/cm^3 uranium density and used 19.89 % ^{235}U enrichment uranium made according to the dimensions of RSG - GAS fuel plate. Fuel plate size $625^{\pm 0,2} \times 70,75^{\pm 0,15} \times 1,3^{\pm 0,07} \text{ mm}$ and meat about 570 min x 60,35 x 0,6 mm .**
- **The U_3Si_2/Al fuel with of 4.8 gU/cm^3 uranium density were irradiation tests up to 60% burn-up on RSG – GAS. NDT test results the performance of fuel is good .**

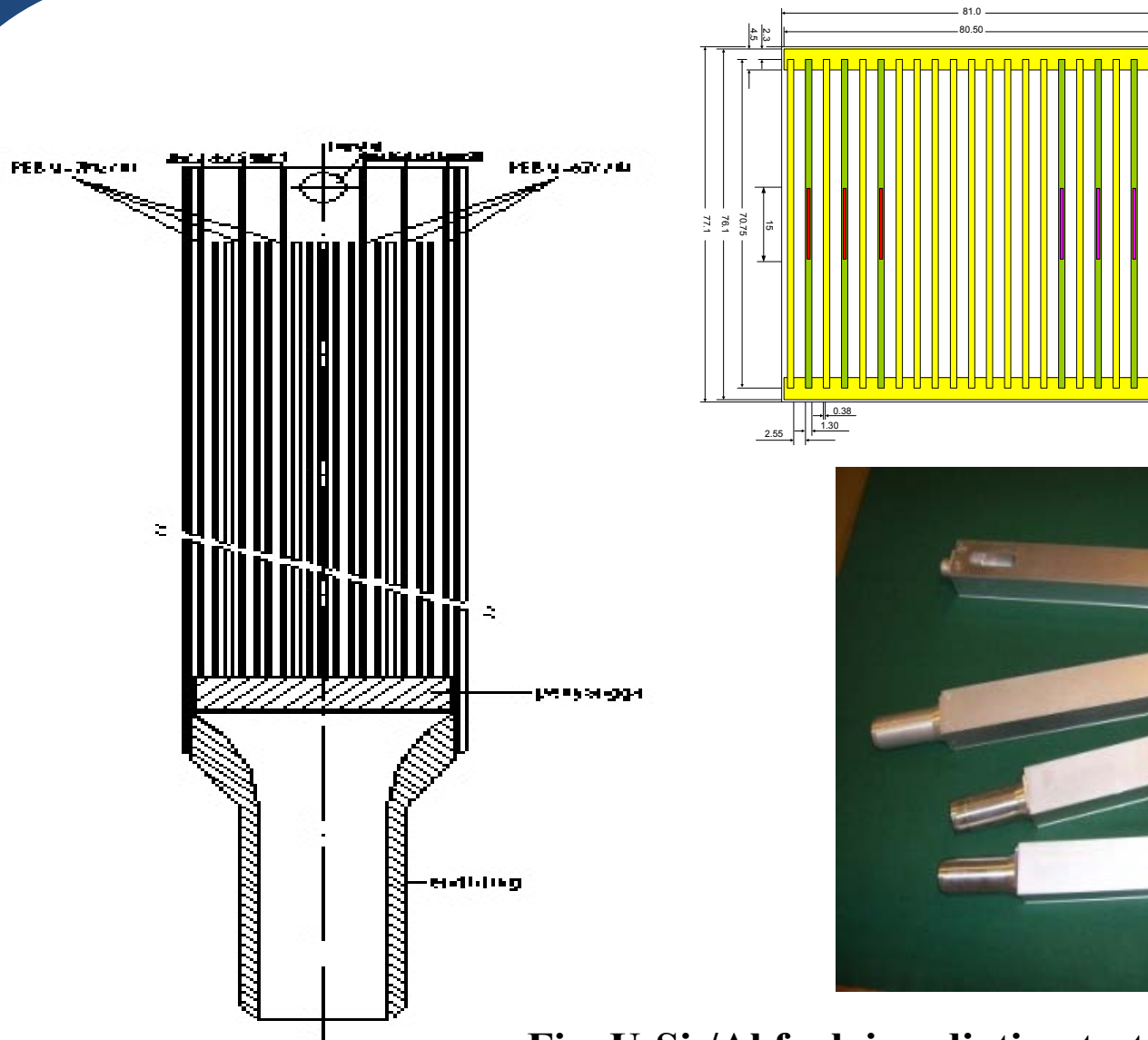


Fig. U_3Si_2/Al fuel irradiation test configuration (*stringer*)

2. R & D Dispersion Fuel Plate Base On U-Mo Alloys



- **R & D of U-Mo/Al, U-7Mo-xSi/Al, U-7Mo-xTi/Al and U-7Mo-xZr/Al dispersion fuel plate using depleted uranium with uranium densities up to 7.0 gU/cm³ has been carried out in BATAN**
- **Fabrication methods dispersion fuel of U-Mo based, similar to U₃Si₂/Al fuel. The difference in the process of making the powder. U-Mo alloys are very ductile so it can not be done directly by mechanical means, and selected by the method of hydride - dehydride - grinding mill .**
- **Dispersion fuel core based on U-Mo alloys, designed by size (25 x 15 x 3.15 ± 0.05) mm, and using a AlMg2 for cladding.**
- **Based on the data and the research experience, the designed and fuel plate fabricated with 7.0 gU/cm³ uranium density use 19.75%²³⁵U enrichment, and will to do irradiation testing at the RSG – GAS.**

U-7Mo powder

- Making of fuel plate U-7Mo/Al using powder fuel U-7Mo fuel powder from the hydride – dehydride – grinding mill process produces irregularly shaped powder particles.

U-7Mo/Al fuel core

- The powder of U-7Mo and Al matrix mixed are then compacted at a pressure of 20 bar to form a U-7Mo/Al slab with dimensions of 25 x 15 x 3.15^{±0,05} mm

Fuel plate of U-7Mo/Al

- AlMg2 plate with dimensions of 1000 x 170 x 6 mm thinned by cold rolling to obtain to thickness of 3.15 mm as frame and 2.68 mm as cover.
- Making of frame and cover was done by machinery, i.e. piece of frame with dimensions of 145 x 180 x 3.15 mm that have one hole (25 x 15 x 3.15 mm) and 2 pieces of cover with dimensions of 145 x 180 x 2.68 mm.

Fuel plate of U-7Mo/Al

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- **Some experimental manufacture of fuel plate with U-7Mo/Al, U-7Mo-xTi/Al and U-7Mo-xZr/Al alloy has been done to obtain fuel plate optimally.**
- **Research and development on manufacture of U-7Mo/Al fuel element plate using depleted uranium with a density of 7.0 gU/cm³ has been successfully conducted.**
- **Test data and parameters obtained are used as a base for the design of fuel plate of U-7Mo/Al using LEU with a uranium density 7.0 gU/cm³ and irradiation testing in RSG – GAS.**

Design of U-7Mo/Al Fuel Plates To Irradiation Test

- Dispersion fuel of U-7Mo/Al with a density of 7.0 gU/cm^3 using LEU (19,75% ^{235}U) designed in the form of plates with dimensions of $625 \pm 0.2 \times 70.75 \pm 0.15 \times 1.3 \pm 0.07 \text{ mm}$ and the U-7Mo/Al meat dimensions of $25 \times 15 \times 0.6 \text{ mm}$ in the upper position.

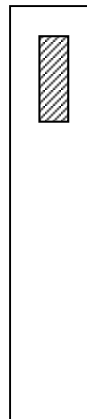


Fig. Design of U-7Mo/Al fuel plates

Design and manufacture of irradiation test facility (stringers)

- Three pieces of U-7Mo/Al fuel elements plates with a density of 7.0 gU/cm^3 and U-6Zr/Al planned for irradiation testing in RSG-GAS.
- Irradiation testing configuration of fuel elements is designed similar to RSG-GAS fuel consisting of 21 pieces of fuel plates.
- Irradiation test sample of U-7Mo/Al fuel plates with a density of 7.0 gU/cm^3 assembled into stringers by means of insertion in the grooves 2, 5 and 8, while U-6Zr/Al fuel plates with $5,2 \text{ gU/cm}^3$ are inserted in the grooves 14, 17 and 20.
- The other grooves will be mounted with 15 dummy plates and tied manually using rollers swag machine.
- Irradiation testing in RSG-GAS Serpong will be conducted early 2016.

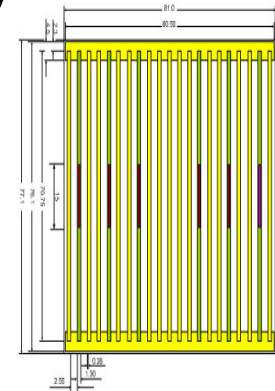


Fig. U-7Mo/Al and U-6Zr/Al irradiation test configuration (*stringer*)

THANKS YOU FOR THE ATTENTION

Tabel. Perhitungan komposisi serbuk bahan bakar U_3Si_2 dan matriks Al densitas uranium 5,20 gU/cm³



Bahan Bakar Dispersi : U_3Si_2/Al				
Dimensi Dan Volume IEB U_3Si_2/Al				
Panjang (mm):	Lebar (mm)	Tebal (mm)	Tirus-1dan 2 (mm)	Volume (cm³)
100	62	3,15	0,05	19,23
Data Hitung		Hasil Hitung		
Berat U^{235}	19,89 g	Berat U dalam U_3Si_2	100,00 g	
Perkayaan U-235	19,89 %	Berat U_3Si_2	108,47 g	
Kadar U dalam U_3Si_2	92,19 %	Volume U_3Si_2	8,89 cm³	
Berat Jenis U_3Si_2	12,20 g/cm³	Volume	1,76 cm³	
Fraksi (asumsi)	9,15 %	Volume matriks Al	8,58 cm³	
Berat Jenis matriks Al	2,7 g/cm³	Berat matriks Al	23,16 g	
		Berat bahan bakar + matriks Al	131,63 g	