# A MATERIAL DATABASE OF SS316L(N)-IG FOR ITER BLANKET SHIELD BLOCKS

[1]S.W. KIM, [1]J.Y. JEONG, [1]J.S. CHANG, [1]T.H. KWON and [2]D.H. KIM

[1]Institute of Korea Fusion Energy, Daejeon, Korea
[2]ITER Organization, Route de Vinon sur Verdon, France

Email: swkim12@kfe.re.kr

## 1. OBJECTIVE

The International Thermonuclear Experimental Reactor (ITER) is a large-scale fusion energy project to demonstrate the feasibility of nuclear fusion as a sustainable energy source. The Blanket Shield Block (BSB) is a critical component of the ITER configuration, designed to absorb high-energy neutrons and provide structural integrity under extreme operating conditions [1]. Austenitic stainless steel SS316L(N)-IG (ITER Grade) has been selected as the primary structural material for the BSB due to its excellent mechanical properties, radiation resistance and corrosion resistance [2]. Generally, SS316L(N)-IG is 316L grade steel with narrower tolerances for alloying elements ranges and controlled impurities. The closest analogy is X2CrNiMo17-12-2, a controlled nitrogen content austenitic stainless steel described in the RCC-MR Code, Edition 2007. Chemical composition to be determined by ladle (cast) and product analyses shall comply with the requirements given in Table 1. This study aims to establish a comprehensive database of the mechanical and physical properties of SS316L(N)-IG based on fabrication experience to ensure reliable assessment of material performance for applications.

Table 1 Required range of chemical compositions of SS316L(N)-IG (wt. %)

| Element | Alloying elements and impurities content, wt. %. | |
|---|---|---|
| | min | max |
| C | | 0.030 |
| Mn | 1.60 | 2.00 |
| Si | | 0.50 |
| P | | 0.025 |
| S | | 0.010 |
| Cr | 17.00 | 18.00 |
| Ni | 12.00 | 12.50 |
| Mo | 2.30 | 2.70 |
| N | 0.060 | 0.080 |
| Cu | | 0.30 |
| B | | 0.0010 |
| Ti | | 0.10 |
| Nb# | | 0.10 |
| Ta# | | 0.01 |
| Co# | | 0.05 |

## 2. FABRICATION

SS316L(N)-IG is produced through a controlled fabrication process which includes vacuum induction melting (VIM) and electroslag remelting (ESR) to ensure uniform microstructure and reduced impurity levels. The nitrogen-enhanced composition contributes to increase strength and stability under irradiation. Various fabrication processes such as forging, solution annealing and machining were employed to produce BSB raw material. The material has been verified to conform to the strict quality requirements for ITER through destructive/non-destructive testing (ultrasonic and liquid penetrant) and metallographic examination. Fig. 1 shows products in several main fabrication processes such as ESR ingot, die forging and machining.

Fig. 1 Fabrication of the SS316L(N)-IG on each step
a) ESR electrode, b) ESR ingot, c) die forging, d) forged ingot, e) machined block and f) NDE testing

## 3. MATERIALS DATABASE OF SS316L(N)-IG

The technical specification for BSB materials is based on the product procurement specification RM 3321 in RCC-MR 2007 for forgings plus additional requirements for the operational environments of the ITER blanket system. Ferrite content, magnetic permeability, grain size and non-metallic inclusions are reported as physical characteristics, whereas tensile strength (RT and 250C), 0.2% yield strength (RT and 250C) and elongation (RT) according to specified sampling and test methods are the reported as mechanical properties.

In this study, a comprehensive evaluation on mechanical and physical properties of the two hundred and twenty ESR forgings of SS316L(N)-IG was conducted to establish a database which would support design and engineering assessments. The materials database serves as a critical reference to ITER engineers and researchers for ensuring the reliable application of SS316L(N)-IG in the Blanket Shield Block. Furthermore, this study enhances the predictive capabilities on material performance under fusion reactor conditions through incorporating fabrication experiences and extensive property evaluations.

## 4. CONCLUSION

A materials database which shows only ±5% levels of a shift line from the trend curves, has been established from the procurement activities for the two hundred and twenty ESR forged blocks of SS316L(N)-IG for the ITER Blanket Shield Block, and it could be applied toward experimental and computational standards and to design data for materials in such a way efficient retry by humans or computer programs. It not only confirms the consistency of the fabricated materials, but the results can be used as design data for future fusion reactors like Compact Plasma Devices and DEMO.

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