Potential application of Laser Solid Forming Technology for fabrication of breeding blanket

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To solve the fabrication of breeding blanket with complex structure, LSF (Laser Solid Forming) as a novel technology is proposed. The fabrication process of U-shaped first wall (one of components in breeding blanket) by LSF was shown. To verify the feasibility of LSF being applied in fabrication of breeding blanket, experiments based on CLF-1 (one of Reduced Activation Ferritic/Martensitic (RAFM) steels) by LSF (which is assigned as LSFed CLF-1 in this paper) is performed. The preliminary results show that main chemical composition is almost not changed from forgings of CLF-1 to LSFed CLF-1. As-deposited LSFed CLF-1 has high tensile strength, anisotropy and low ductility. However LSFed CLF-1 after proper heat-treatment can achieve homogenized structure, fully martensite phase, better tensile strength (ultimate tensile strength is 848 MPa) and comparable ductility (elongation is 17.3%), which suggests the possibility that LSF can be applied in fabrication of breeding blanket.

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1. Introduction

Breeding blanket (BB) as an important component of fusion reactor is designed to ensure tritium self-sufficiency and fusion power conversion. In recent years some welding technologies such as HIP and EB, have been applied in fabrication of BB components with complex structure [1–5]. During conventional fabrication process it is hardly to avoid the occur of welding joints which induce difficulty in non-destructive inspection.

Here Laser Solid Forming (LSF) as one kind of solid-freeform-fabrication technology without welding joints is introduced. LSF combining the laser cladding with rapid prototyping technique can achieve high performance and fully dense metal parts in any geometry, such as near net shape. LSF has been applied in fabrication of key components of Chinese aircraft, which is due to its so many advantages [6]:

1. Flexibility: LSF has high manufacturing flexibility because no mold is needed in the forming process and all the design is performed on the computer.

2. Efficiency: The production process is simplified and only three steps are needed: computer design, Laser Solid Forming and post treatment. So the production cycle from design to fabrication is short.

3. Economics: In the near-net-shape process, pre-alloyed powders with the required compositions as the deposited materials is fed into a molten pool sharply along the computer based path and much material can be saved which reduce the processing costs to a large extent.

Considering the advantages of LSF and its successful application in Chinese aviation, it is proposed as a candidate fabrication technology for breeding blanket in China future fusion reactor.

It is known that Reduced Activation Ferritic/Martensitic (RAFM) shall be candidate structural materials for fusion reactor due to its good performance at high temperature and under neutron irradiation damage of 100 dpa [7]. Therefore to verify the feasibility of LSF applied in the fabrication of breeding blanket, mechanical properties of LSFed RAFM (RAFM after LSF process) is very important. The present work is just focused on the mechanical properties of LSFed RAFM at room temperature, as a start of a serious of studies on application of LSF in fabrication of BB components.

2. LSF fabrication process design

The process flow chart for fabrication of BB components by LSF is designed to consist of four steps as shown in Fig. 1.