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LOW-COST MANUFACTURING TECHNOLOGIES OF COMMERCIAL LIQUID ROCKET ENGINE (LRE) AND RAPID IMPLEMENTATION OF HOT-FIRE TEST SYSTEM FOR THE CHINESE FIRST METHA-LOX LRE DEVELOPMENT

Abstract

Developing Liquid Rocket Engines (LREs) in a commercial manner inevitably requires low-cost, high-efficiency and high-quality manufacturing and frequent hot-fire test capabilities. A China's privately-owned launch vehicle enterprise, has developed the Chinese First private LRE Hot-fire test bench and carried out a number of attempts on manufacturing technologies in the process of liquid Metha-LOX engine development.

This paper proposes two variations of laser-welding technology for reducing the manufacturing costs in the launch vehicle industry. Critical process RD was accomplished by means of computational simulations on structural welding and scale tests. The feasibility and reliability were verified by engine hot-fires. Laser-welding assisted by optical visual positioning compensation and online programmable robotic technologies was implemented to replace the conventional welding options for large-size nozzles. Meanwhile, hybrid welding-brazing with the heat source of laser achieved reliable joins between copper and nickel, which enlarged the existing tool kit of liquid rocket engines' thrust chamber manufacturing.

As the well-known prerequisite of prompt iteration and optimization on the design for rocket engines, highly efficient construction and operation of the test facility has been constantly proceeded by the company. By taking the advantage of managing projects in parallel and temporary hot-fire supporting system, the 100-ton thrust-level engine had successfully been tested with no delay of the entire test facility acceptance examination after 18 months since the construction commencement. Additionally, as the entire system is based on a modular design concept, the preparation duration on the facility prior to the engine hot-fire also gets cut down to 1 to 3 days including tanking liquid -methane at the purity of 94 percent the lowest. This relatively low requirement of methane purity, technically allowed by propellant-compatibility consideration during design phase, significantly reduces the cost per test, and which is proven exits subtle differences on the performance compared to higher ones.

As a result, , over 2000s components' and 15-time entire engine hot fires in total leads to the fact that the Chinese private commercial launcher sector has finalized the design and is capable of starting mass production of two types of Metha-LOX engines, 80-ton thrust level and 8-ton thrust level respectively,

within 2 years from scratch. Meanwhile, China's first 100-ton thrust level private LRE hot-fire test bench with three different stations was completed.