Development of Laser Clad Welded Valve Seat

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ABSTRACT

Laser clad welded valve seats can expand the flexibility of layout compared to conventional press fit valve seats. The slot form, the shape and amount of the powder to be supplied, and the laser output parameters were optimized and balanced, quality assurance requirements were established, and the valve diameter was expanded by 1 mm. This achieved an increase in engine power of 6 kW at high water temperatures. In addition, the continuous use of one engine over the distance for two Formula One race events was supported by enhancing the powder materials.

1. Introduction

The valve seat (hereafter, "seat") pressed fit require sufficient wall thickness around the seat press fitting area of the cylinder head (hereafter, "head"), and also stiffness of annular rigidity of the seat itself. For this reason, the flexibility of the combustion chamber layout, including the valve diameter, valve pitch, and port angle, was limited. In addition, the area between the seat and the head is crimped, so heat transfer is insufficient between the valve, seat and head. This development realized a large diameter valve layout by establishing laser clad welded seat technology that forms the seat directly on the head, and also aimed to reduce weight by reducing the head wall thickness and increase engine power by enhancing cooling performance.

Figure 1 shows the press fit seat port section, and Fig. 2 shows the laser clad welded seat port section. Laser clad welding enabled a thinner water passage wall thickness.

Fig. 1 Layout of press fit valve seat

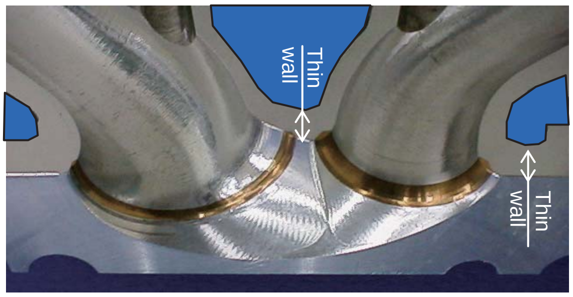

Fig. 2 Layout of laser clad welded valve seat

2. Establishment of Laser Clad Welded Seat Technology and Quality Assurance

The form of the slot used to clad the powder, the diameter of the powder to be supplied, the manufacturing conditions for welding the powder, and the quality requirements were set.

2.1. Laser Clad Slot Form

Figure 3 shows the laser clad slot form. The powder is collected in the center in a symmetrical form. When the clad thickness differs at the center and both edges of the slot, the welding time also differs. This may result in non-welds at the bottom of the slot, so the slot bottom form was an arc and the slot walls formed an obtuse angle. In addition, excess powder may likewise produce a difference in thickness, so the slot height was set at 4 mm to prevent unnecessary powder from collecting.

2.2. Powder Supplied for Laser Clad Welding

A copper alloy in the form of a spherical powder with a diameter of 80 ±5 μm was used as the clad powder. The powder was supplied using a vibration powder feeder, and supply was controlled at an accuracy

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of 0.005 g/s. This enabled the manufacture of homogeneous laser clad welded seats.

To support the continuous use of one engine over the distance for two Formula One race events, seat wear resistance was enhanced by mixing stellite and tribaloy powder into the copper alloy powder. Figure 4 shows the transition in the development specifications. Efforts were made to simultaneously achieve wear resistance and fracture toughness in accordance with changes in the valve train system specifications.

2.3. Laser Clad Welding Conditions

The welding process is an important process for the laser clad, and is controlled by the laser output and the amount of powder. In particular, the start point overlaps with end point, so start area of laser clad form must be inclined. Therefore, cladding start point was performed by gradually increasing the amount of powder according to the form, and increasing the laser output power in steps. Figure 5 shows this image drawing.

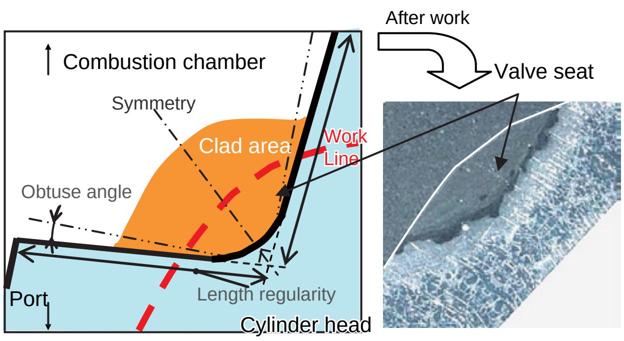

Fig. 3 Laser clad welding slot form

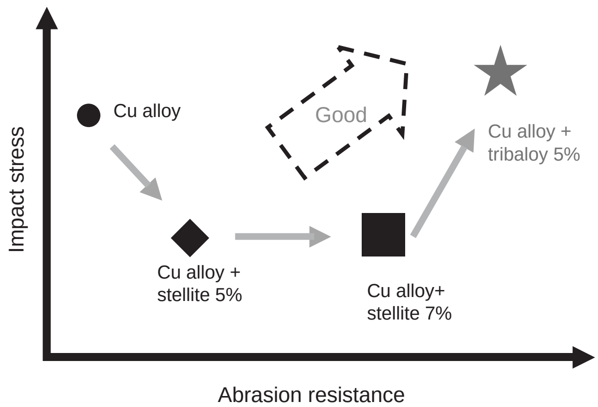

Fig. 4 Valve seat development corresponding to higher loads

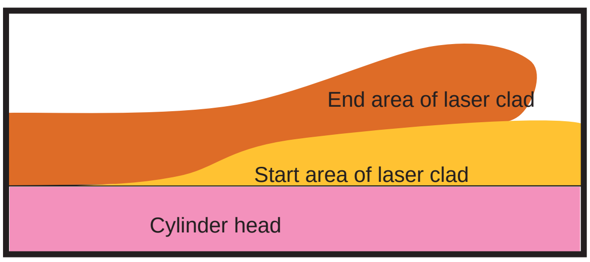

Fig. 5 Start and end form of laser clad

2.4. Quality Assurance of Laser Clad Welded Seats

Low quality in the start area may result in seat defects and lead to engine blowout or reduced engine power.

Non-welds can result from an excess powder amount or insufficient laser output, and brittleness can result from an insufficient powder amount or excessive laser output. Figure 6 shows examples of these cases. Non-weld and embrittlement layer limit standards of quality were prepared by analyzing the materials of seats in which defects actually occurred.

Limit standards were judged by analyzing the cutting planes of lot samples. The non-weld limit standard was no pinholes of diameter ø0.3 mm or more, and the embrittlement layer limit standard was no embrittlement 0.4 mm or thicker as obtained by measuring the hardness of the start area at the two points 1 mm and 4 mm from the start point. Figure 7 shows the limit standard of quality.

Fig. 6 Limit quality examples

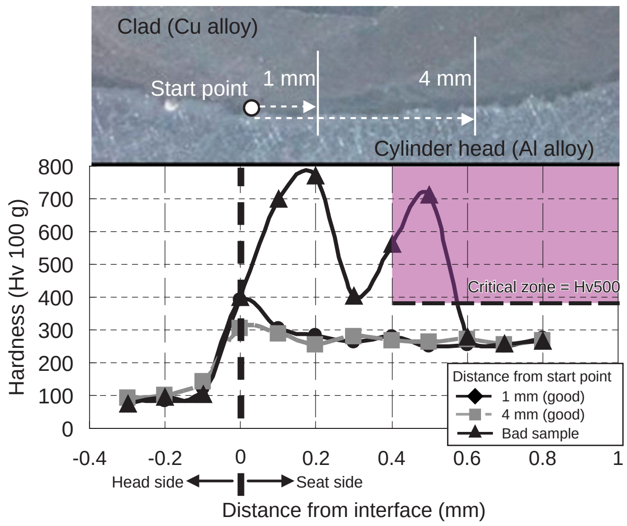

Fig. 7 Quality standard for dilution brittleness

3. Results

Laser clad welded seat technology increased the flexibility of the layout around the valve seat, enabled expansion of the valve diameter by 1 mm, and achieved a 6 kW increase in the engine power at a high water temperature of 120°C.

4. Conclusion

Laser clad welded valve seat manufacturing technology was established and applied to Formula One races from 2004. Hard particle powder was added and quality standards were established, which helped achieve the durability and reliability required to support the continuous use of one engine over the distance for two Formula One race events.

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