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Influence of Substrate Surface States on Interface Bonding Quality for Bonding Joints Manufactured by hot-compression bonding

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Abstract: The hot-compression bonding process is a new technology used to manufacture heavy forgings which can avoid the size effect caused by the traditional casting process. In this new technology, the surface state of substrates is a key factor to guarantee the quality of bonding joints. At present, the influence of different surface states on the quality of interface bonding is uncertain. Therefore, the effect of surface state on the bonding quality of interface was studied in this paper for the first time. Different methods were used to composite characterize the surface state. Furthermore, the microscopic morphology was used to analyze the quality of interface bonding. The influence of the surface state on interface bonding quality was obtained by analyzing the relationship between the surface state and interface bonding quality. The results suggest that a clean surface state can greatly improve the bonding quality of bonding joints. This study is beneficial to guarantee the interface bonding quality of the substrate and is of great significance to further improve the quality of the joint.

Keywords: Substrate Surface States; Bonding Quality; hot-compression bonding

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Outlines:

1. Background

2. Research object

3. Experimental procedure

4. Results and discussion

5. Conclusions

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Background

- **Heavy forgings are widely used as the key components in some major equipment.**
- **Heavy forgings are usually made from cast ingots by subtractive processing and forging processing in traditional processing methods, and some problems will arise with following this manufacturing route.**
- **Sun et al. proposed a method for manufacturing high-quality heavy forgings based on hot-compression bonding.**
- **The present studies mainly focus on interfacial bonding mechanisms and surface oxide scale evolution mechanisms, the influence of surface states on the quality of interface bonding is uncertain.**

Research object

- To establish a new composite characterization method to characterize the surface cleanliness of the substrate.
- Use different methods to judge the bonding conditions of the interface.
- To established the relationship and degree of influence between surface state and interface bonding state.

Experimental procedure

- ***Substrates preparation***
  - **316H stainless steel with dimensions of 90×90×70 mm were fabricated by a milling machine.**
  - **Put the substrate into the ultrasonic cleaning machine, and cleaned the substrate for 15 minutes within anhydrous ethanol solution.**
- ***Hot-compression bonding***
  - **Hot-compression bonding process.(Vacuum packaging, Vacuum heating, Forging, Heat treating)**
- ***Specimens preparation***
  - **Preparation of cross-section specimens and tensile specimens**

Results and discussion--- Surface cleanliness

Different cleanliness characterization methods were adopted in the composite characterization method according to the type of contaminant. (Mainly include optical observation and water contact angles.)

- **Water contact angles**

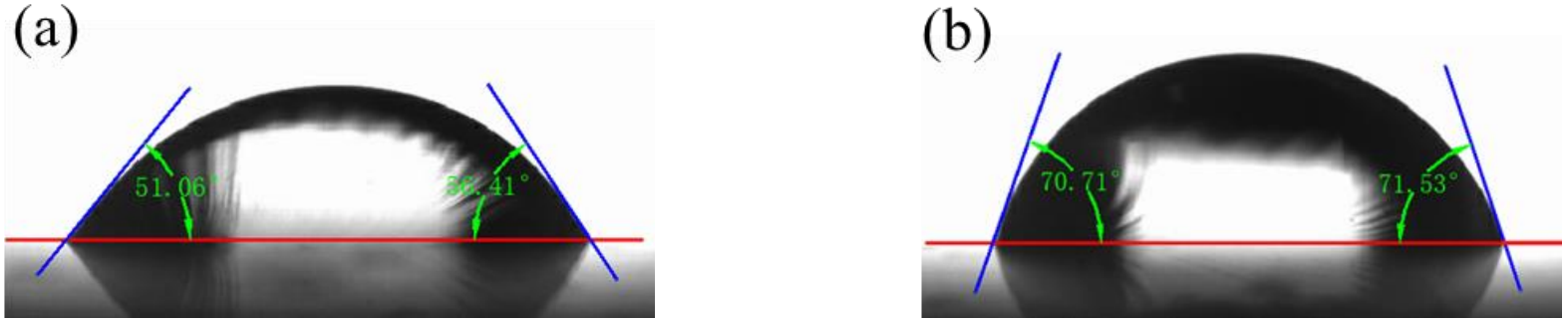

Fig. 1 Water contact angle obtained from (a) the uncleaned substrate surface and (b) the cleaned substrate surface

- **Water contact angles can more accurately characterize surface cleanliness in terms of oil contaminants**

Results and discussion--- Surface cleanliness

➢ Microscopic morphology

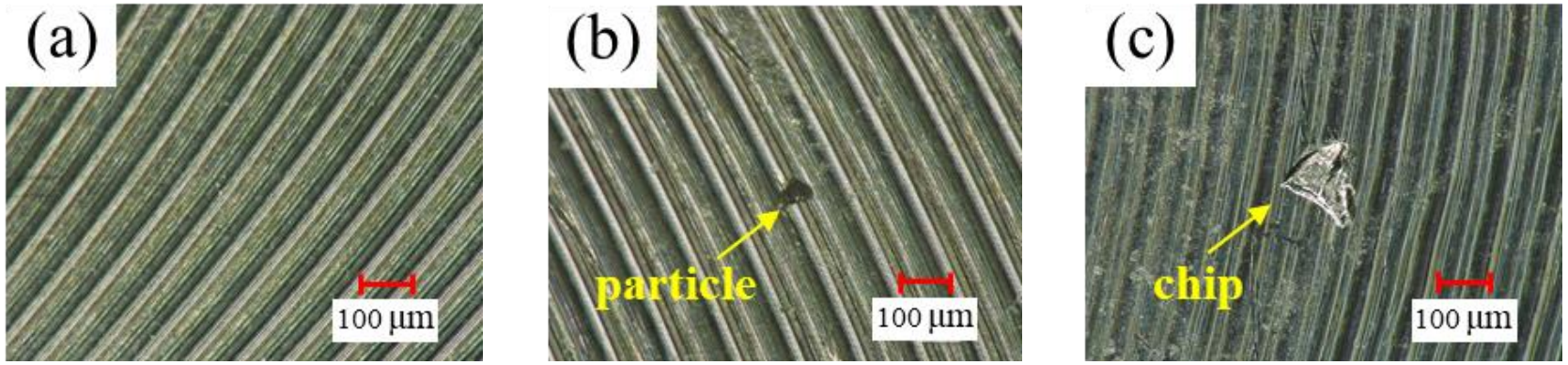

Fig. 2 Microscopic morphology of (a) cleaned substrate and (b),(c) uncleaned substrate surface

- **Microscopic morphology can effectively characterize surface cleanliness in terms of visible contaminants**

The composite characterization method indicates that the cleaned substrate surface possesses better cleanliness than the uncleaned substrate surface.

Results and discussion--- Bonding performance

The bonding performance of bonded samples mainly represented by cross-section morphology.

- **Cross-section morphology.**

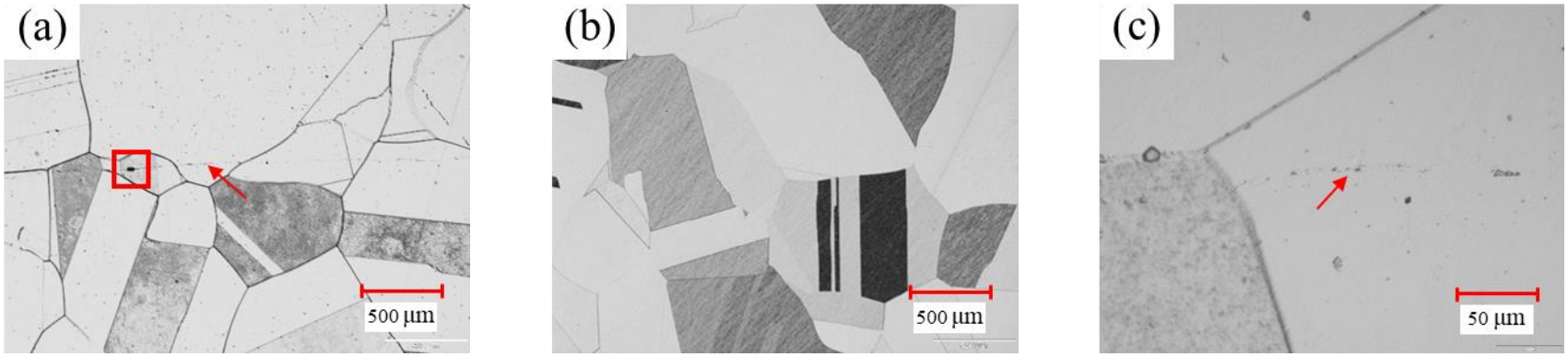

Fig. 3 Images of cross-section got from bonding joints manufacturing by (a) uncleaned substrates (5X) (b) cleaned substrates (5X) and (c) cleaned substrates (50X)

The cleaned substrate is more conducive to the bonding of the interface, and to obtain a nearly perfect bonding state. On the contrary, the uncleaned substrate is faced with the obstruction effect brought by contaminants in the interface bonding process, resulting in poor interface bonding performance.

Results and Discussion

Discussion

- The cleaned substrate is supposed to bring a perfect bonding state, however, the interface is still found.
- The water contact angle which got from the cleaned substrate surface is bigger than that got from the uncleaned substrate surface, this conflicts with our conventional perceptions.

Conclusions

- Surface cleaning has a great influence on the bonding performance manufactured by hot-compression bonding.
- A new method for evaluating the surface cleanliness of substrate surfaces was proposed, and experimental results show that the characterization method is effective

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