Automobile structure, Gas turbine, Mold

Microstructural control of a joint by linear friction welding and its application

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Researchmap https://researchmap.jp/read0051741?lang=en

Abstract

We established "Perfect welding technology" which enables continuous welding of metal materials as if without joint part. Regarding solid phase welding of heating up on pressing of material to be welded, we succeed in controlling of welding temperature by welding pressure, due to the invention of unexpected welding principle i.e. "Application of high welding pressure causes descend of welding temperature". In existing welding method, the joint part became the singular element of structure. Therefore, the property of metal material structure could not be made full use of the metal material. However, in "Pressure Control Linear Friction Welding" joint parts can be regarded same as the base material. For example, as for titanium alloy and steel, reliability of the joint part can be secured by non-transformation welding, and as for aluminum alloy, softening of heat affected zone can be suppressed completely.

Background & Results

Welding technology is indispensable for manufacturing metal structure, therefore various kinds of welding methods have been developed. However, in case of titanium alloy and steel, it is very difficult to obtain the welded body which shows the property of base material in full scale, due to the embrittlement of the joint part caused by phase transformation. In case of aluminum alloy, it is very difficult to control softening of the joint part caused by temperature increase in welding. Even in solid phase welding such as Friction Stir Welding (FSW) without melting material, it is necessary to decide structure design considering strength of the joint part. To solve these problems, we studied how to decrease welding temperature by focusing on Linear Friction Welding (LFW). It is revealed that welding temperature increases by applying lower pressure and high pressure led to low welding temperature. This is due to the principle that welded interface is deformed at lower temperature by applying higher pressure. By utilizing this principle, welding temperature can be controlled accurately. For example, aluminum alloy was welded at 200℃, and the joint part showed completely same hardness as base material. Thus, the joint part is no longer the singular element, we can consider the joint part same as the base material. As a result, ideal welding structures utilizing and keeping the original property of base materials can be realized.

Significance of the research and Future perspective

By utilizing this research result, considering of decrease in strength and reliability in joint parts become unnecessary. Superior welding structure that shows original property of titanium alloy, steel and aluminum alloy which is strengthened by various method can be obtained. Moreover, this welding method can be applied not only for manufacturing of metal structure but also utilized as partial reinforcement and repair technology. It would contribute the conversion from "conventional manufacturing method which deletes material by cutting" to "new manufacturing method which adds requisite minimum material". Additive manufacturing which can build up metal material in any desired shape and size will be realized.

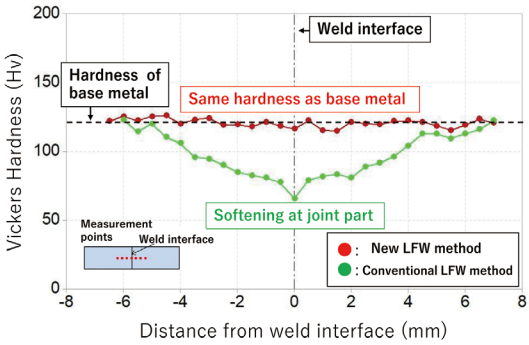

Fig. Hardness distribution of Al6061-T6 joints
Formation of softening region can be completely suppressed by new LFW method.

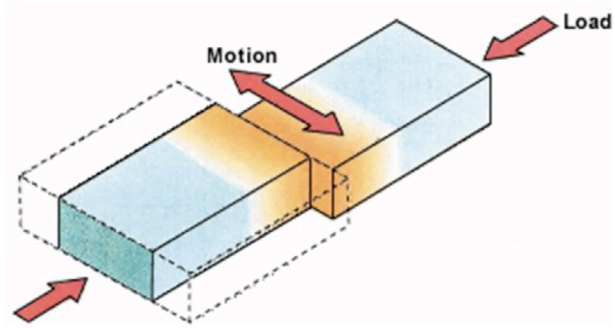

Fig. Schematic drawing of LFW
In linear friction welding, a softened flash is discharged from a welding interface to form a new surface to accomplish the welding.

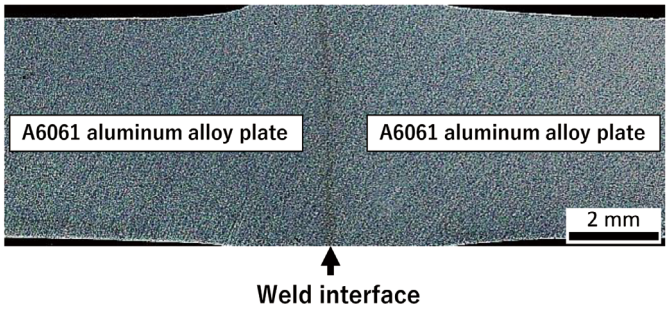

Fig. Cross sectional image of A6061/A6061 weld interface
Very thin weld interface is formed between two aluminum plates.

Patent Japanese Patent No. 6819959, Japanese Patent No. 6819958, Japanese Patent No. 6796839, Japanese Patent Application No. 2022-138404
Treatise Jeong-Won, Choi; Aoki, Yasuhiro; Ushioda, Kohsaku et al. Linear friction welding of Ti-6Al-4V alloy fabricated below β-phase transformation temperature. Scripta Materialia. Volume 191, p. 12-16, doi: 10.1016/j.scriptamat.2020.09.013
URL http://www.jwri.osaka-u.ac.jp/~jthub/
Keyword linear friction welding, microstructural control, welding temperature, hardness distribution