論文 / 著書情報
Article / Book Information

題目(和文)	Al/Fe電磁圧接材の接合界面形態および中間層形成に及ぼす接合パラメーターの影響
Title(English)	Effect of welding parameters on interface morphology and intermediate layer formation in magnetic pulse welded Al/Fe joint
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	材料 系 材料 コース	申請学位（専攻分野）： Academic Degree Requested	博士 (工学) Doctor of
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis is composed of the following six chapters.

In chapter 1 entitled "Status of dissimilar metal bonding and characteristics and significance of magnetic pulse welding", the significance and background of dissimilar metal joining, as well as the characteristics and welding principles of MPW were described. Previous researched on impact welding about the effect of welding parameters of collision angle β and impact velocity v on the joint interface were reviewed. The purpose of this research and the structure of this thesis were also described.

In chapter 2 entitled "Joint interface morphology and composition of intermediate layer in magnetic pulse welded Al/Fe joint", magnetic pulse welded joints of 1050-O/SPCC were fabricated under different welding conditions to obtain joint with various interfacial morphology. Tensile shear tests were conducted to verify the bonding strength. Microstructure observation and EDS composition analysis were carried on the joint interface to characterize the feature of the interface. During the welding collision process between the flyer plate and parent plate in MPW, β and v are inconstant due to that β gradually increases due to the geometric relation during the collision process between flyer plate and coil, while v gradually decreases due to the energy dissipation. This dynamic feature of β and v in MPW resulted in a various morphology for the joint interface accompanied by different types of IML along the welding direction. For Al/Fe joint, the morphologies of joint interface were classified into four types based on the IML formation status. Interface I was accompanied by a thick continuous Al-rich IML. Interface II contains two separate IML of TSL and FSL. The IML at Interface III was characterized by an Al-rich porous structure. Interface IV shows almost no IML and the Al and Fe were directly bonded. The tensile shear test results revealed that the bonding strength of Interface II and IV generally had a higher bonding strength than I and III at the same unit weld width.

In chapter 3 entitled "Wavy interface formation and local melting phenomena at the magnetic pulse welded Al/Fe joint interface", Emag-Mechanical model was used to reproduce the electromagnetic field and the collision process between the flyer plate and the parent plate and calculate β and v. SPH model was carried out to investigate the formation process of the wavy interface, temperature change, and melting point change during collision at the joint interface of Al/Fe magnetic pulse welding materials. With the formation of the wavy interface, a rapid temperature rise occurred in the vicinity of the interface. At the collision point, the melting point increased as the pressure increased, but the duration only last for several microseconds. A local melting phenomenon may occur at the location where the temperature exceeds the melting point. In LMZ obtained from the SPH model, Al and Fe particles were mixed, and the shape of

LMZ was in good agreement with the shape of IML observed at the joint interface. This suggests that IML at the joint interface was formed mainly by rapid solidification of LMZ where the molten Al and Fe was generated and mixed at the interface during the collision.

In chapter 4 entitled “Cooling and Intermediate Layer Formation Process at the Magnetic Pulse Welded Al/Fe Joint Interface”, the formation process of IML and cooling process at the magnetic pulse welded Al/Fe joint interface after the collision process were reproduced by LF model. Right after the formation of the wavy interface, there is a large temperature difference between the vicinity the joint interface and the base metal away from the interface. This resulted in a large temperature gradient between the interface and the base metal, which caused rapid heat removal. The time history of temperature in LMZ and base metal 20 μm away from the interface shows that the cooling rate near the interface is on the order of 10^7~10^9 K/s, while the base metal remains almost unchanged at room temperature. The solidification of LMZ proceeded from the outside to the center of LMZ and completed in about several microseconds. The final solidification area of IML was the center of LMZ. Therefore, it is considered that the voids observed in the center of IML are formed due to the solidification shrinkage that occurred in the final solidification area. By analyzing the temperature change history at the joint interface during and after the MPW collision process, a plausible explanation for the formation of IML at the Al/Fe interface is provided.

In chapter 5 entitled “Effect of collision angle and impact velocity on magnetic pulse welding behavior and joint interface”, the effect of β and v on magnetic pulse welded Al/Fe joint interface was examined. A new method was designed that allow the MPW experiment to perform at different β and constant v by a grooved mold. The effect of v was examined by simulation at different v and constant β. The emission behavior of metal was investigated in the follow subjects: critical condition for emitting metal jet, pressure and temperature of metal jet, amount and component of metal jet. For the joint interface with a wavy shape, β has more effect on the mean wavelength while v has more effect on the mean wave height. The temperature rise at the joint interface is caused by the compression and the plastic deformation near the collision point. Both the amount of LMZ formed at the joint interface and the cooling rate of LMZ decrease as β increases, while increase as v increases. A weldability window for Al/Fe magnetic pulse welding was proposed based on theoretical calculation and the results of simulation and experiment. The weldability window obtained in this study can be used as an empirical tool to select the appropriate welding conditions to obtain good weld products.

In chapter 6 entitled “General summary and conclusions”, the results obtained in each chapter were summarized and the conclusions were given.