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«The influence of the Friction Stir Welding process on the non-heat-hardenable aluminum alloy AA5056 structure formation depending on the sheet workpiece rolling direction»

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Problem statement

- Friction stir welding is one of the main processes for producing welded joints of various metals and alloys used in automotive, aircraft and rocket-space industries. This is because the method has a high welding productivity of both thin plates of light-weight alloys such as aluminum and titanium ones, and large-size thick-walled workpieces. This results in a faster and more efficient manufacturing process.
- A key feature of the friction stir welding method is the process temperature. Material joining is carried out at temperatures around 0.6-0.8 from the melting point, so the process occurs in the solid phase, which makes it possible to weld materials that are difficult to weld using conventional methods.
- Despite the wide range of advantages, this welding process has not yet been sufficiently studied: there are certain issues with understanding the mechanisms of joining materials during FSW. One of such issues is the influence of the sheet workpiece rolling direction on the structure and mechanical properties of welded joints, and, consequently, the process of selecting welding parameters for technological applications.
- In this regard, the present work is devoted to the study of the influence of the FSW process on the formation of the aluminum alloy AA5056 structure depending on the rolling direction of the workpiece.

Solution methods

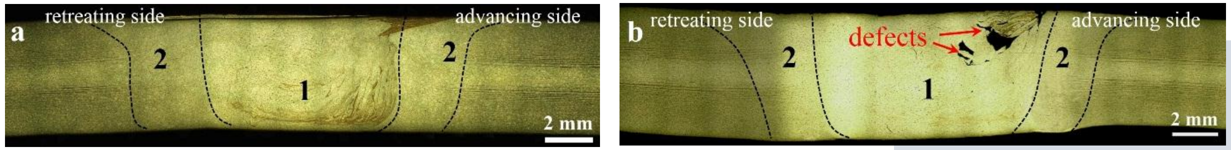
- The friction stir welding were carried out on 5-mm-thick sheets cut along (RD, rolling direction) and across (TD, transverse direction) the rolling direction to study its influence on the selection of FSW-process parameters and mechanical properties of products
- Samples were produced using the modes presented in Table.
- After producing experimental samples of welded joints, mechanical tensile testing was performed on the universal testing machine UTS-110M. The microstructure of FSW-joints was studied using the Altami MET 1C optical microscope

The friction stir welding modes for aluminum alloy AA5056 workpieces with thickness of 5 mm

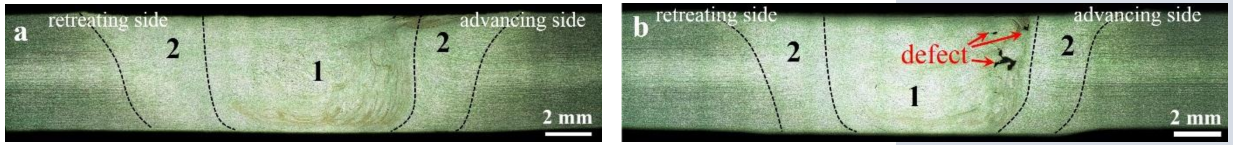
Parameter\№	01	02	03	04	05	06	07	08	09	10	11	12	13	14
P, kg	2200	3000	2600	2800	2700	2800	2900	2600	2900	2800	2400	2950	2850	2900
V, mm/min	600	600	400	500	500	600	450	450	450	450	350	550	450	500
ω, rpm	550	550	500	500	600	650	400	650	550	550	550	550	550	550

Conclusions

As a result of the study it was found that the workpieces of AA5056 alloy with the thickness of 5 mm during welding in different directions relative to the rolling direction are characterized by a wide range of the FSW process parameters adjustment. The conducted research tests allowed to establish these ranges for the workpieces depending on the welding direction in relation to the primary sheet rolled metal. The results show that welded joints with the ultimate tensile strength of 0.9 and above from the base metal can be produced in a wide range of parameters with consistently high strength, sufficiently homogeneous deformation and fracture under tension. However, some modes might lead to the formation of discontinuities and other defects in the stir zone, which is mainly due to a lack of loading force on the tool. At the same time, such modes are generally identical for different welding directions. With regard to the influence of the rolling direction on mechanical properties, the joints produced across the rolling direction allow to obtain the ultimate tensile strength higher than that of the base metal, while this is impossible when welding along the direction of rolling.



- Macrostructure of the sample of the welded joint made of 5-mm-thick AA5056 alloy sheet, produced by the FSW along the rolling direction according to the mode № 04 (a), № 01 (b).



- Macrostructure of the sample of the welded joint made of 5-mm-thick AA5056 alloy sheet, produced by the FSW across the rolling direction according to the mode № 14 (a), № 01 (b).

- 1 - Stir zone, 2 - Thermomechanically affected zone

The ultimate tensile strength of AA5056 welded joints, MPa.

Mode	RD	TD	Base metal RD	Base metal TD
01	160.15±3.44	202.95±27.36		
02	323.38±1.39	294.34±58.81		
03	323.55±1.56	329.42±0.25		
04	323.51±0.68	329.42±1.10		
05	285.78±63.34	254.52±121.97		
06	250.35±67.86	293.84±46.65		
07	323.13±0.35	328.16±1.32	327.85±1.59	318.65±3.61
08	319.35±1.14	321.22±16.34		
09	320.44±7.11	327.11±6.2		
10	318.99±3.11	327.26±2.43		
11	319.02±2.86	328.06±1.34		
12	319.26±1.04	279.71±75.35		
13	320.95±1.74	330.05±2.47		
14	294.04±44.96	329.71±1.17		

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