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機関番号：58001

研究種目：基盤研究(C) (一般)

研究期間：2016～2018

課題番号：16K06761

研究課題名(和文) 疲労損傷した摩擦攪拌接合材の光による健全性確保と放射光ラミノグラフィによる評価

研究課題名(英文) Maintenance of fatigue damaged friction stir welding joints by laser peening and integrity evaluation with synchrotron radiation laminography

研究代表者

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交付決定額(研究期間全体)：(直接経費) 3,700,000円

研究成果の概要(和文)：疲労き裂を付与したアルミニウム合金の摩擦攪拌接合継手の疲労健全性を確保するため、疲労き裂先端に2種類のレーザピーニング処理(水中で処理する従来のLPwC処理と大気中で処理できるDry-LP処理)を施した。Dry-LP処理を施すと試験片内部も含めてき裂進展をほぼ抑制できたが、LPwC処理を施工すると20000回の負荷繰返しで1mm程度成長し、さらにき裂進展を加速させる結果となった。この結果より、薄板に対してはDry-LP処理が適切であることを明らかとした。また、放射光ラミノグラフィを用いて疲労き裂と攪拌組織を同時に可視化した結果、攪拌組織と母材の境界部分を疲労き裂が進展することを明らかとした。

研究成果の学術的意義や社会的意義

本研究では、摩擦攪拌(FSW)継手材を対象として、放射光ラミノグラフィを利用した疲労き裂と摩擦攪拌組織の同時可視化をおこない、世界で初めてFSW継手材に発生した疲労き裂進展状況と摩擦攪拌組織を可視化した。この成果は、FSW継手のき裂発生・進展メカニズム解明に大きく貢献するものである。さらに、疲労損傷を受けたFSW継手材にレーザピーニング(LP)処理を施し、特にDry-LP処理によって疲労き裂の成長を停止させた成果は、航空機などの薄板構造物の安全性を確保することにつながり、社会的に大きな意義を持つものである。

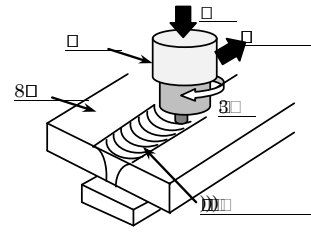
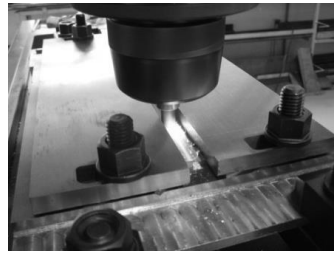
研究成果の概要(英文)：In this study, in order to ensure integrity of fatigue damaged friction stir welded (FSW) joints of 3mm thickness which has a fatigue crack at center part of welding center, two types of laser peening treatment are applied at the tip of the fatigue crack. One is conventional LPwC treatment treated in water and the other one is newly developed Dry-LP treatment treated in atmosphere. When the Dry-LP was applied, crack growth was almost suppressed including the inside of the specimen. However, when the LPwC was applied, fatigue crack propagate about 1 mm during  $2.0 \times 10^4$  cycles and its fatigue crack propagation rate had accelerated. This study suggested that Dry-LP is suitable for FSWed thin plate. In addition, as a result of simultaneously visualizing the stirred structure formed by FSW process and the fatigue crack using synchrotron radiation laminography, it became clear that the fatigue crack propagates in the boundary portion of the stirred structure and the base material.

研究分野：材料力学

キーワード：摩擦攪拌接合 疲労き裂進展 放射光ラミノグラフィ レーザピーニング

>265b

FSW  
 TWI 86  
 ISM 1 gM  
 M  
 4  
 3  
 76  
 5 b 7



(a)

(b)

5bS4  
 4 504  
 WAS e 1  
 S44b3

W/ )

WDB6bbNISub75F8

0

6B6e14NI

MC FSW 88

Su b2WB

I 8GM2/8

e 2

M[ FSW )mb

5S44

8e

BA/b

OM/0004ESBA/WOb/

Mb808b/

8

2

LP 7eW8

8

e 3 --b

2 cM4b2

LP

A6061

FSW )mb8

FSW )mSBA/))a

90iM/gSeSM

LP

FSW )mbB15X85

NASA b O

Hatamleh

2MMu8

e 4

FSW )mb/000501B/BA/

EM LP b88E

b

LP b8eW

2 b

d OM

6

000b/

/

4S

8

8 ON8

7/2

2

8

b 8

M

db

60b8TS

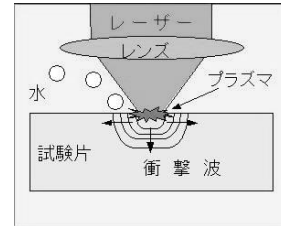
e/00W

8

e 5



(a)



(b)

W 2

LP

02bX

(1) LP BA/4D50

X

fb

M4b2E

8S

/

W FSW )mDSB

AM1gM8

90iM/g

8/8SA/b

0i8

LP

FSW

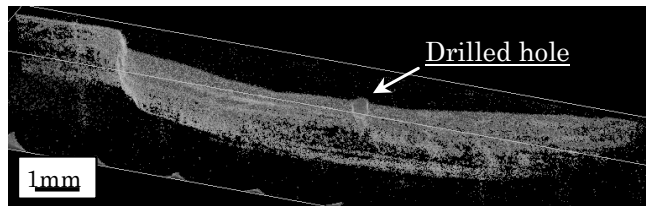
)mbBA/4D

b

5X

06

0s



W

A/b0i

(2) FSW )mb/000EM

LP bW0X

BA/S

FSW )mB

bOM

LP

08S

LP 4bBA/4DB1M

b

D5X6X06EBA/MSub

X

LP d0b8TM

8

LP

FSW )mB/000b

/

wOM

(3) FSW )mBA/b0i(X)X

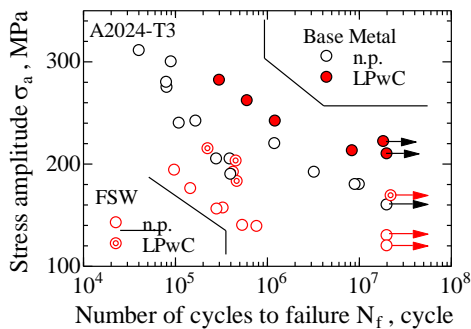
FSW )mb))BA/0iM72e0P4

10 2b2  
 0b4)BbSuW0b38pg2 S  
 (1) LP W FSW )m bB15  
 rNe 2bOMSu 55 A2024 b  
 FSW )m 8B 50M LP W LPwC 0 0  
 LP W Dry-LP 48dFB1  
 c0b PBF-30X 8dFB0 R=-1  
 0 0 B0X8 X)08Sg 00  
 b 0 1 B16 1 M

(2) FSW )m PM LP bBA/4D50  
 08b A2024 A6061 8 FSW )m 8B rN  
 bOX 8dF B1 1M LPwC 48bB15  
 X8 M b FSW b LPwC 40  
 0 120MPa B08bA/6xI 4mm g 6mm B  
 A/ M bBA/bA/ LPwC g Dry-LP d  
 S 120MPa bB00080  
 40W4pbA/bB6x M b10  
 LP BA/4D0 M

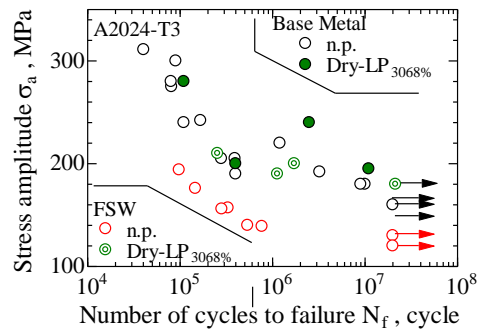
(3) FSW )m BA/4b0i  
 3b (2) A6061/A2024 FSW )m bA/48054  
 08S OMC A6061/A2024 FSW )m  
 b4bA/g 1 M 8BS FSW )m  
 140MPa 8dFB080  
 40

2>28Y  
 (1) LP W FSW )m bB15  
 S B 0)W 4 gMW 4(a) LPwC W 4(b) Dry-LP b  
 6 B bSu A2024 Base Metal 8 BM n.p. LP  
 b)g 8 BM 0bB1BM rN BM B LP  
 M bB7H 10<sup>7</sup> B LPwC 40MPa Dry-LP  
 20MPa bWS bM LPwC bIC  
 6WS Mb FSW )m M rN BM BBT 2/3 r  
 WS b FSW )m LP M LPwC Dry-LP BM bB  
 1b1S FSW 00S M mb0  
 p 3~5mm 7Sd b /8 2slWSS BA/  
 S81S FSW FSW-Dry-LP 8cg8 FSW-LPwC  
 6c8bs 6WS gb1S LP b/8  
 D)icWSS 8)gSWS  
 BA/ db60S )gbsA  
 Cs8SWS b) LPwC Dry-LP FSW )m  
 bB15w6sb1Dgbs8  
 6S



(a) LPwC #b: %

W2 LP #\_ |



(b) Dry-LP #b: %

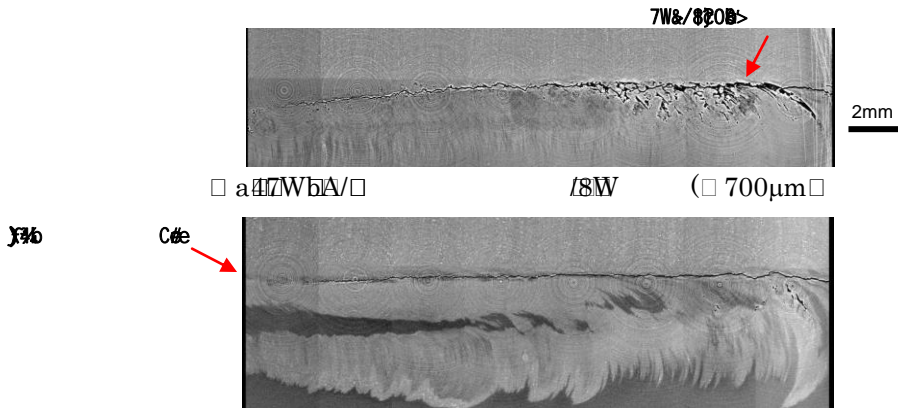
FSW )Emj B15



7(b) (b) (6)

SB5566SUGD(6A/B6×  
MMSO  
4)66M

FSW )mb7WbA/11b  
AS



(b) (6) CW 4E/A (1.8mm)  
W 7 A6061/A2024 FSW )mbA/B6×

> 4%  
q i FSW (4) 60% k  
r PK3M5 5 )Em (17 4 5)  
79 s 2009 590-594  
s ,57\$ k Bj #æ 1000 p  
% 26 s 1998 793-799  
t Omar Hataml eh Jed Lyons Royce Forman Laser and shot peening effects on fatigue crack growth in friction stir welded 7075-T7351 aluminum alloy joints International Journal of Fatigue 29 s 2007 421-434  
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<https://doi.org/10.2351/1.4967013>

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r T. SANO K. MASAKI Y. SANO 6 j 8 \$> DRY LASER PEENING: FEMTOSECOND LASER PEENING WITHOUT A SACRIFICIAL OVERLAY UNDER ATMOSPHERIC CONDITIONS 7th International Conference on Laser Peening and Related Phenomena 2018 "  
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