様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９　（共通）

科研費 KAKENHI

科学研究費助成事業　　研究成果報告書

令和　元 年　　５ 月 １５ 日現在

機関番号：１０１０１
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研究期間：2016～2018
課題番号：１６Ｈ０４２８６

研究課題名（和文）非接触レーザー加振システムによる機械／生体システムの動特性評価および異常診断

研究課題名（英文）Dynamic characteristic evaluation and diagnosis of mechanical/biological systems by non-contact laser excitation system

研究代表者
梶原　逸朗（Kajiwara, Itsuro）

北海道大学・工学研究院・教授

研究者番号：６０２２４４１６

交付決定額（研究期間全体）：（直接経費）　　13,300,000円

研究成果の概要（和文）：本研究では，機械構造物におけるさまざまな損傷を検知する手法および技術を構築した．達成された成果として，パイプ構造物に開けられた穴を損傷とし，レーザー誘起プラズマによる音響加振および音響計測に基づく損傷検知システムを開発した．本システムでは，アクリルパイプを対象構造物とし，レーザー誘起プラズマによる音響加振，マイクロホンによる音響計測によって音圧の時刻歴応答を収集した．パイプ内部の音圧の時間変動に対して，連続ウェーブレット変換を適用し，損傷穴による反射波を抽出することで損傷位置の同定を行った．実験により，損傷の位置が高精度で同定できることを確認し，本手法の有効性を検証した．

研究成果の学術的意義や社会的意義
本研究で開発した技術は，非接触かつ高周波数帯域の振動計測を可能にするが故，MEMSなどを対象にした振動計測および自動車など実稼働時の計測が要求される分野において，革新的な振動計測技術となることが期待できる．さらに，高周波数帯域での微小な振動特性の変化を捉えることにより，システムの故障や異常を高感度で検知できるヘルスモニタリングシステムの構築が可能になる．本技術はシステム全体の高周波振動計測に基づく検査法であるため，システム全体としての大域的な診断における高感度化および高効率化が達成され，振動実験解析法の発展およびシステムの高信頼化に大きく寄与し，工学的に極めて有用であるといえる．

研究成果の概要（英文）：　This study developed a health monitoring system for detecting damage on structures. An approach for detecting a hole drilled on a pipe based on laser plasma acoustic excitation and acoustic measurement is included in the results of this study. Non-contact acoustic impulse excitation can be realized by laser-induced plasma and a microphone is used for measuring the time response of acoustic pressure. In this study, we focus on the detection of the hole on the pipe. The time response of acoustic pressure changes due to reflection of acoustic wave caused at the hole drilled on the pipe. The position of the hole is identified by applying continuous wavelet transform to measured time response data with/without the hole. This study demonstrated the effectiveness of the present damage detection method based on the acoustic excitation using the laser-induced plasma.

研究分野：機械力学・制御

キーワード：機械力学・制御　振動解析・試験　非接触レーザー加振　損傷検知　インパルス応答

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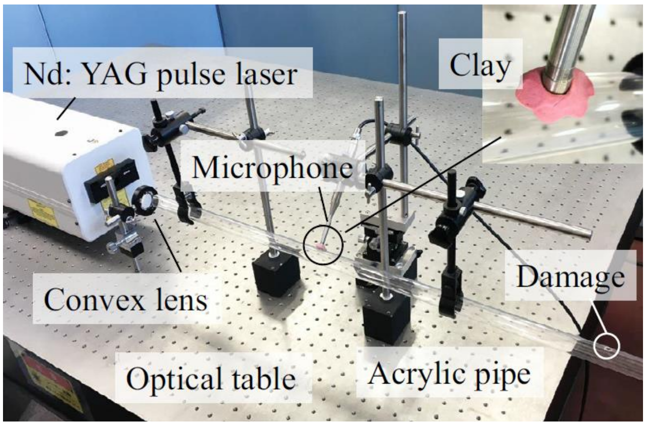

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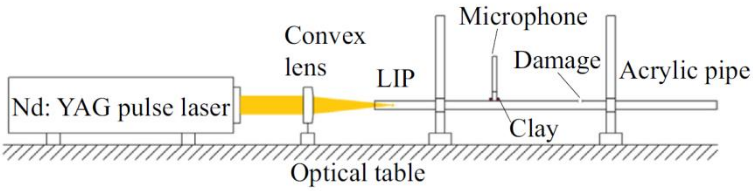

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$$\psi(t)=(1-t^2)e^{-\frac{t^2}{2}} \tag{1}$$

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 (2)[/Y€

$$\psi\left(\frac{t-b}{a}\right)=\left\{1-\left(\frac{t-b}{a}\right)^2\right\}e^{-\frac{1}{2}\left(\frac{t-b}{a}\right)^2} \tag{2}$$

' (1)[/ $a=1,\ b=0$ (2)bg'
2Xb a\ b
Mb6XPM4)Fc* (3)[/Y€

$$W(a,b)=\frac{1}{\sqrt{a}}\int_{-\infty}^{\infty}x(t)\psi\left(\frac{t-b}{a}\right)dt \tag{3}$$

GG[* $W(a,b)$ c[6;> $x(t)$ c0S8[
8bIT'M; a c f
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$$f=\frac{f_c}{a} \tag{4}$$

f_c c4#bp[6;
œ f_c ;> 0.251

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vX[6S8bbIT'W 4 gM;W 4(a)* (b)cbb
WZ;W 4(a)b8gb
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XG0Su W 4 (b)X
I† T_a T_b M $T_a=9.927$ ms * $T_b=13.79$ ms
 (W 5(a))bZ* T_a T_b

•G;Q b &c $\Delta T=T_b-T_a=3.863$ms [6?8 3
($c=341.2$ m/s)ECGb b8 $l'=\Delta T\times c=1.318$m b
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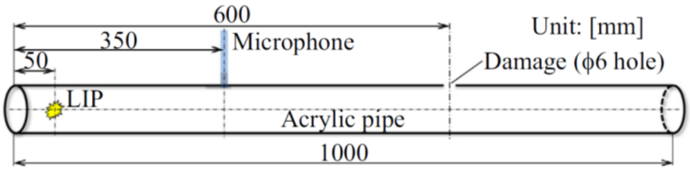

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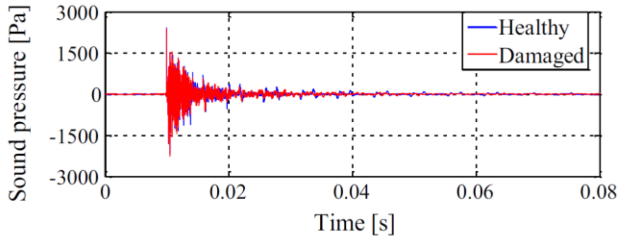
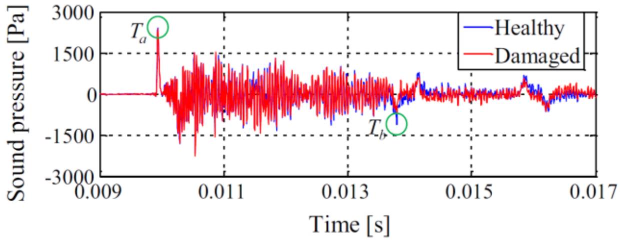


(a) Time [0-0.08 s]

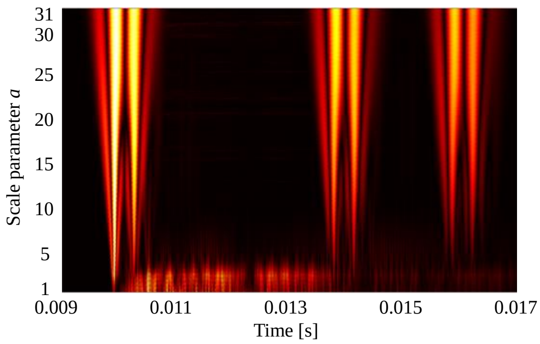


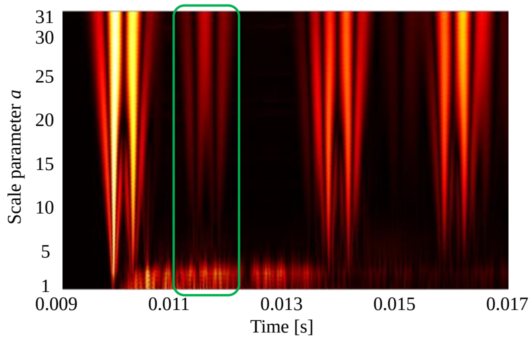
(b) Time [0.009-0.017 s]

W 4 ÄÅ

(2)ÿÆ)Ý

0ÍÍ6S8b8jÊK4)F5Ê4:#Ý K*b2ú)(b7c0Ó7*KÓIÇ MATLAB Qb[É6• Wavelet Toolbox bM4)FÊÆÈÇ6Ý5e4)FÊÈM ň4:#ŔS)ÝW 5 gMÅW 5 (a)cÅ0ÍKS8b]bIT'ÅÅ K4)FÊ4:#ŔS)Ý6* (b)c/b6ÉÆ4:#Ý Ý6ÅW 5 (a)* (b)b3HcÈ3HcÉ a ÈÆ ÈM $W(a,b)$ ÈÈM É $W(a,b)$ bÉÉÊÆ ÉÉÉÉ W 4(b)bIT'ÅW 5(a)bÈ#)ÝÝb8ňbÉŠ ZUIÈÈISI#ÕÈÈÈM É(b)/PÉÉC8 WSI'ÈMPUÈd/É• GÈMGÊA*QKÈW 5(a)* (b)$QM* (a)/ÉÈM ÉbIÉ* (b)v]/ÉGÈ2K* (b)b)sbßVrÉ 4Éc* (b)b)ÝsŘÈ (a)c QbÉÉC/É8> (a)* (b) b9É48cÉE$/*0bwTE[6b[*Gbb48c* /*0W2b@UI6s8j[6ÉG[A>





(a)Éˆ ÈM (b) /bÈM

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5 b

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7bIQMG[b480K)A GG[cM)

(c a=16 EKS a=16 PMb

IW 6 M;3H)3H KS3KSD

b AI KS 6 ZXKK

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K8bWZ 0.011 s 2xS6S 0b6

sZGbIcW 5(b)b)sb[KSIop'KC

WQG[WMgASI† t_1 0b6

bsSI† t_2 KGb6b S2m $t_1 = 9.810$ ms

$t_2 = 11.30$ ms [6b[8bb $\Delta t = t_2 - t_1 = 1.490$ ms QKE b

3bbZ $\Delta L = \Delta t \times c = 0.5084$ m W 3

/'0r[b2bŸ 0.5 m WZSu G[Sop'KCWZ

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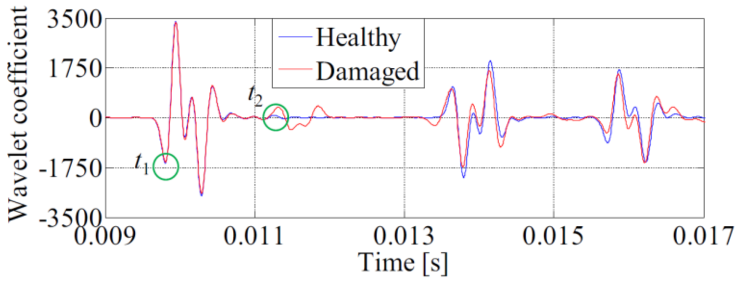

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http://labs.eng.hokudai.ac.jp/labo/lsm/

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TOSHIRO OHASHI

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