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# Dynamic analysis of an excavator manipulator by experimental data

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**Key Words:** Excavator( ), Experimental Data( ), Inverse Dynamics( )

## Abstract

This paper presents the inverse dynamic analysis of the hydraulic excavator manipulator based on the experimental data. A three dimensional rigid multi-body model of the hydraulic excavator manipulator was built up. Inverse dynamic analysis for typical operation mode was carried out by the ADAMS program. In order to verify the analysis results with the measured, the hydraulic pressure and displacement of the cylinders were measured and the dynamic analysis was carried out using experimental data. From the results of the cylinder driving forces, good agreements are obtained between the analysis and the measurement.

1. 가

가 ADAMS<sup>(1)</sup>

가

, , / , /

2.

가

가 가

2.1

Fig. 1  
(boom), (arm), (bucket),  
(upper frame), (control rod),  
(control link), , ,  
/ (bore/rod)

2 가

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CAD 3 CAD  
 I-DEAS  
 ADAMS  
 (bore, rod)가 (translational joint)  
 (ground)

(2)

16 body, 21 joint, 5

Revolute Joint(RJ), Universal Joint(UJ), Spherical Joint(SJ), Translational Joint(TJ)

(inertial coordinate system) Fig. 1

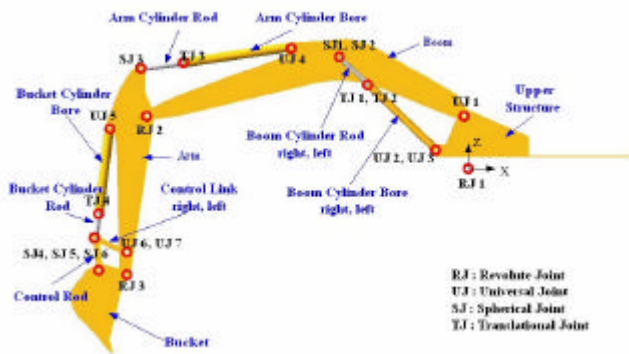


Fig. 1 Dynamic model of an excavator

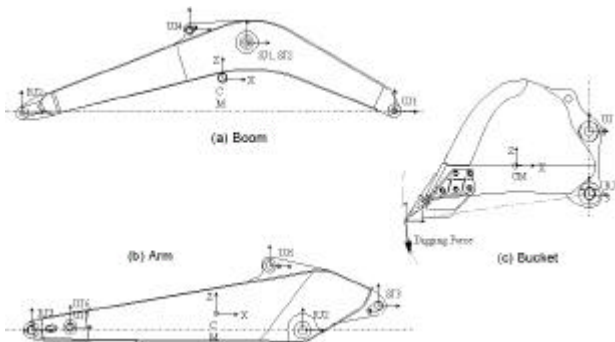


Fig. 2 Local coordinates of main parts

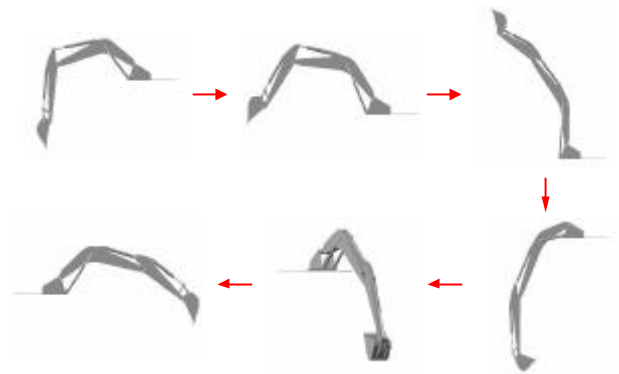


Fig. 3 Scenario for dynamic analysis

RJ1 ( , , )  
 , , , 가 (local coordinate)  
 Fig. 2

2.2

Fig. 3

가  
 180°

Fig. 4  
 ADAMS

Fig. 5

Fig. 6

(2)

x, y

3.4 5.32

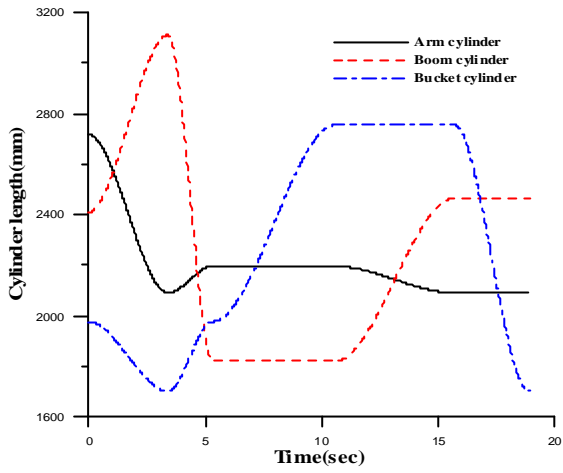
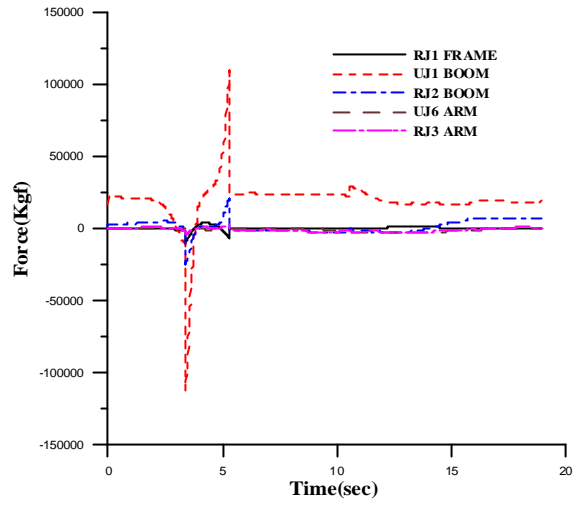
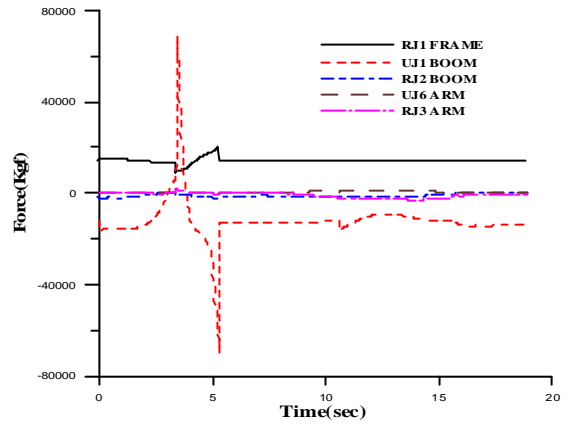


Fig. 4 Displacements of cylinders according to the scenario



(a) x-direction



(b) y-direction

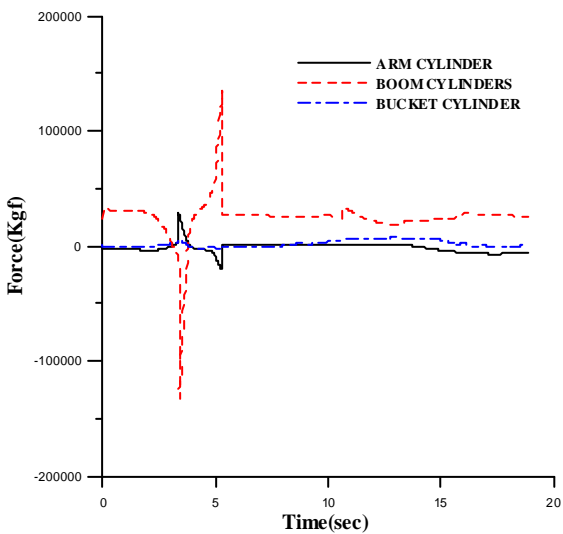
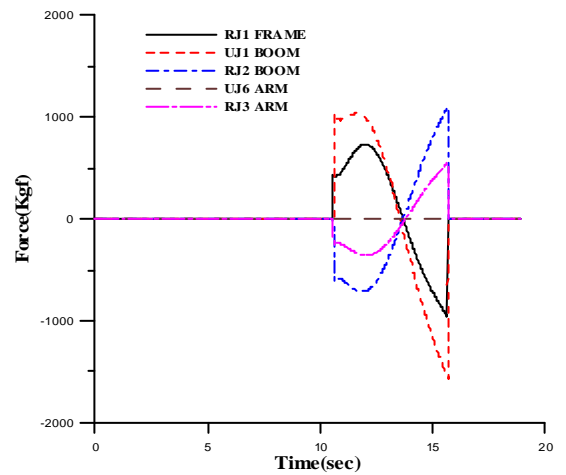


Fig. 5 Cylinder driving forces



(c) z-direction

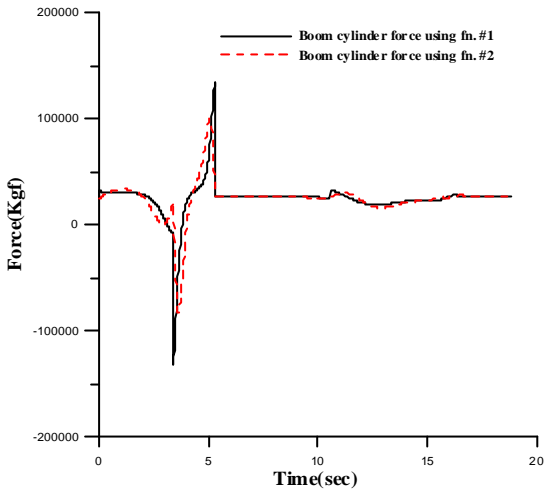
Fig. 6 Reaction forces in local coordinate

ADAMS

ADAMS

Fig. 7

(3)



**Fig. 7** Comparison of boom cylinder driving forces according to interpolation functions

4.

4.1

Fig. 8

down-up

3

8

Fig. 9

4.2

Fig. 10

ADAMS

MATLAB<sup>(4)</sup> 2 Butterworth low

pass filter

Fig. 11

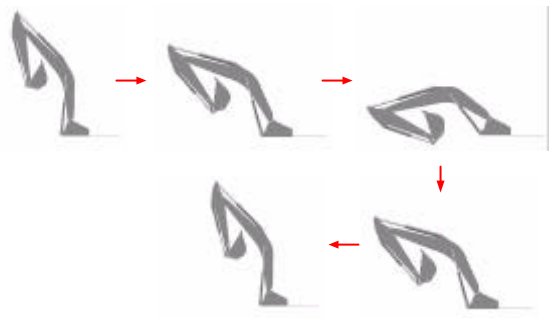
Fig. 12

Fig. 13

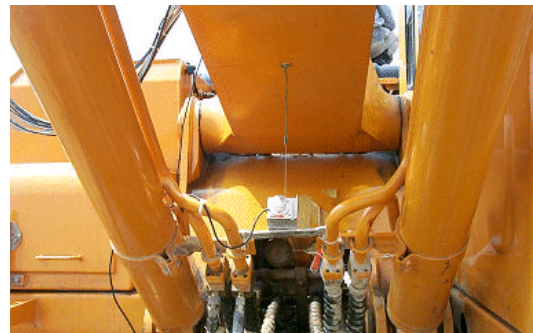
Fig. 13

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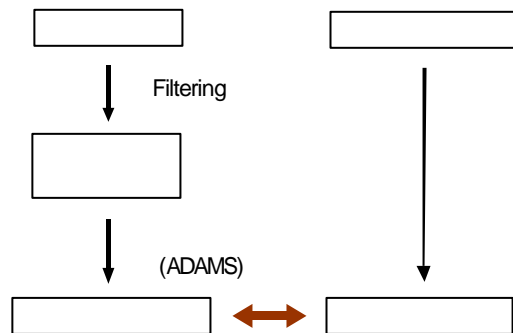
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**Fig. 8** Scenario of the boom down-up motion



**Fig. 9** Measurement for boom cylinder displacement



**Fig. 10** Flow chart for dynamic analysis using experimental data

stroke cushion  
 cushion 8.5  
 chamber

Fig. 12

Fig. 15

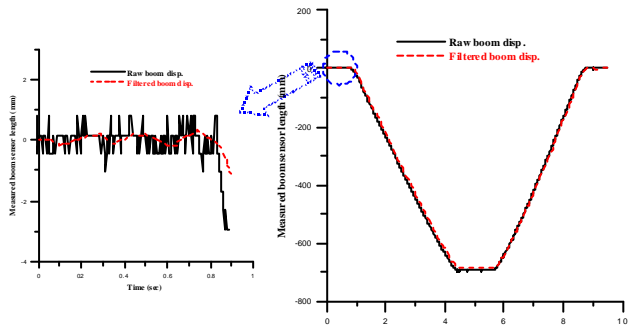


Fig. 11 Measured displacement after filtering

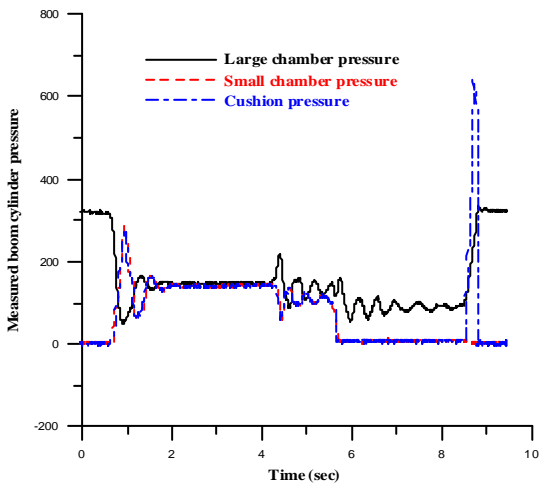


Fig. 12 Measured hydraulic pressure

8.5  
 가  
 가

Fig. 14

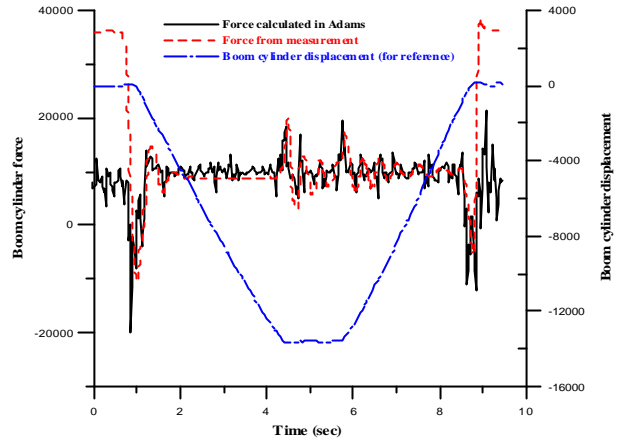


Fig. 13 Comparison of boom cylinder driving forces

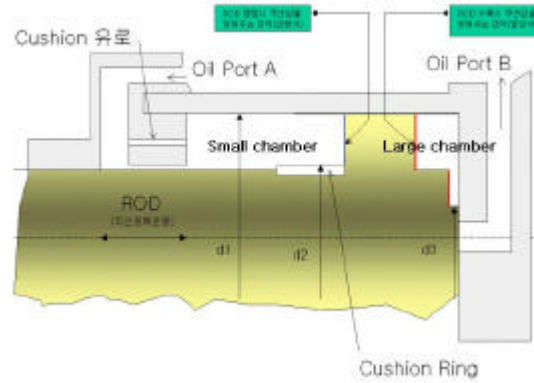


Fig. 14 Boom cylinder chamber

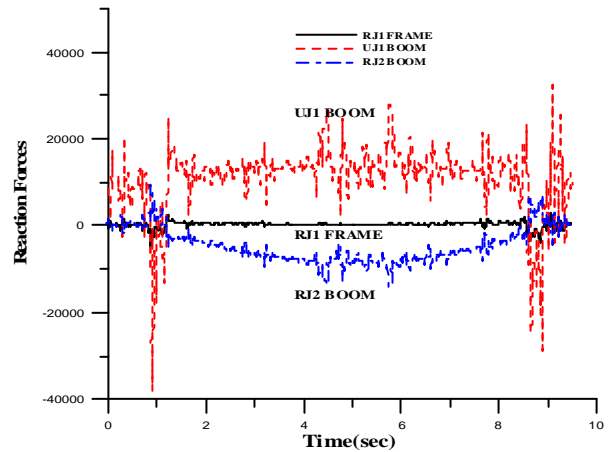


Fig. 15 Reaction forces in local x-direction

ADAMS

Fig. 16 ADAMS

18 . Fig. 17  
 5.75 가  
 가  
 Fig. 17  
 Fig.  
 , Fig. 13  
 4.5

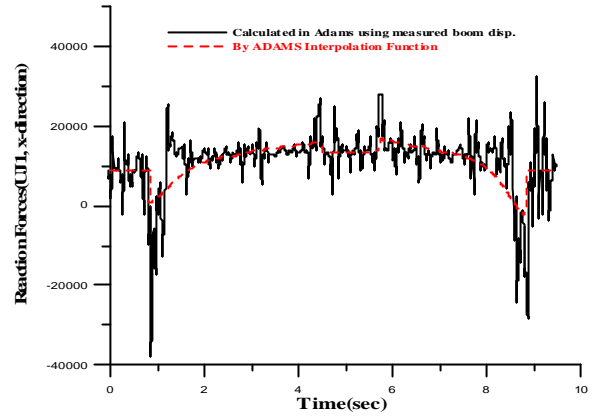


Fig. 18 Comparison of boom reaction forces

5.

ADAMS

ADAMS

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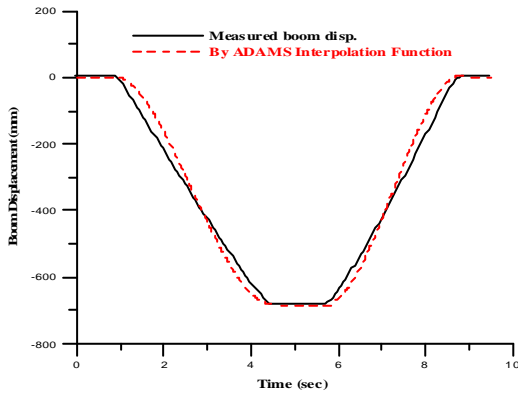


Fig. 16 Comparison of boom displacements

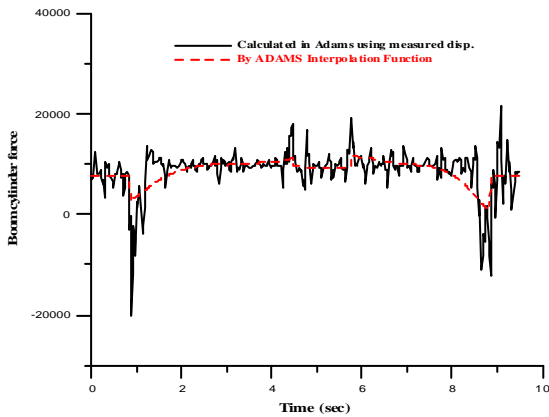


Fig. 17 Comparison of boom cylinder driving forces

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- (2) Oe-Jo Kim, Wan-Suk Yoo, Byung-Hoon Lee, Man-Hyung Lee and Kyeong-Hwa Yoon, 1993, "Three Dimensional Modeling and Inverse Dynamic Analysis of An Excavator," KSME, Vol. 7, No. 8, pp. 2043 ~ 2050.
- (3) Wan-Suk Yoo, Oe-Jo Kim, Byung-Hoon Lee, Man-Hyung Lee and Kyeong-Hwa Yoon, 1994, "Dynamic Analysis of an Excavator Using Experimental Data," KSME, Vol. 18, No. 5, pp. 1150 ~ 1157.
- (4) MATLAB, The MathWorks Inc., U.S.A.