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## Dynamic Tensile Tests of Steel Sheets for an Auto-body at the Intermediate Strain Rate

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**Key Words :** Strain Rate Hardening( ), Intermediate Strain Rate( ), Dynamic Material Property( ), High Speed Material Testing Machine( ), Fracture Elongation ( )

### Abstract

The dynamic behavior of sheet metals must be examined to ensure the impact characteristics of auto-body by a finite element method. An appropriate experimental method has to be developed to acquire the material properties at the intermediate strain rate which is under 500/s in the crash analysis of auto-body. In this paper, tensile tests of various different steel sheets for an auto-body were performed to obtain the dynamic material properties with respect to the strain rate which is ranged from 0.003/sec to 200/sec. A high speed material testing machine was made for tension tests at the intermediate strain rate and the dimensions of specimens that can provide the reasonable results were determined by the finite element analysis. Stress-strain curves were obtained for each steel sheet from the dynamic tensile test and used to deduce the relationship of the yield stress and the elongation to the strain rate. These results are significant not only in the crashworthiness evaluation under car crash but also in the high speed metal forming.

1. 가  
 가 , 가  
 가 , 가 /s  
 가 , 가 /s 가  
 가 가 1000/s 가

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 \* (drop weight test), (cam  
 \*\* plastometer)  
 \*\*\* POSCO

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[2,3].

[4],

가

가

Inston

[5].

가

/s

가

17

(load ringing)

Fig. 2

2.

2.1

/sec

(intermediate strain rate)

Fig. 1

(high speed material testing machine)

가 1000mm, 600mm, 가

2300mm , 220

mm 3

4000 mm/sec 30kN,

100mm .

300kg/cm<sup>2</sup> , 240 l/min .

45kW

2 ,

5l

(accumulator) .

Moog D662 .

Kistler

9051B,

Sentech LVDT

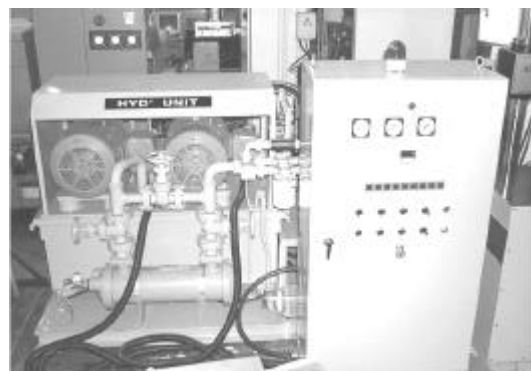
(Linear Variable Differential Transformer)

, LVDT 100 mm

15 kHz .



(a)



(b)

가

Fig. 1 High speed tension testing machine: (a) loading frame; (b) servo-hydraulic unit.



Fig. 2 Upper gripping jig

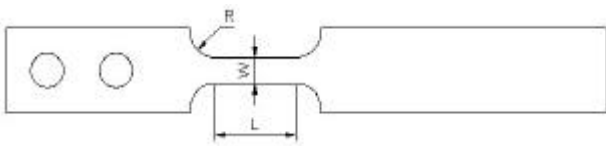


Fig. 3 Schematic diagram of a specimen.



Fig. 4 Tensile specimens with the length of the gauge section of 15 mm and 20 mm.

2.2

(extensometer)

가

가

Table 1 Scaling factor with respect to the variation of length.

Model	Reference Strain	Strain at center	Scaling Factor
L (mm)	10	0.1	0.0876
	15	0.1	0.0908
	20	0.1	0.0928
	25	0.1	0.0942
	30	0.1	0.095

가  
가

Fig. 3

(fillet)  
가 가  
가  
(L) 가 가

(W)가 가 가  
가 가 (R) 가 가

가

0.1

Table 1 0.1 L

0.9~0.95 , L 가 가 1

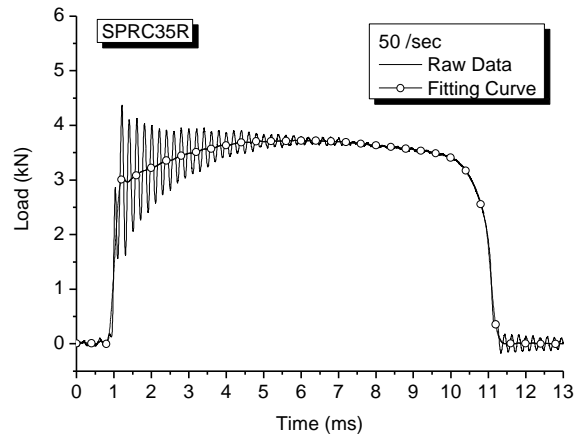
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15 mm 30 mm

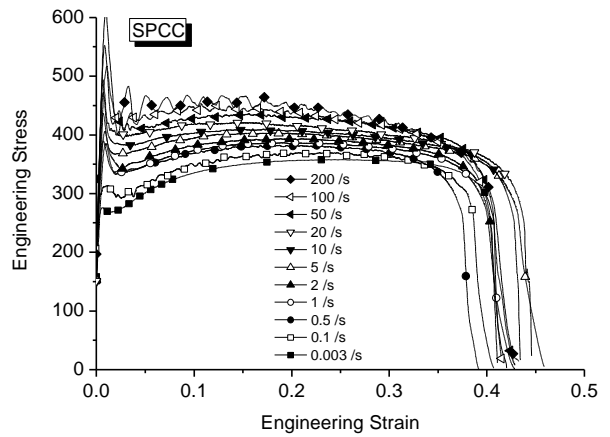
Fig. 4 15mm 20mm

**Table 2** Experimental conditions.

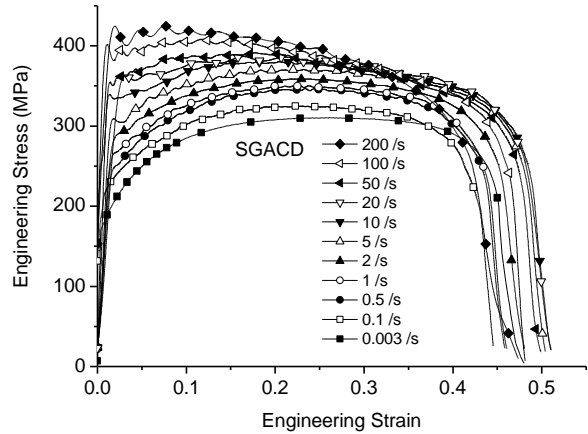
Machine	Strain Rate [1/s]	Length of gauge section [mm]	Quantity
Static UTM	0.003	20	3
High Speed Material Testing Machines	0.1	20	3
	0.5	20	3
	1	20	3
	2	20	3
	5	20	3
	10	20	3
	20	20	3
	50	20	3
	100	20	3
	200	15	3



**Fig. 5** Stress-strain curve and curve fitting



(a)



(b)

**Fig. 6** Stress-strain curves at various strain rate: (a) SPCC; (b) SGACD.

3.

3.1 3.

17

SPCC, SGACD, SPRC35R,

SPRC40R

Table 2

0.003 /s

0.1, 0.5, 1, 2, 5, 10, 20, 50, 100, 200 /s

3

200 /s

20 mm

/s

가

100 /s

FFT (Fast

Fourier Transform)

Fig. 5

SPRC35R

Fig. 6

SPCC

SGACD

100 /s

200 /s

가 가

가

가

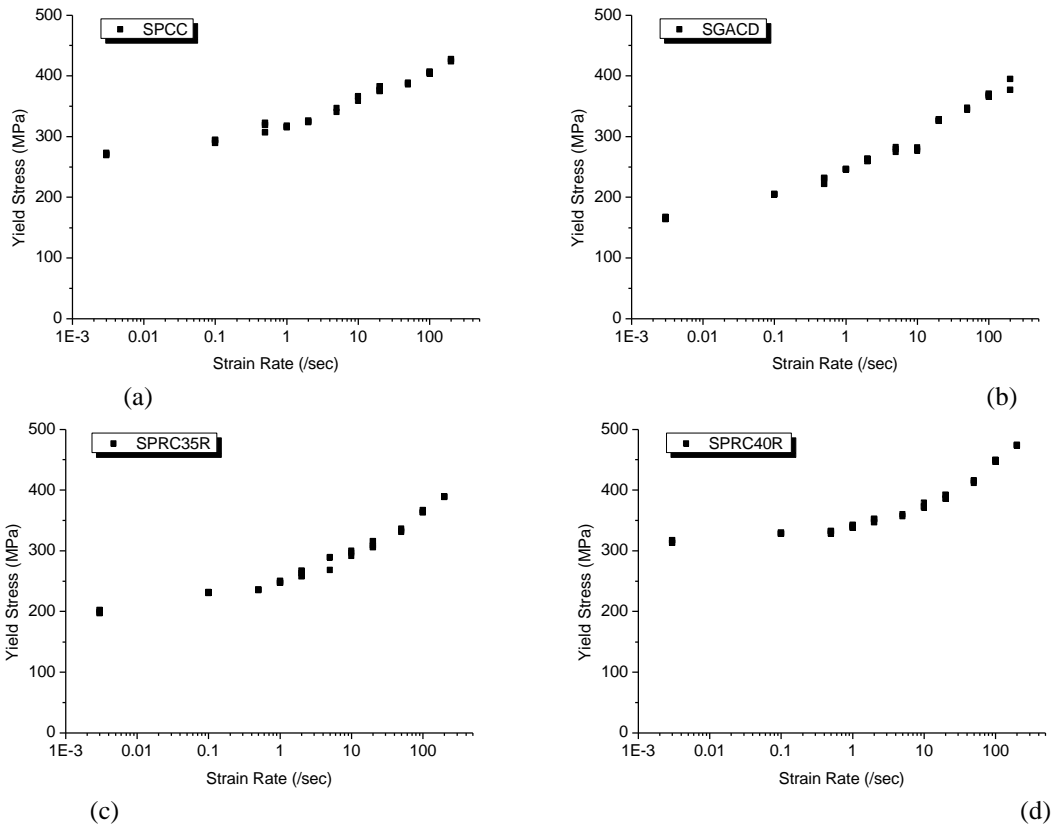
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SGACD

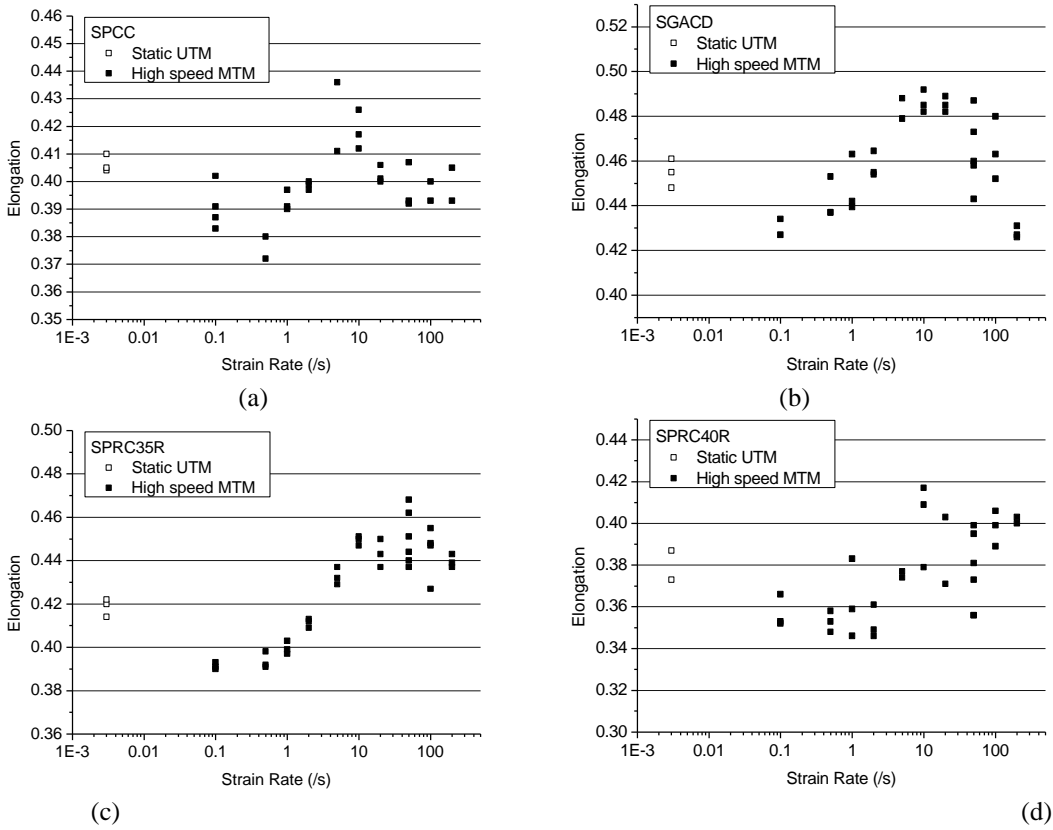
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**Fig. 7** Yield stress according to strain rate: (a) SPCC; (b) SGACD; (c) SPRC35R; (d) SPRC40R.



**Fig. 8** Fracture elongation according to strain rate: (a) SPCC; (b) SGACD; (c) SPRC35R; (d) SPRC40R.

Fig. 7 가 17  
SGACD

가 SPRC40R 1.5  
가 가 6 mm  
가 15 mm 20 mm

Fig. 6 가 가 0.003, 0.1,  
가 가 0.5, 1, 2, 5, 10, 20, 50, 100, 200 11 가  
, 100/s FFT

Fig. 8 가 가

가 가

가 0.1~0.5 /s

가 10~20 /s

가 가 S  
(necking)

가

가

가

가

가

4.

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