The Effects of Numerical Result and Computing Time Due to Mass Scaling in Rolling Analysis

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Abstract

To enhance the structural performance for vehicle, a patch is attached. For various section shapes, each patch has different performance in energy absorption. In despite of efficient patch, formability may be a problem. Because the depth of groove is about 0.2mm, it needs a large FEM model for rolling analysis and has very small time step. We have to choose a method to reduce analysis time. This paper presents the effects of mass scaling in rolling analysis of a reinforcement patch for vehicle. We examined applicable mass or velocity scaling range. Besides to resolve severe mesh distortion in the sharp pattern forming, we apply efg formulation that is a new function in LS-DYNA version 970 and compare it with standard method.

INTRODUCTION

To enhance the structural performance of vehicle generally a patch is attached. Patches are flat shape or grooved. In the development of grooved patches, it needs two types of analyses: formability analysis for each section, performance analysis for formed patch. Because the size of groove depth is so small formability analysis needs enormous computing time. We have to take a method to reduce cpu time. This paper presents about the effects of numerical results and computing time due to mass scaling in rolling analysis of a reinforcement patch for vehicle.

The size of work piece is 50mm x 50mm x 0.7mm (figure 1) and it is roll-formed vertically and horizontally with U-groove, V-groove and trapezoidal-groove. The depth of groove is about 0.2mm and the width 0.4mm. For full size analysis, assumed that element size is 0.05 mm along surface direction, 12 layers along depth and symmetric condition it needs more than 1000K solid elements. To reduce execution time, we can choose mass scaling, velocity scaling or coordinate scaling. With small size U-groove model (figure 3), we examined applicable scaling range.

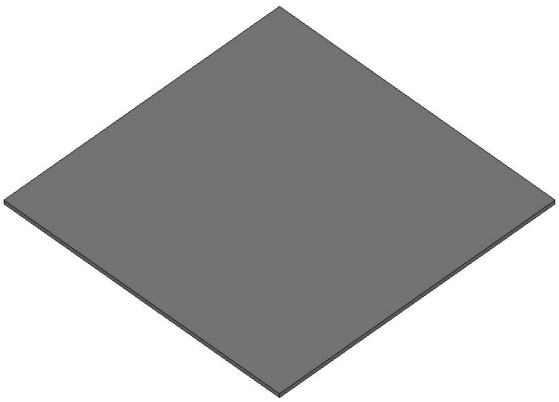

figure 1 initial work piece

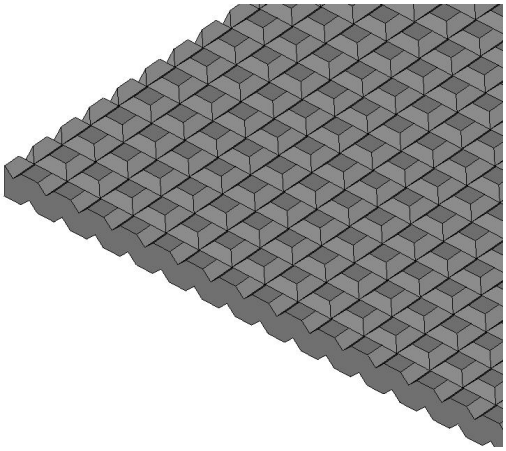

figure 2 final work piece

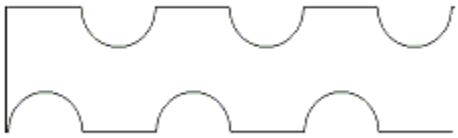

figure 3 section types

APPROACH

We could treat 10 times velocity scaling as 100 times mass scaling. Compared input value in [mm, ton, sec] units with [mm, 10E5kg, 10sec], we can be aware of it.

This approach is applicable to coordinate scaling. Similarly scaling nodal coordinates 10 times is the same as scaling mass density 100 times. Velocity scaling or coordinate scaling can be treated density scaling. So, We examined the difference of results as increasing mass density.

Sharp corner exists in V-groove and trapezoidal-groove, so we compare standard method results with EFG method to examine applicability.

FE Models

The FE model is generated with general purpose pre-processor eta/FEMB v28. Tool diameter is 6mm and its shape is U-groove, work piece size is 2.2 x 2.2 x 0.7 mm. The number of solid elements is 23232 and the minimum mesh size is 0.05mm. The rotation speed of tool is 40 radian/s and the material feeding speed is 120mm/s.

For computational efficiency, it is only applied EFG formulation in the formed region. Both comparison models are scaled density 100 times.

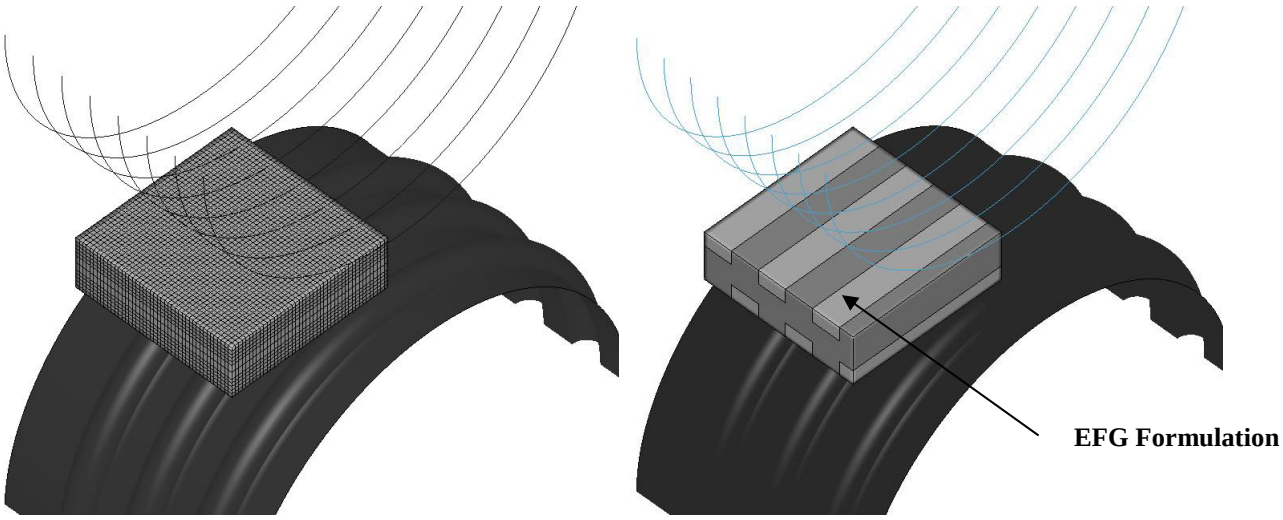

figure 4 FE Model

Results

Mass Scaling Results with Lagrangian method

The base model time step is 7.34 ns and cpu time is about 101 hours. It shows similar results up to 10000 times mass scaling.(table1, figure 5, 6, 7) In case 100k times mass scaling, kinetic energy is about 5 % of internal energy.

table1 Mass Scaling Results

% diff. from base model	Base	10X	100X	1000X	10kX	100kX	1000kX
Eff. Plastic Strain	-	1.7%	2.2%	2.2%	2.5%	2.8%	8.7%
Internal E.	-	0%	1.2%	1.3%	1.6%	2.4%	33.0%
Internal E/kinetic E.	2.0E+6	2.0E+5	2.0E+4	2.0E+3	2.0E+2	20	1.7
Timestep	7.34E-9	2.37E-8	7.34E-8	2.37E-7	7.34E-7	2.37E-6	7.34E-6
Elapsed time	101 hrs	31 hrs	10 hrs	3 hrs	1 hrs	20 mins	6 mins

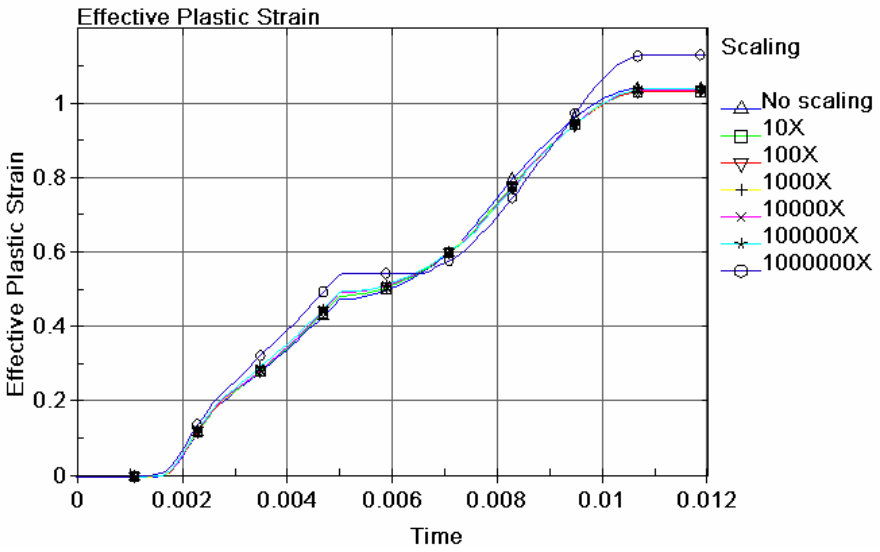

figure 5 Effective Plastic Strain

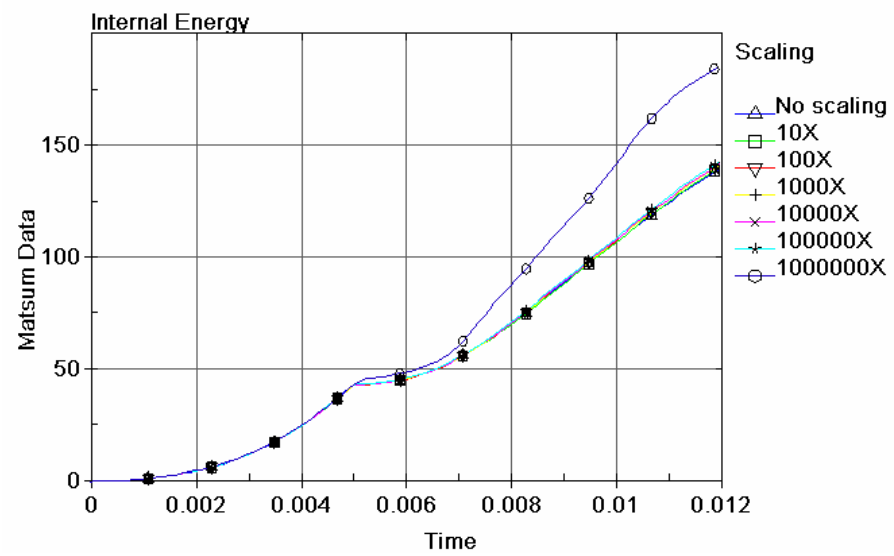

figure 6 Internal Energy

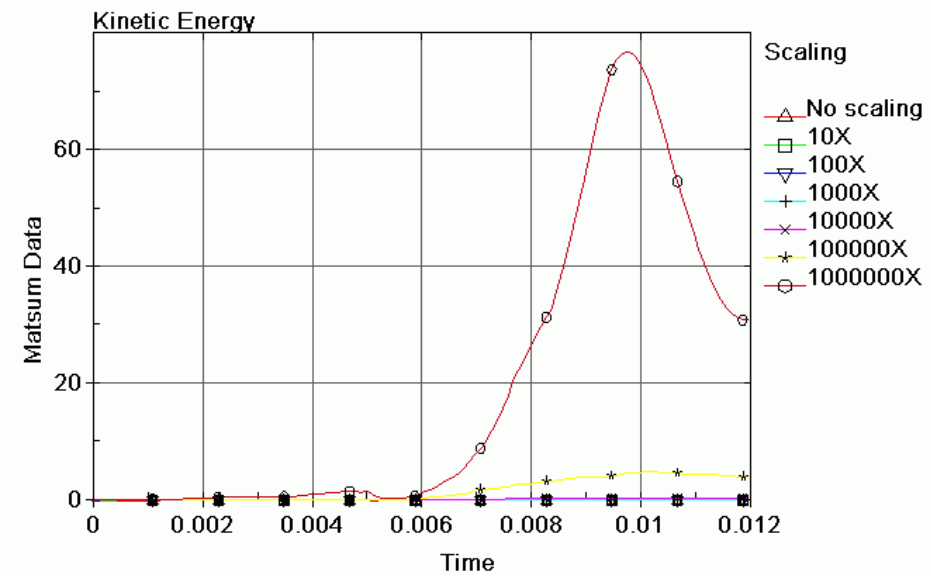

figure 7 Kinetic Energy

Comparison between Lagrangian and EFG methods

The coupled standard and EFG method model shows similar effective plastic strain distribution (generally 10% lesser) and smooth deformation (figures 8,9). But, cpu cost is 4 times more expensive, it took about 40 hours to complete simulation. The required memory size is 8 times as large as standard method. To run a input including 20k efg formulation solid element is needed about 80 million words.

table2 Lagrangian Vs. EFG results (100 times mass scaled)

	Effective Plastic Strain	Internal Energy
Lagrangian method	1.96	141 E-3 J
EFG method	1.67	153 E-3 J

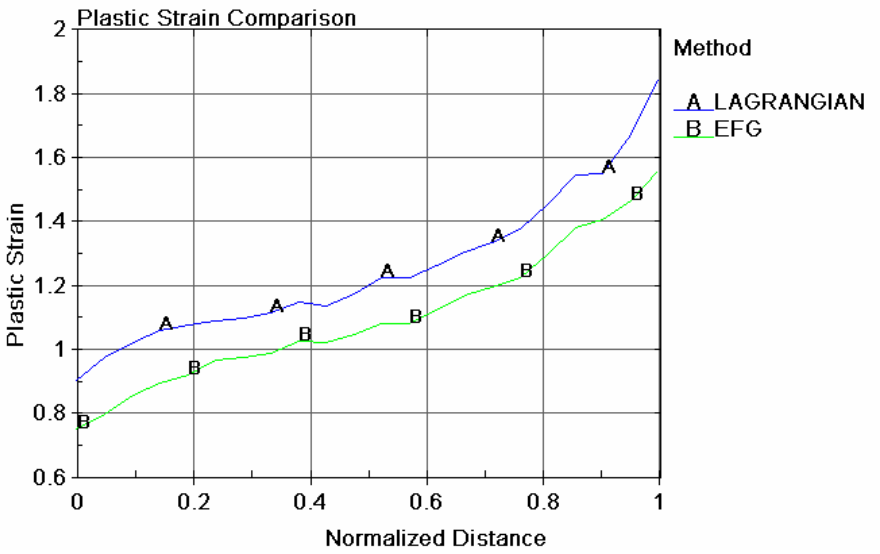

figure 8 LAG vs. EFG Plastic Strain

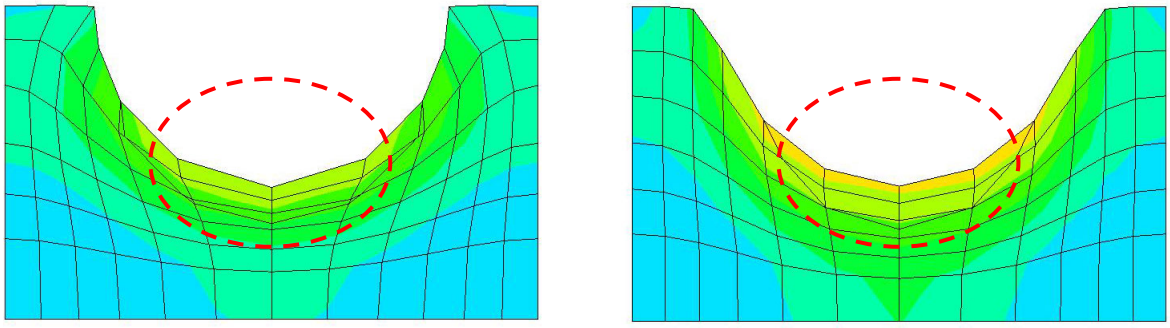

figure 9 LAG vs. EFG Deformation

Summary

To simulate efficiently full size model, it would be appropriate 10 times velocity scaling and 100 times mass scaling. The EFG method shows smooth and non-localized results but it is difficult to apply to a large model because of expensive cpu cost and large required memory size. If using EFG method locally in the severe mesh distortion area, it would be efficient and give realistic results.

References

1 LS-DYNA KEYWORD USER'S MANUAL Version970, April 2003, LSTC