Updated Design of DAVINCH Detonation Chamber and Its New Application

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Koichi Hayashi
Takao Shirakura

Kobe Steel, Ltd.

Presentation outline

General

- History of chemical agent destruction
- DAVINCH system advantages

Design scheme of DAVINCH system

- Example analysis (implosion, blast wave, structural)

Improvement (structural, operability, and analysis model)

Analysis model verification

New Application of DAVINCH system

- High explosive munition and missile
- A novel small chamber for urban area

History of chemical agent destruction by Kobe steel, Ltd.

1. Global experience on chemical agent destruction from 2000.

1.1 Kussharo; neutralization(chemical agent), detonation(burster)

1.2 Samukawa; neutralization(chemical agent), incineration(soil)

1.3 Kanda; detonation (chemical munition)

1.4 China; detonation (chemical munition and canister)

1.5 Belgium; detonation (chemical and conventional munition)

2. Plan, test, operation and improvement

2.1 Basic design technology on critical items such as Nuclear

2.2 Experience of testing and operation of actual chemical agent

2.3 Accumulation of operation data

2.4 Lesson learned by operation

2.5 Improvement for updated design

DAVINCH system advantages

1. Destruction capabilities
   - 1.1 Large munitions
   - 1.2 Various type of chemical agent
   - 1.3.Deformed / Corroded non- stockpiles
2. No need for pretreatment
3. High destruction efficiency
4. High throughput
5. Environmental Friendly
6. Transportable
7. Applicable to conventional munitions

Design scheme of DAVINCH system

1. Design requirement of DAVINCH

   1.1 Structural integrity

      1.1.1 Outer chamber ; ASME pressure vessel code

      1.1.2 Inner chamber ; Fragments damage

   1.2 Operational and maintenance feasibility

2. Design software

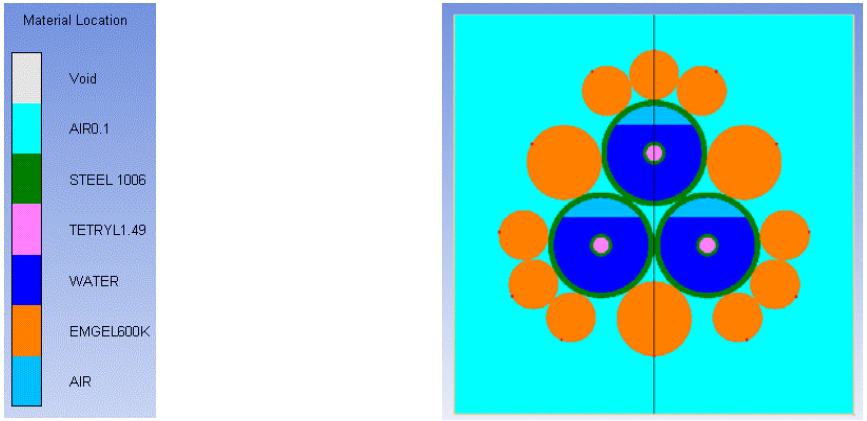
   2.1 Implosion analysis

   2.2 Blast wave analysis

   2.3 Structural analysis

   2.4 High velocity deformation analysis

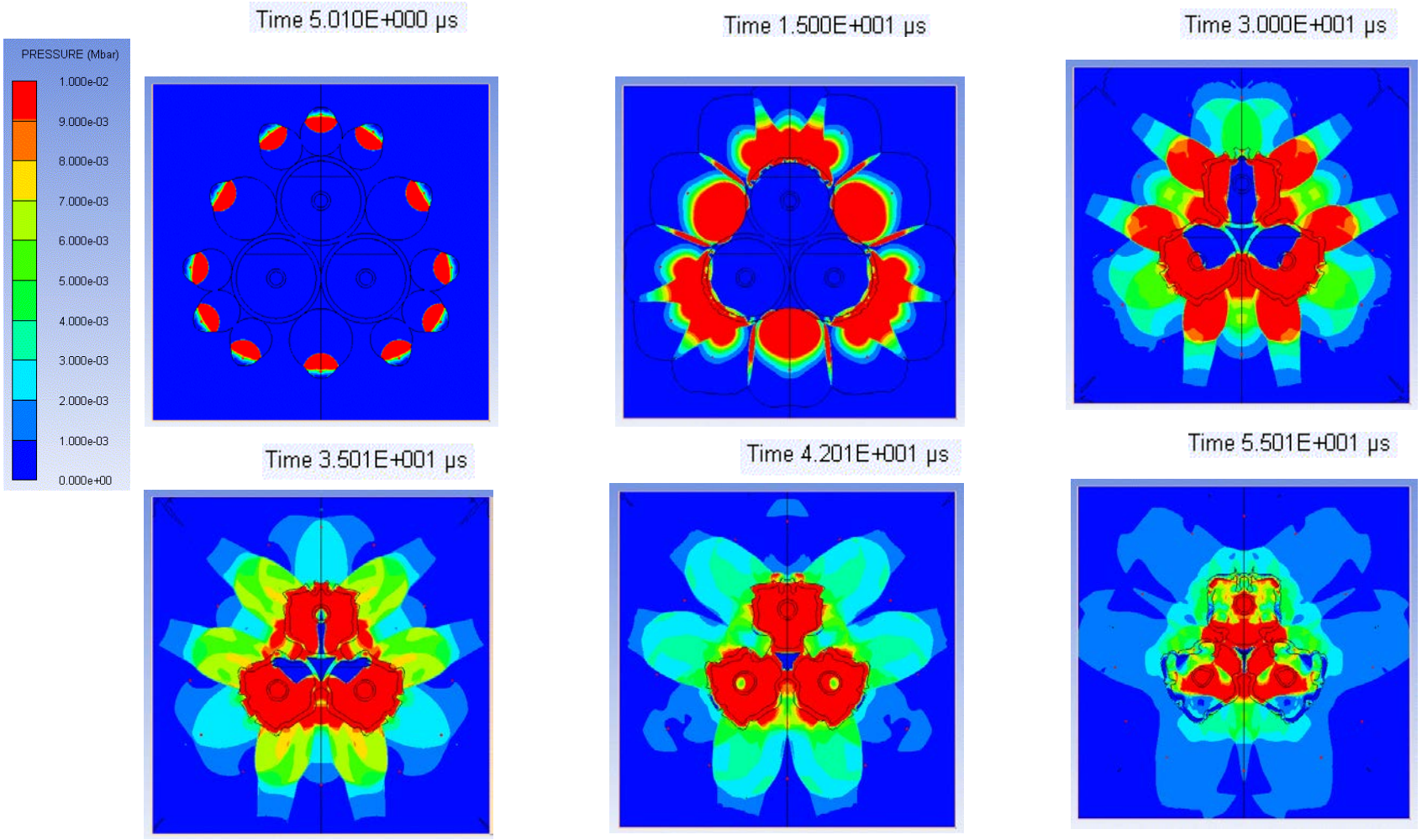
Implosion analysis



Implosion analysis model of mortars with donor charges

1. Implosion analysis
   1.1 Confirm the pressure of the chemical agent reaching to the specified value
   1.2 Confirm the fracture of the structure of munition
2. Operation and/or test
   Obtain the actual data
3. Lesson learned and improvement
   Reflect on the updated design with most suitable donor charge arrangement on amount and configuration

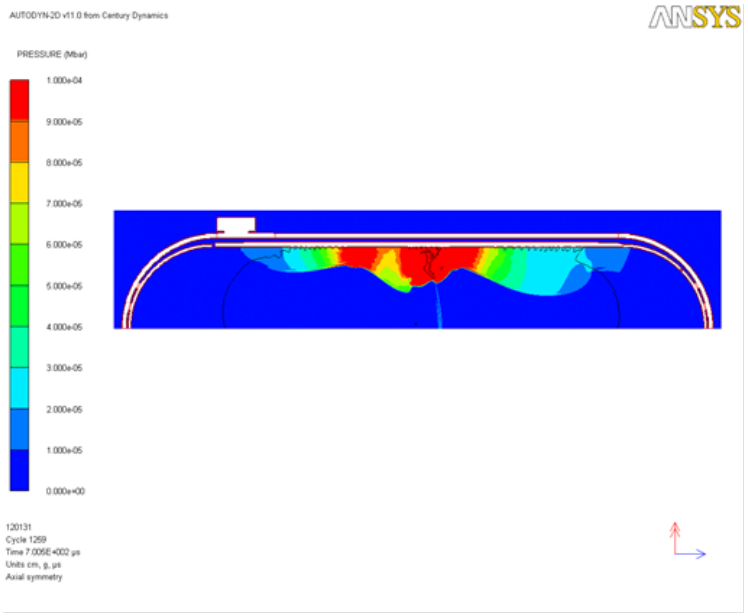
Implosion analysis

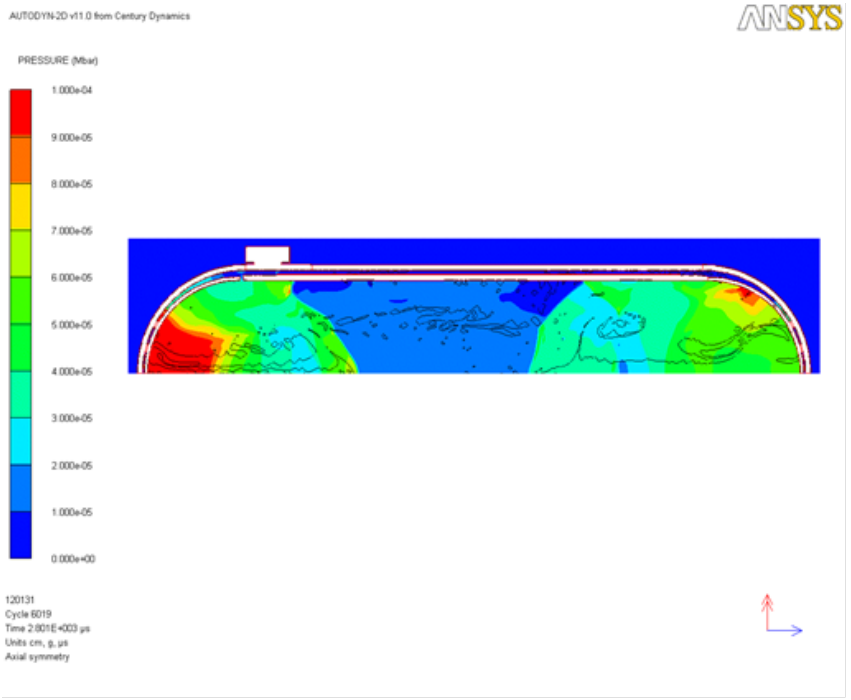


Pressure history of mortars implosion with donor charges

Blast wave analysis in the chamber

TNT60Kg





7msec after detonation
Blast wave reaches to the cylindrical part of the inner chamber

28msec after detonation
Blast wave reaches to the outer chamber

ASME code design
Impulsively loaded pressure vessel

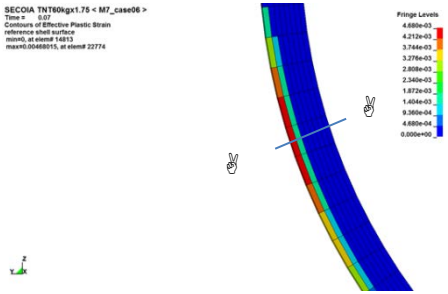
The four failure modes specified in ASME Code SEC.VIII Div.3 and Code Case 2564 are evaluated by analysis*1 and/or experimental test*2

Design Issue	ASME Code Design Requirement	Assessment Results
Global Plastic Instability State *1	Code Case 2564-3 Section 3.1 (a)	No plastic instability state observed from detonation loads with 175% of TNT 60kg and TNT 75kg
Leak Before Burst *1	SectionⅧ Division 3 Article KD-140	Assumed initial flaw at worst location in outer vessel ,leak-before-burst mode of failure could be shown
Local Plastic Strain Limit *1*2	Code Case 2564-3 Section 3.1 (a)	Total accumulated damage at any point in the chamber under the specified operation cycles meets ASME Code requirement
Fatigue Strength *1*2	SectionⅧ Division 3 Article KD-3	Detonation Chamber has sufficient fatigue strength for a life term under the specified operation cycles

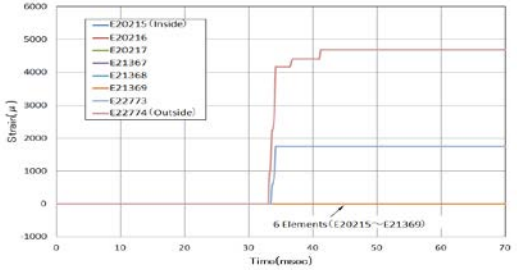
Structural analysis

1. Global Plastic Instability

No plastic instability state(the formation of the complete plastic hinge around opening)

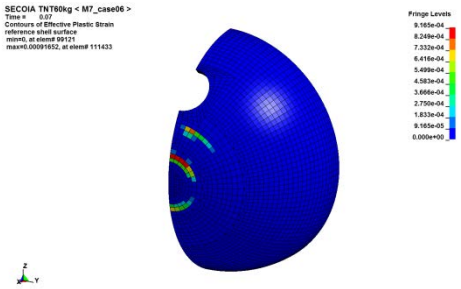


Equivalent Plastic Strain Distribution in the Section of Lid Side Flange
(175% of design capacity)



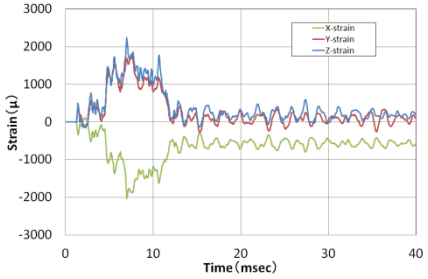
Equivalent Plastic Strain History at Critical Section A-A of Lid Side Flange
(175% of design capacity)

2. Local strain limit



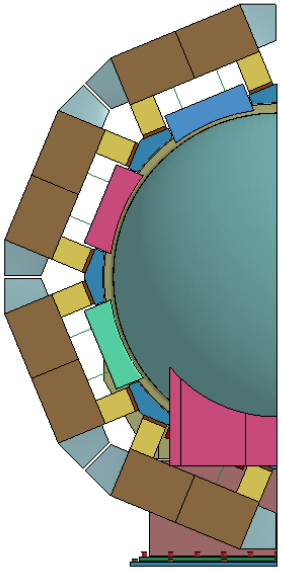
Residual plastic strain at
Bottom Head (TNT60Kg)

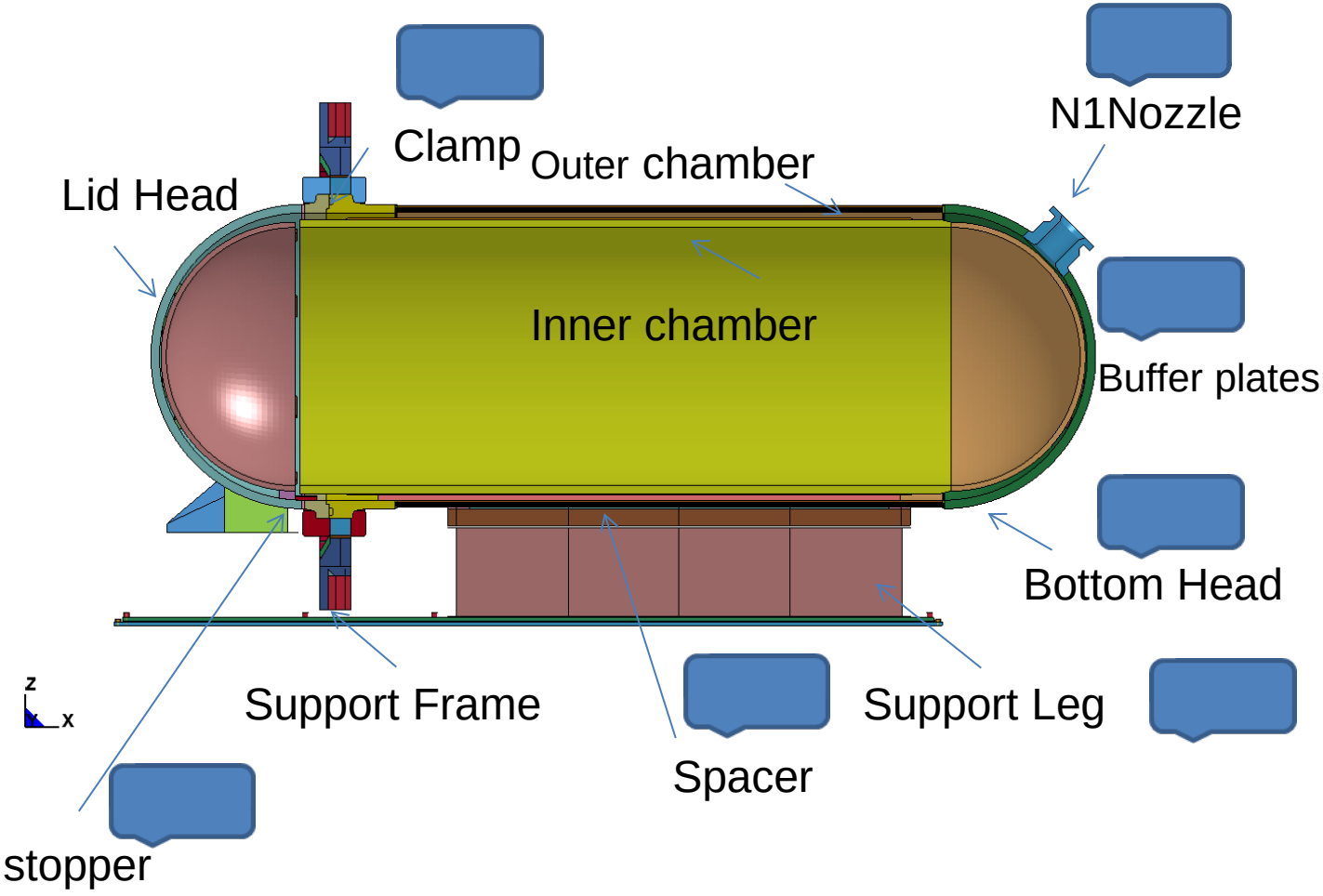
3. Fatigue evaluation



Strain time history at
Bottom Head (TNT 60Kg)

Updated DAVINCH chamber configuration





Improvement of structural design

1. Structural design improvement

1.1 Nozzle orientation

1.2 Head shape

1.3 Saddle reinforcement

1.4 Buffer plates between O/I chambers

1.5 Clamping system

1.5.1. Bolting type to hydraulic cylinder type
1.5.2. From self standing to being incorporated in the chamber

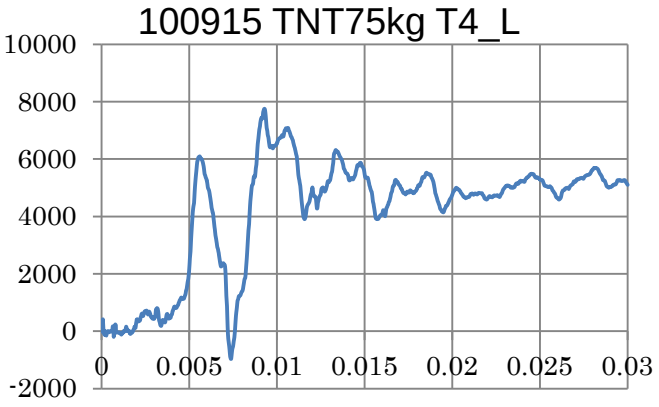
1.6 Structure to minimize the inner chamber movement

2. Performance improvement

2.1 Lower strain of critical points

Improvement of analysis model

Analysis model modification reflecting the operation and test data

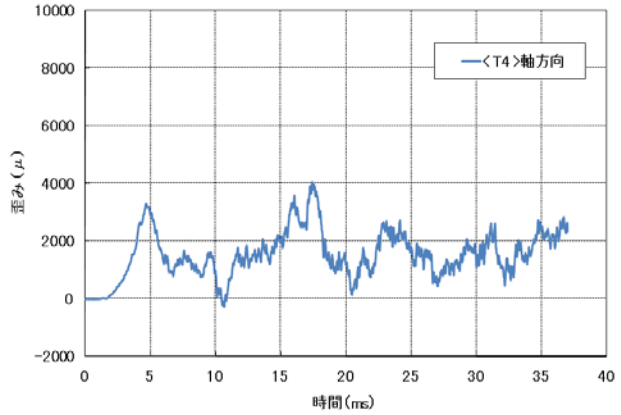


There is a deficiency between test data and previous analysis model. The following improvements of the analysis model result in the better coincidence.

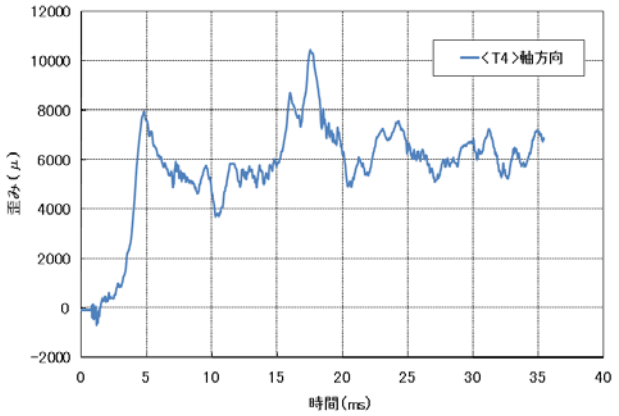
1. Refined the mesh size of around the discontinuity location such as welding
2. Refined evaluation cycle time to be same as test
3. Considered the effect of the strain change rate and hardening of the material

The experimental data(strain history)

Critical point;
Outer shell to saddle



The analytical data original

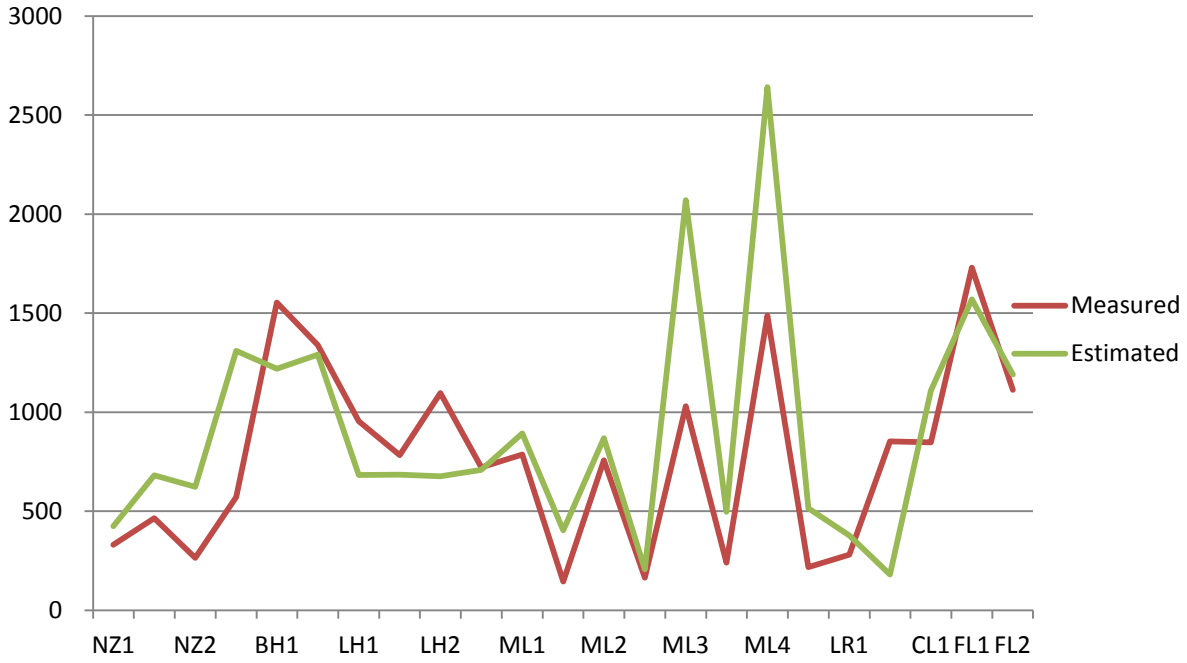


The analytical data improved

Analysis model verification

The experimental test data of updated DAVINCH chamber shows the good coincidence with the analytical result with improved analytical model .

Figure. The peak strain data of critical location of updated DAVINCH Chamber (Estimated; analytical data, Measured; experimental data)

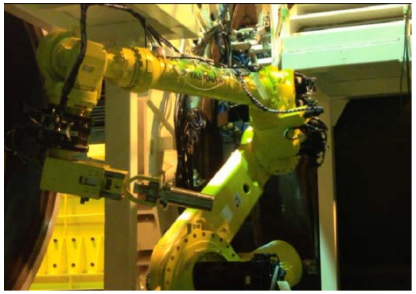


Improvement of operability

1. Reduce the risk to enter into the confinement area

The moving deck and robotic
(Transport the munition and hang it on the hook)

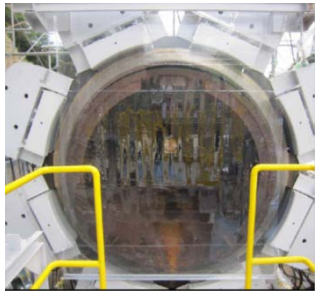
Magnet lifter
(Remove the fragment after detonation)



Robot
(Complete the detonation circuit)

2. Prevent the dust dispersion

Shroud
(Keep the dust in it when the Lid is opened)



Roll curtain
(Keep the air flow rate higher when the Lid is opened)

These special tools and equipment are applied according to the site requirements

New Application of DAVINCH system (1/2)

High explosive munition and missile

1. Advantage of other application of DAVINCH system
   - 1.1 Closed system
   - 1.2 Low risk of transportation

2. Required structural integrity of DAVINCH chamber
   - 2.1 Blast wave and air tightness for outer chamber
   - 2.2 Fragment damage to the inner chamber (special attention to this requirement)
     - 2.2.1 High velocity deformation analysis
     - 2.2.2 High velocity impact test

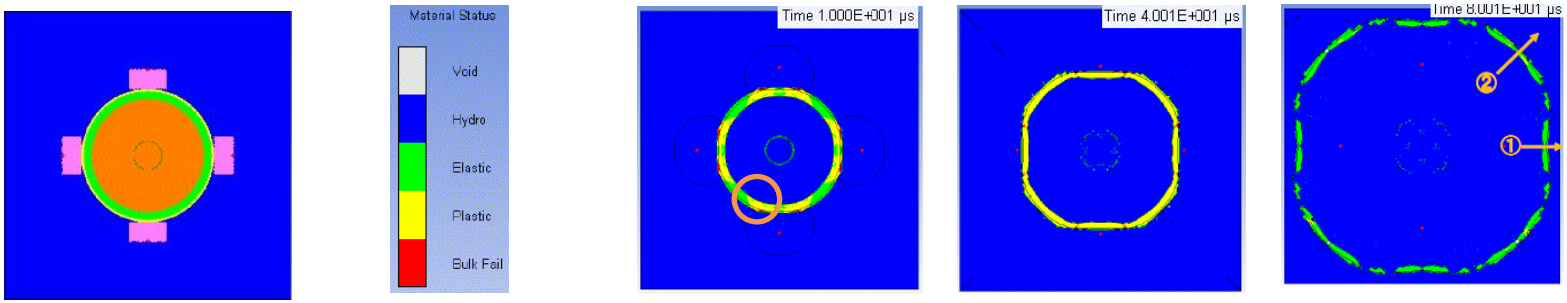
New Application of DAVINCH system(1/2)
High explosive munition and missile

1. Operation process

Setting the donor charge onto munition to detonate the munition explosive

2. Purpose of evaluation

Investigate the implosion behavior of the munition and the inner chamber and minimize the damage and extend the life by most suitable amount and arrangement of donor charge.



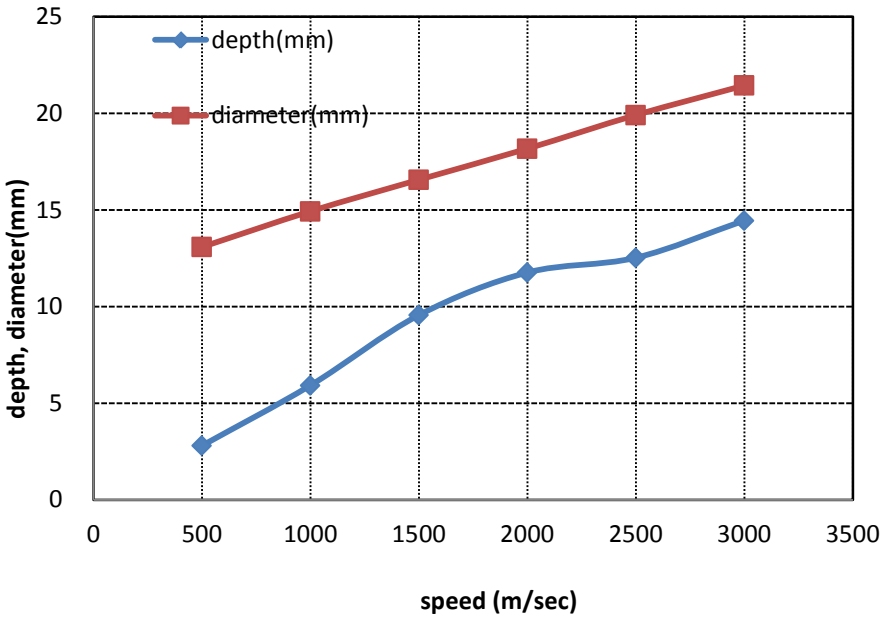
Material status 1 micro sec 4 micro sec 8 micro sec

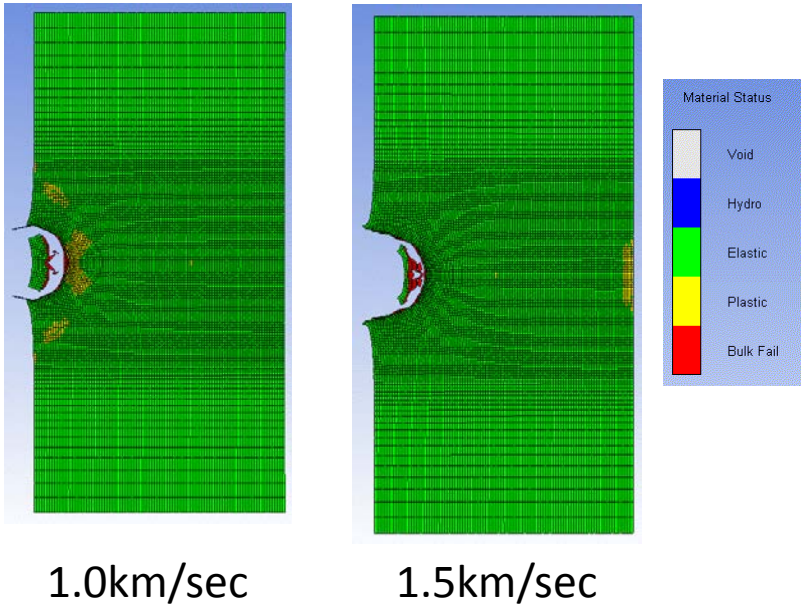
Figure. Example of high explosive war head destruction behavior

The velocity and direction of fragments after explosion of H.E. using donor charge will be obtained by the calculation and analysis

New Application of DAVINCH system(1/2)
High explosive munition and missile

The depth and diameter of the deformation of the inner chamber by the fragment will be investigated by the calculation and analysis using the data of the fragment size and velocity analyzed.
This analysis model and the obtained result are reviewed and verified by comparison with the actual operation or experimental data.





1.0km/sec　　1.5km/sec

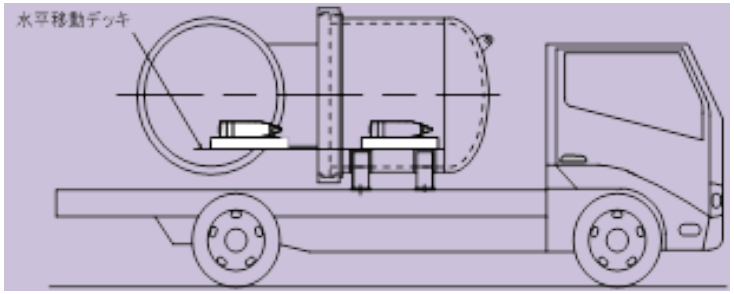
SS400 steel plate deformed by impact of 10mmDx10mmL 4340 steel cylinder

New Application of DAVINCH system(2/2)
A novel small chamber for urban area

DAVINCH chamber technology can be applied to a novel small chamber with following performances appropriate for the problem in the urban area for defusing, transportation and temporary storage of UXO.

1. Mounted on the 3 ton truck. (limited size and weight)
2. A feasible handling supporting system.
3. Structural integrity when unintentional explosion occurred

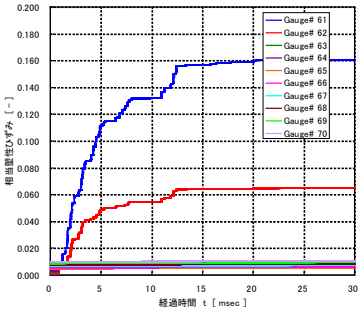
. 3.1 No collapse by the blast wave
3.2 No penetration by the munition fragment
3.3 Blast wave effect through clutch door satisfies the requirements of the safety standard for human and glass



New Application of DAVINCH system(2/2)
A novel small chamber for urban area

3.1 No collapse by blast wave

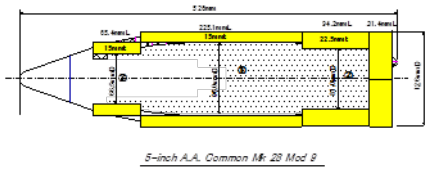
Pressure distribution
(Blast wave analysis)



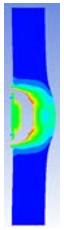
Equivalent plastic strain history

Analyzed strain is expected
to be less than braking strain(1.10),
so no fracture is observed.

3.2 No penetration by the munition fragment



Analysis model of
explosion of munitions



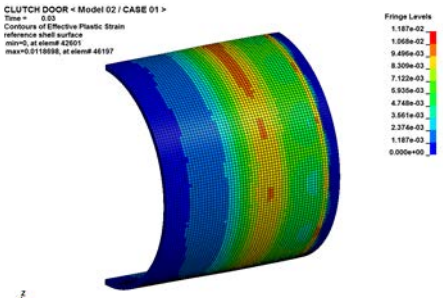
High velocity
deformation
analysis

High velocity impact test

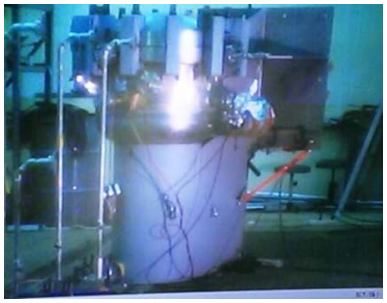
The penetration by
fragment will not be
observed by test in
some conditions

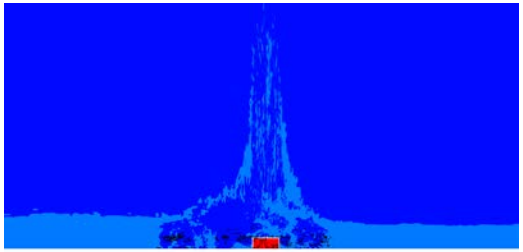
New Application of DAVINCH system(2/2)
A novel small chamber for urban area

3.3 Blast wave effect through clutch door satisfies the requirements of the safety standard for human and glass

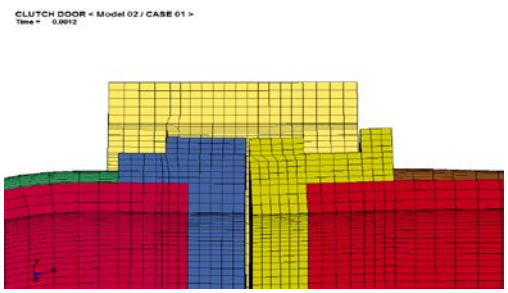


Deformation analysis for structure





Blast wave experiment and analysis with estimated gap



Deformation analysis for clutch door

to estimate the expected gap after detonation

The safety standard of DOD6065.9 is satisfied at designated location.

Pressure shall be below followings

1) Window Glass(big size); 0.45KPa
2) Ear drum; 21KPa
3) Lung; 103KPa

Summary

1. Kobe Steel, Ltd. has 15 years' experience for chemical agent destruction and has accumulated a substantial volume of test and operation data.

2. The lessons learned data is reflected not only on the hardware design of the DAVINCH system but also on the software design scheme including an analysis model.

3. The improved design scheme established in the DAVINCH system has been applied the development of a novel small chamber for the urban areas.