

Imperial College

OF SCIENCE, TECHNOLOGY AND MEDICINE

DEPARTMENT OF MECHANICAL ENGINEERING

Prediction of Dynamic Fracture in Pressurised Plastic Pipes

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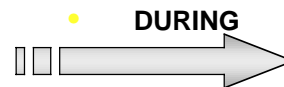


Introduction - experimental procedures

Full scale test



• BEFORE

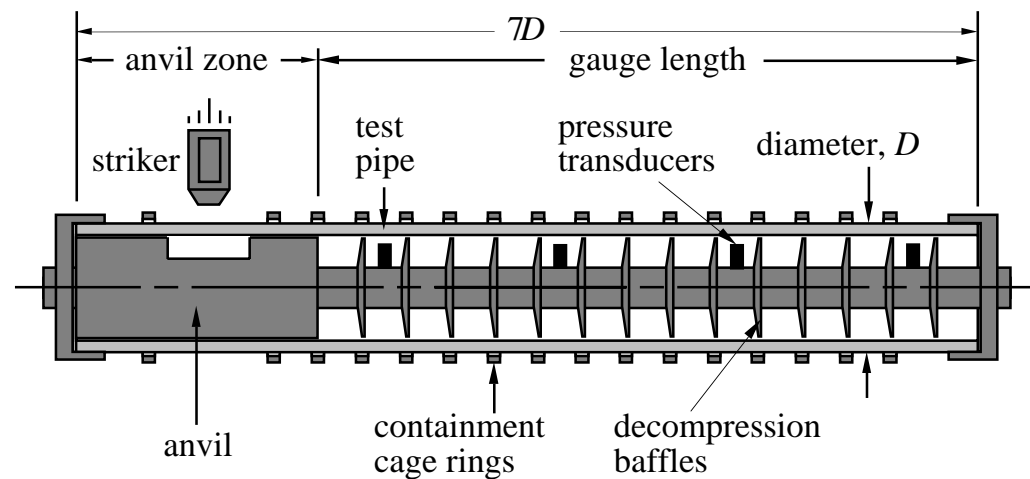


• AFTER



Introduction - experimental procedures

Small scale steady-state test (S4)

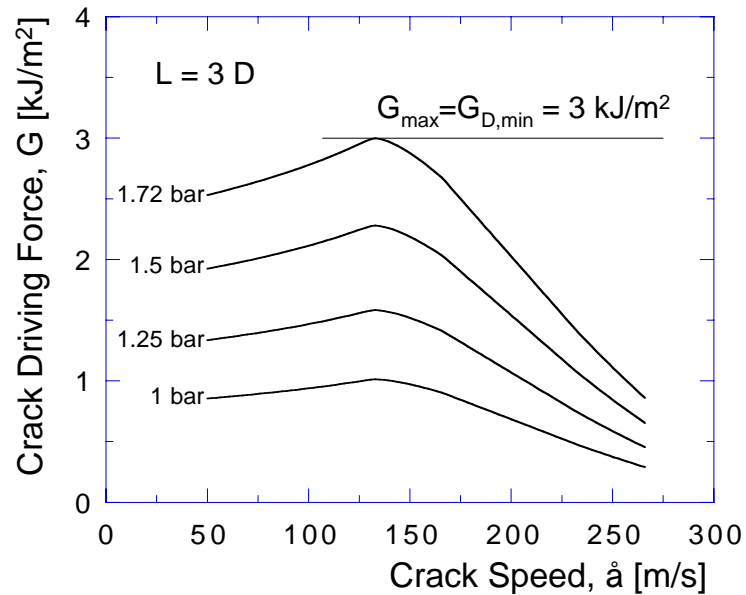




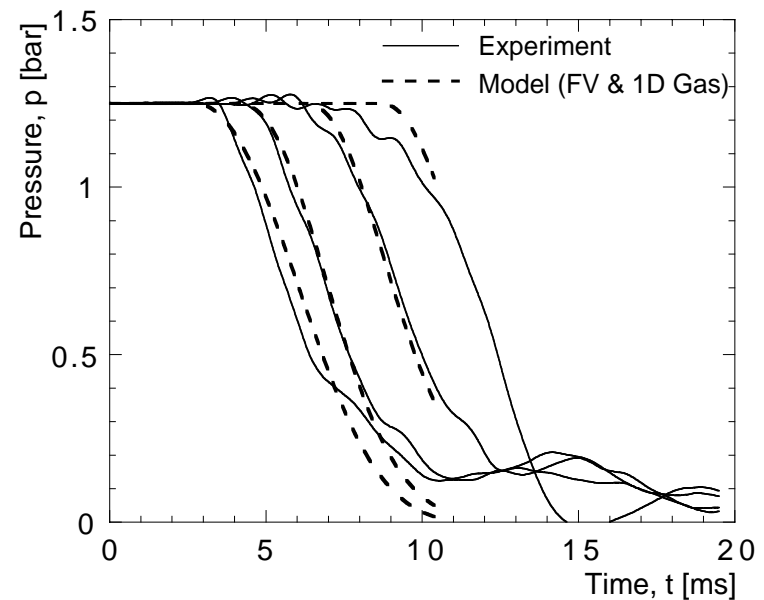
Introduction - numerical procedures

Previous work

1. Solid + pressure profiles



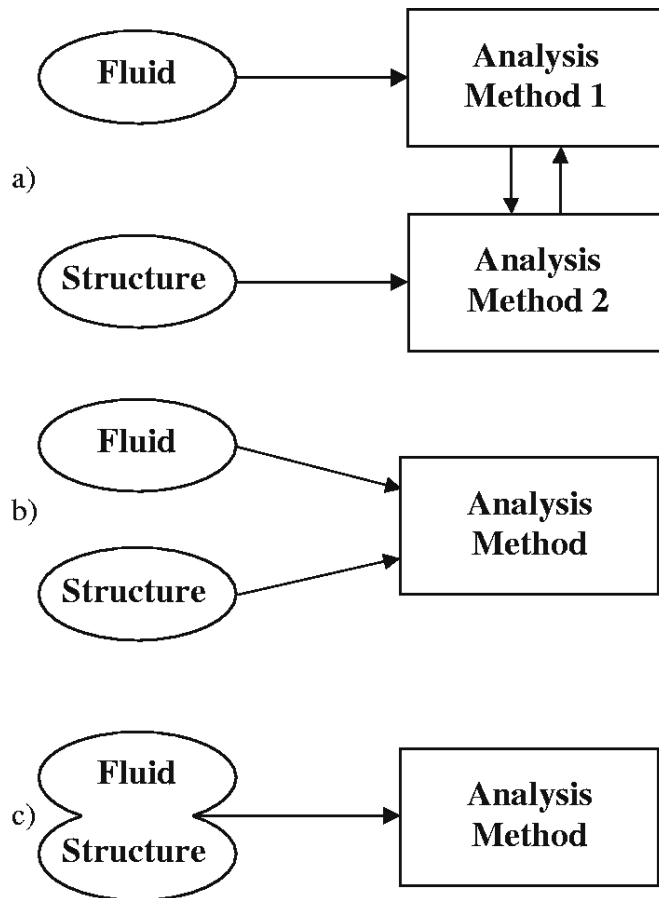
2. Solid + 1D gas dynamics





Fully predictive 3D model

Fluid-structure coupling



a) Weakly coupled - interacting

b) Strongly coupled - interacting

c) Fully coupled - coupled



Fully predictive 3D model

Solution scheme for FSI

START OF TIME STEP

Solve fluid

- Continuity equation (ρ)
- Momentum equation (\mathbf{V})
- Temperature equation (T)
- Equation of state (ρ)
- Pressure equation (p)
- Velocity correction (\mathbf{V})

PISO

Solve structure

- Transfer traction from the fluid to the solid boundary on interface
- Momentum equation (\mathbf{U})

Equate velocity at interface (\mathbf{V}) to solid wall velocity ($\partial \mathbf{U} / \partial t$)

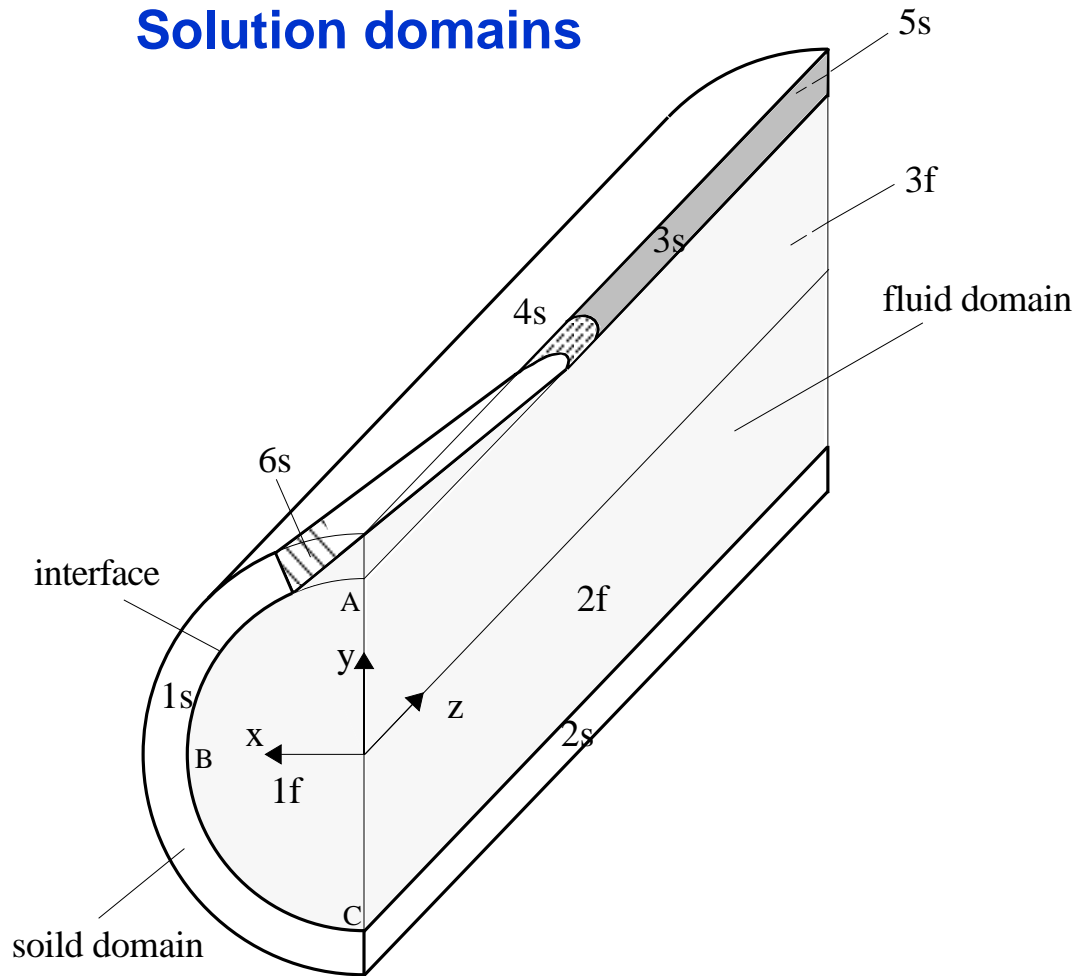
END OF TIME STEP

(implicit scheme only)

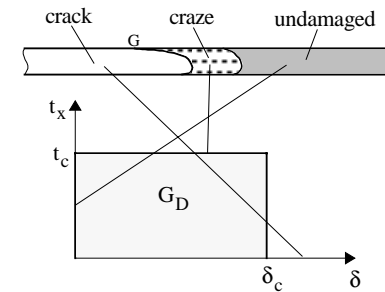


Fully predictive 3D model

Solution domains



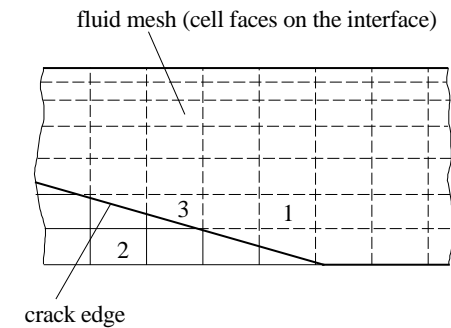
a) Crack propagation model
(view of 3s from -ve x direction)



t_x - normal traction on the fracture surface 3s
shear tractions assumed zero (mode I)

δ - crack opening displacement

b) Coupling procedure for fluid domain
(view from +ve y direction)

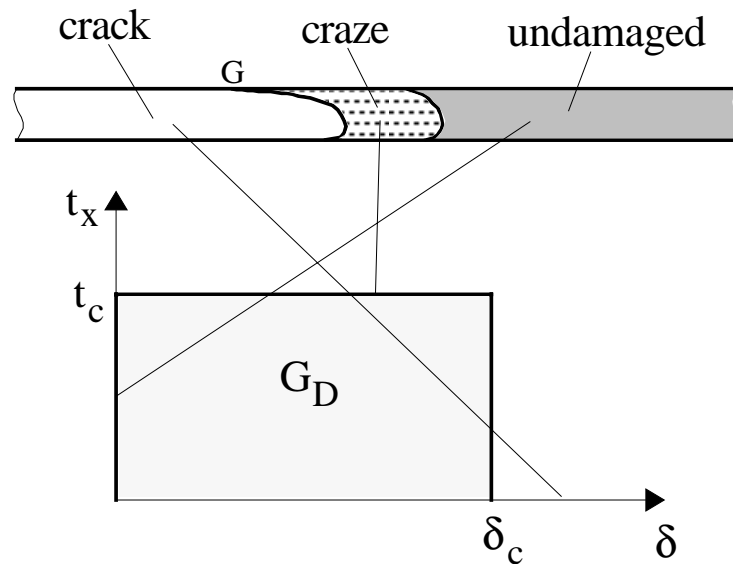


- 1) fully covered
- 2) fully uncovered
- 3) partly covered



Fully predictive 3D model

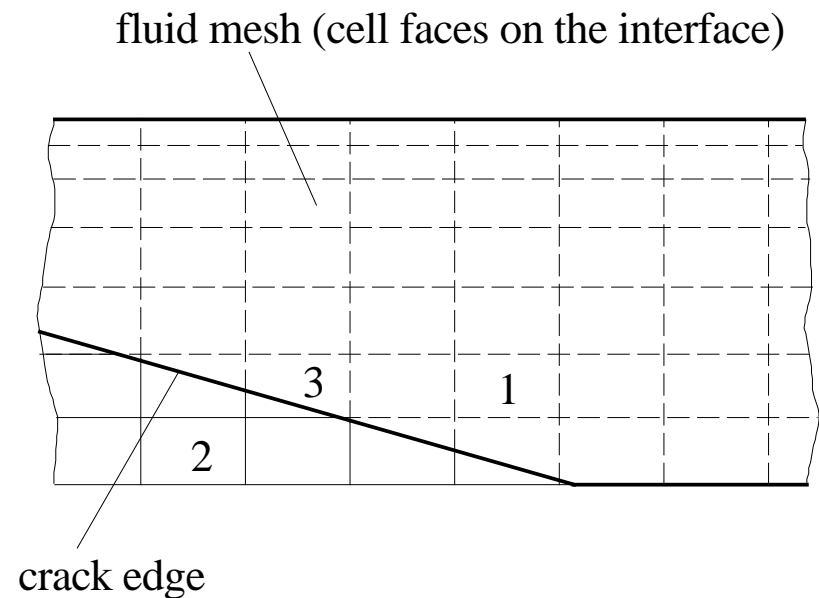
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(view from +ve y direction)



- 1) fully covered
- 2) fully uncovered
- 3) partly covered



RCP simulation

- 3m long 250SDR11 PE80
- The solid domain was discretised with 67968 cells, while 77408 cells were used to represent the fluid domain
- The initial nominal pressure was set at $p = 5$ bars (absolute).
- Solid (linear elastic Hookean sold):

Young's modulus	$E = 2.5$ GPa,
Poisson's ration	$\nu = 0.4$,
Mass density	$\rho = 940$ kg/m ³ .
- Fluid (ideal gas):

Dynamic viscosity	$\eta = 18.45$ μ Pas
Specific heat	$C_v = 717.86$ J/kgK,
Gas constant	$R = 287.14$ J/kgK,
Density	$\rho = p/RT$
- Cohesive zone model parameters:

Maximum stress t_c	$= 20$ Mpa
Fracture resistance G_D	$= 5$ kJ/m ²
- The computations were performed using a constant time step of 5 μ s for both domains, and the solution was run for 0.01 s.



RCP simulation

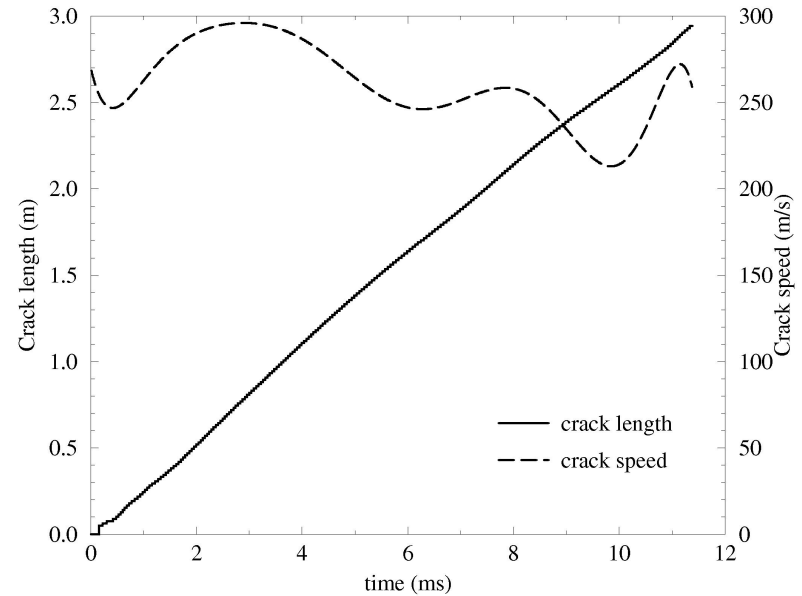
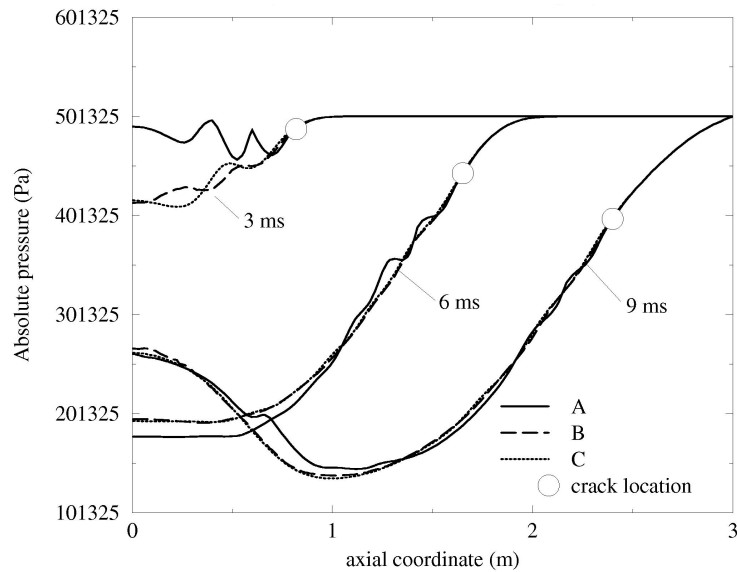


RCP simulation



RCP simulation

Some quantitative results





Conclusions and future work

- The fully 3D fluid -structure-RCP model is developed
- The model can be used for accurate, efficient and economical calculation of **critical pressure**, for both FS and S4 tests
 - the number of tests can be reduced
 - the large-diameter pipes can be easily simulated
- The final goal: **Development of the model for predicting brittle-tough transition of plastic pipes**
 - temperature dependent traction-separation law required