Smoothed Particle Hydrodynamics Method in LS-DYNA

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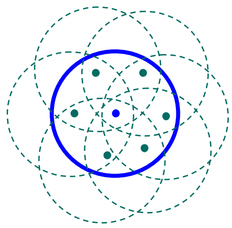
Outline

LS-DYNA

- Aspects of Smoothed Particle Hydrodynamics
- The SPH method in LS-DYNA
- LS-PRE/POST



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I.
ASPECTS OF
SMOOTHED PARTICLE HYDRODYNAMICS

Smooth Particle Hydrodynamics in LS-DYNA LS-DYNA

- A lagrangian collocative method - explicit
- Solve 1. Conservation of mass
  2. Conservation of momentum
  3. Conservation of energy if necessary
- Apply for Impact/Penetration, In/compressible Flow
- Difficult to handle boundary conditions
- Accuracy is low compare to F.E. or EFG Methods

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INTERESTS OF THE METHOD

LS-DYNA

- No connectivity between the particles (meshfree method)
- Can handle high deformations in a lagrangian frame
- Particles = interpolation points => simple

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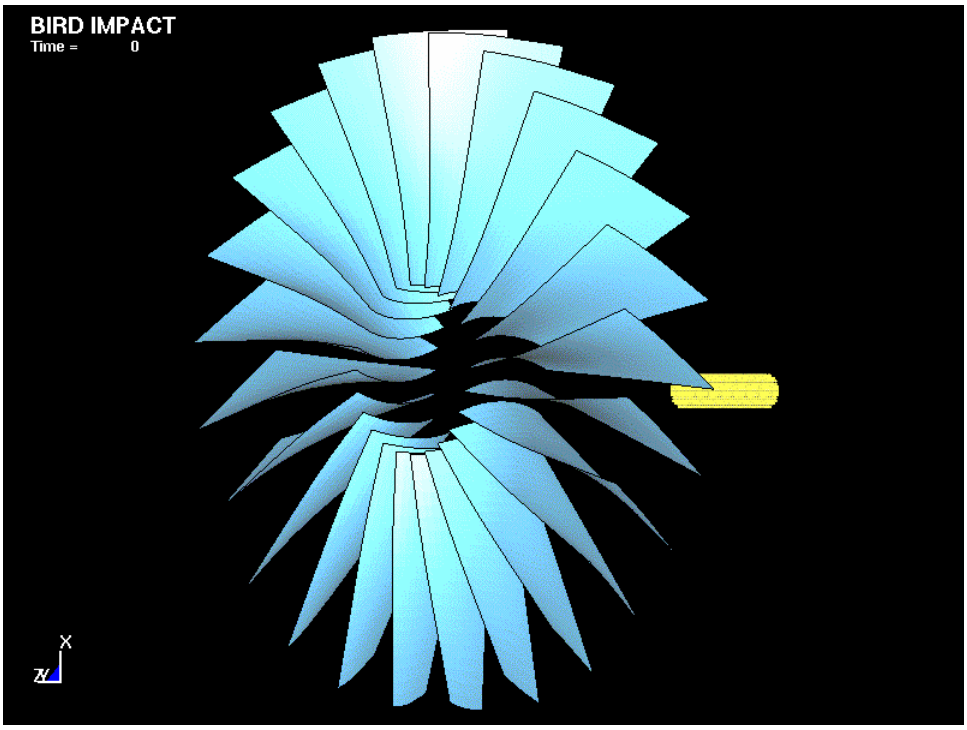
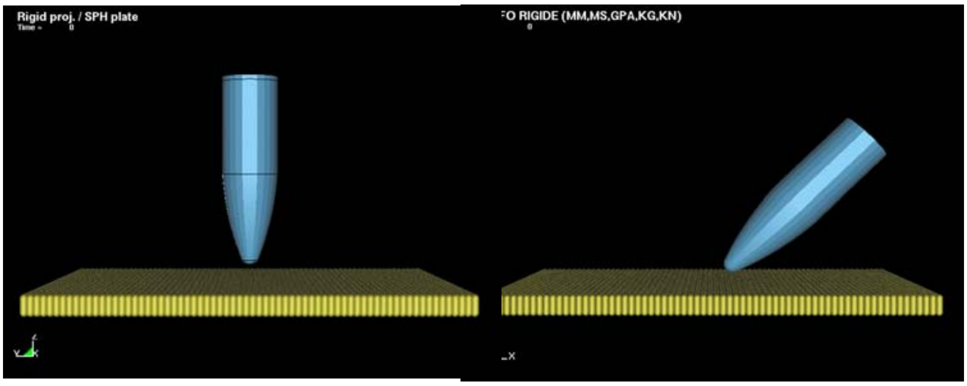


LS-DYNA



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II.

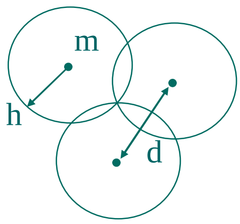
The SPH Method in LS-DYNA

PARTICLE MODEL

LS-DYNA

Typical lengths

- mass *m*
- distance *d* between particles
- Smoothing length *h*



2 parameters of discretization : h and d $\neq$ classical methods

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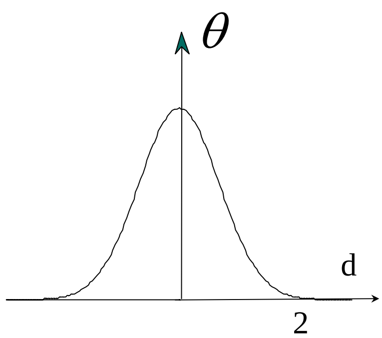
SMOOTHING FUNCTION

LS-DYNA

$$W(d,h) = \frac{1}{h^{\alpha}(x,y)}\,\theta\left(\frac{d}{h(x,y)}\right)$$

$$\theta(d) = C \times \begin{cases} 1 - \frac{3}{2}d^2 + \frac{3}{4}d^3 & \text{si} \quad 0 \le /d/ \le 1 \\ \frac{1}{4}(2-d)^3 & si \quad 1 \le /d/ \le 2 \\ 0 & \text{elsewhere} \end{cases}$$



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SPH APPROXIMATIONS

LS-DYNA

Particle approximation of a function:

$$\Pi^h u(x_i) = \sum_j \frac{m_j}{\rho_j} u(x_j) W(x_i - x_j, h)$$

Particle approximation of the Gradient :

$$\Pi^h \nabla u(x_i) = \sum_j \frac{m_j}{\rho_j} [u(x_j) A_{ij} - u(x_i) A_{ji}]$$

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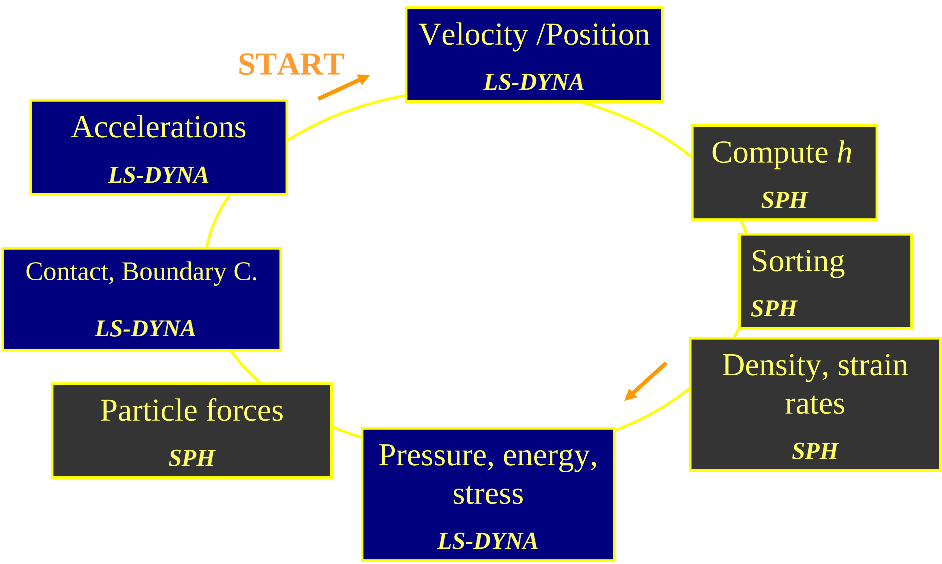
ONE CYCLE LOOP IN LS-DYNA

LS-DYNA



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*CONTROL_SPH

LS-DYNA

- Global keyword on SPH. Deals with all the SPH parts of the model

Variable	NCBS	BOXID	DT	IDIM	NNEI	IFORM	START	MAXVEL
Type	I	I	F	I	I	I	F	F
Default	1	None	1.E20	none	150	0	0.	1.E20

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*CONTROL_SPH

LS-DYNA

- 2nd card(optional)

Variable	CONT	DERIV	INIT
Type	I	I	I
Default	0	0	0

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*CONTROL_SPH in LS970_5434 (aug'04) LS-DYNA

- IFORM : *Particle approximation theory*

- Gives which formulation is used for the approximation

0 : standard formulation (default)

1 : renormalized formulation

2 : symmetric formulation

3 : symmetric formulation with renormalization

4 : elliptical formulation (not to be defined here)

5 : fluid formulation

6 : fluid formulation with renormalization

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SUMMARY OF IFORM VARIABLE LS-DYNA

- *Conservation of momentum*

$$\frac{dv_i}{dt} = -\sum_{j \in P} m_j \left(\frac{\sigma_i}{\rho_i^2} A_{ij} - \frac{\sigma_j}{\rho_j^2} A_{ji} \right)$$ *IFORM = 0*

$$\frac{dv_i}{dt} = -\sum_{j \in P} m_j \left(\frac{\sigma_i}{\rho_i^2} + \frac{\sigma_j}{\rho_j^2} \right) \nabla W_{ij}$$ *IFORM = 2*

$$\frac{dv_i}{dt} = -\sum_{j \in P} \frac{m_j}{\rho_i \rho_j} \left(\sigma_i A_{ij} - \sigma_j A_{ji} \right)$$ *IFORM = 5*

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SUMMARY OF IFORM VARIABLE

LS-DYNA

- *Conservation of momentum*

$$\frac{dv_i}{dt} = -\sum_{j\in P} m_j \left(\frac{\sigma_i}{\rho_i^2} A_{ij} - \frac{\sigma_j}{\rho_j^2} A_{ji} \right) : B_{ij}$$

IFORM = 1

$$\frac{dv_i}{dt} = -\left(\sum_{j\in P} m_j \left(\frac{\sigma_i}{\rho_i^2} + \frac{\sigma_j}{\rho_j^2} \right) \nabla W_{ij} \right) : B_{ij}$$

IFORM = 3

$$\frac{dv_i}{dt} = -\sum_{j\in P} \frac{m_j}{\rho_i \rho_j} \left(\sigma_i A_{ij} - \sigma_j A_{ji} \right) : B_{ij}$$

IFORM = 6

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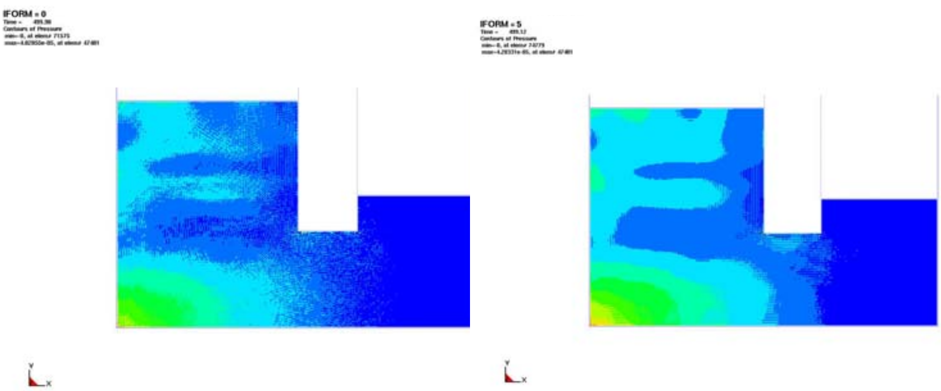
LS-DYNA



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*BOUNDARY_SPH_SYMMETRY_PLANE LS-DYNA

• Allows the definition of a symmetry plane. Creates ghost particles

Variable	VTX	VTY	VTZ	VHX	VHY	VHZ		
Type	F	F	F	F	F	F		
Default								

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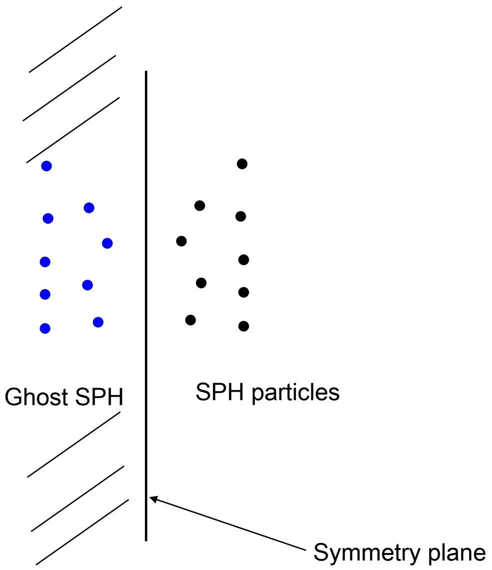
*BOUNDARY_SPH_SYMMETRY_PLANE LS-DYNA



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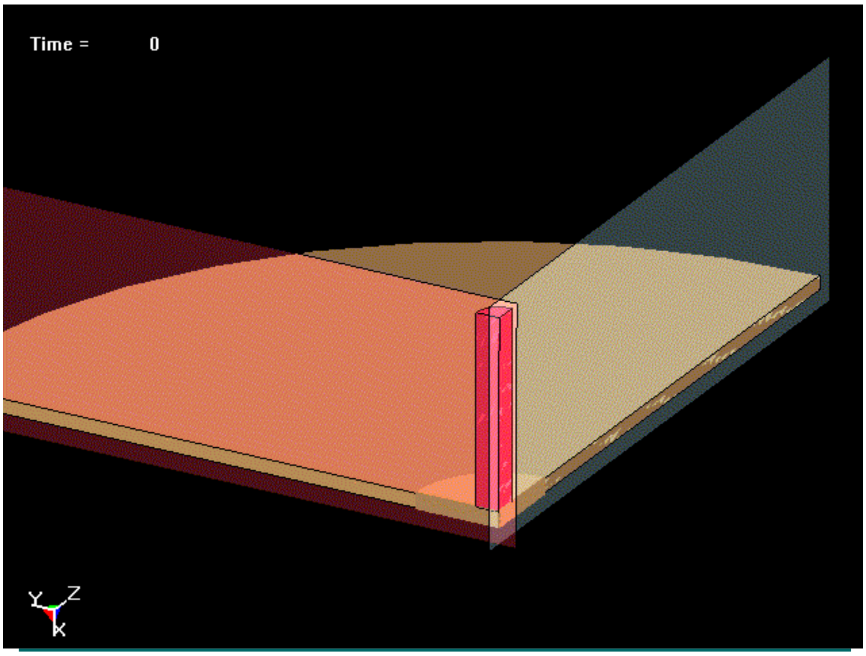


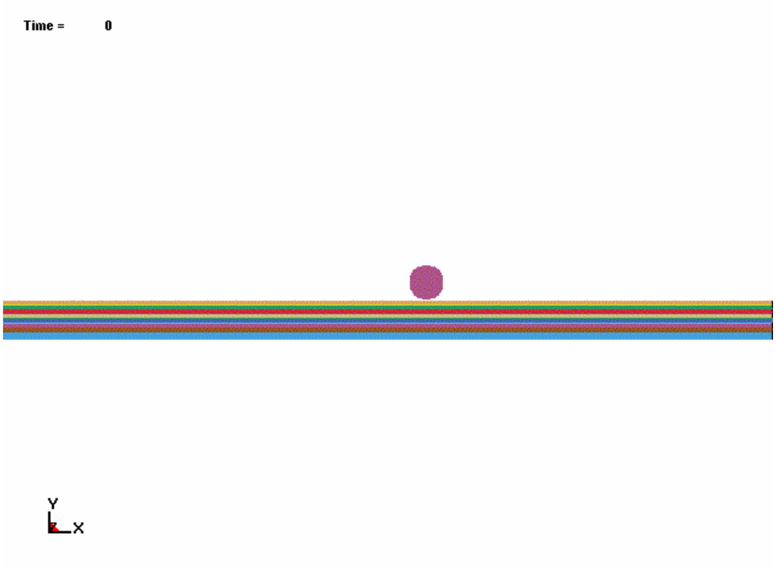
*SECTION_SPH_USER

LS-DYNA

- Allows the user to define his own variation for the smoothing length
- Have to define the variables of the first card of *SECTION_SPH
- Subroutine *hdot* is defined in *dyn21.f* and is called by the code.
- Available only in ls971

*SECTION_SPH_USER

LS-DYNA



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III.

LS-PRE/POST

REGULAR MESH (1/3)

LS-DYNA

- Regular mesh

  => correct

- Irregular mesh

  => not correct

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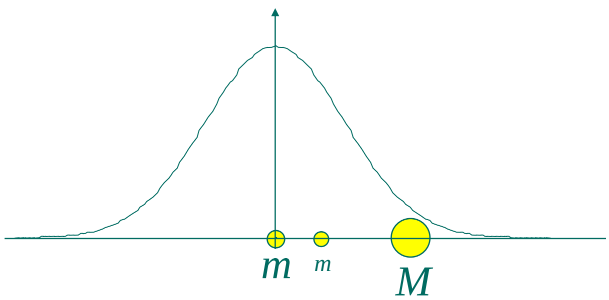
REGULAR MESH (2/3)

LS-DYNA

- Try to avoid situations like :



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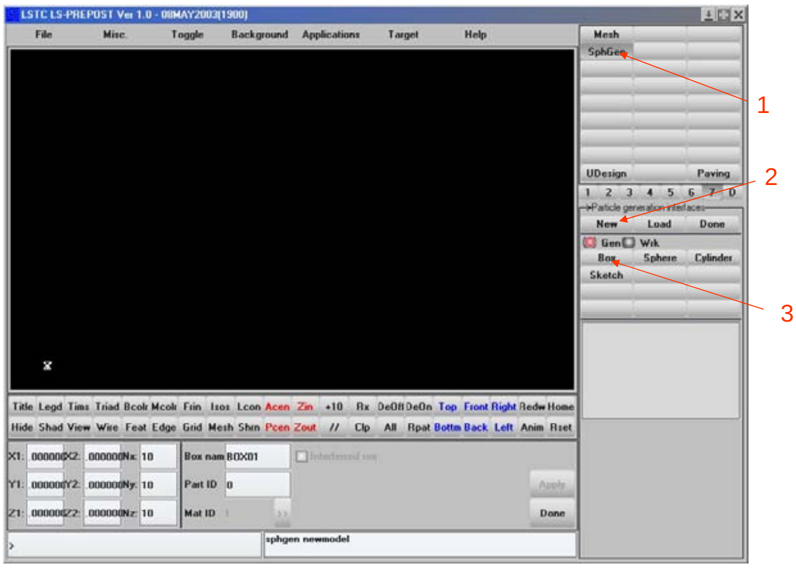
CREATE A CUBE

LS-DYNA



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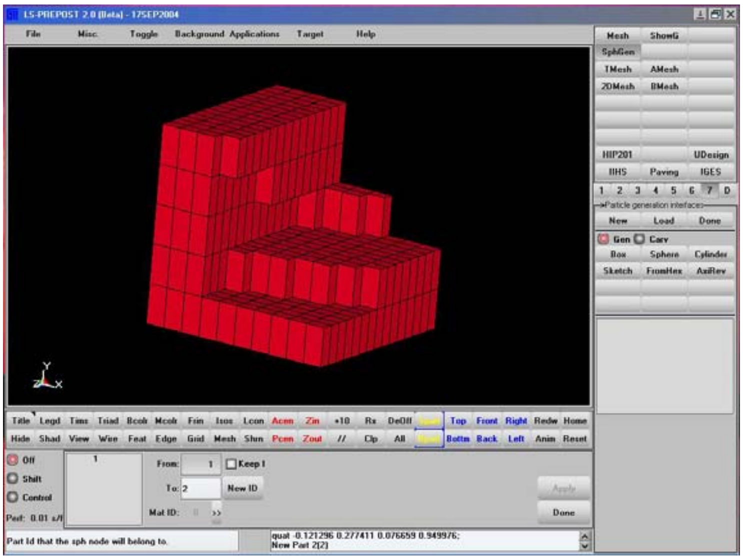
SWITCH FROM HEXAHEDRON

LS-DYNA



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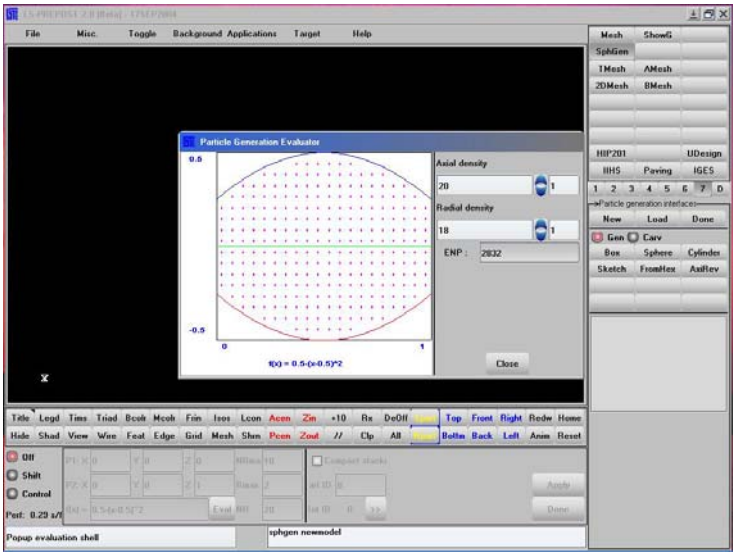
Axis of Revolution

LS-DYNA



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