Open Opened 7 months ago by **Alan Stagg** 0 of 2 tasks completed

implement multimaterial framework in restructured FLEXO

Task

What Needs to be Done?

- [ ] implement data structures and code logic to support multimaterial problems.
- [ ] add multimaterial test problems.

Done Criteria

Weight

Question	Points
Q_1: Is this story time consuming to program or develop? Yes = 5, No = 1	3
Q_2: Is this story difficult to test? Yes = 3, No = 0	1
Q_3: Will the completion of this story rely on other people? Yes = 3, No = 0	0
Q_4: Is this body of work brand new to you? Yes = 5, No = 1	1
Total: $(Q_1 + Q_2) \cdot (Q_3 + Q_4)$	4

Alan Stagg @akstagg added Task label 7 months ago

tevoth @tevoth · 7 months ago Owner

Implemented (@akstagg , @bngranz , @micpowe , @tevoth) 5-equation, uniform strain, multi-material capability in FLEXO (currently p=0 elements).

$$\begin{cases} \frac{\partial \alpha_1}{\partial t} + u\frac{\partial \alpha_1}{\partial x} = 0 \\ \frac{\partial (\alpha\rho)_1}{\partial t} + \frac{\partial (\alpha\rho)_1 u}{\partial x} = 0 \\ \frac{\partial (\alpha\rho)_2}{\partial t} + \frac{\partial (\alpha\rho)_2 u}{\partial x} = 0 \\ \frac{\partial (\rho u)}{\partial t} + \frac{\partial (\rho u^2 + p)}{\partial x} = 0 \\ \frac{\partial (\rho E)}{\partial t} + \frac{\partial (\rho E + p) u}{\partial x} = 0 \end{cases}$$

$$\rho = (\alpha\rho)_1 + (\alpha\rho)_2$$

$$e = m_1 e_1 + m_2 e_2$$

$$m_k = \frac{(\alpha\rho)_k}{\rho}$$

$$p = \frac{\rho e}{\frac{\alpha_1}{\gamma_1 - 1} + \frac{\alpha_2}{\gamma_2 - 1}}$$

$$E = e + \frac{1}{2}u^2$$

see LA-UR-11-04985.

Movie below shows Sod problem:

```
in.gamma(0) = 2.0
in.gamma(1) = 1.4
in.rho[0] = 1.0
in.rho[1] = 0.125
```

```
in.vf[0] = (x[0] < 0.5) ? 1.0 : 1.0e-8
in.vf[1] = (x[0] < 0.5) ? 1.0e-08 : 1.0
in.v = {0, 0, 0}
in.p = (x[0] < 0.5) ? 1.0 : 0.1
```

0:00 / 0:10

sod_diffgamma

tevoth @tevoth · 6 months ago Owner

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0:00 / 0:10

sod_diffgamma

tevoth @tevoth · 6 months ago Owner

Had been having issues with p > 0 where oscillations quickly killed those simulations. Tried SUPG-like stabilization

without much luck. Added (primitive variable based) limiting (no additional stabilization) and now can run initially unmixed, two material (same gamma) SOD shock-tube problem and see no oscillations. This is the same problem as described in the above with the exception that gammas are 1.4.

Below is a movie of the total density (sum of partial densities). Note that p=1 element is sharper in the contact (as well as at the shock).

0:00 / 0:05

P0vsP1_density_total

Next is the partial density of material 0 for p = 0 and p = 1 (black and red lines resp.). Again p = 1 produces sharper resolution of the contact.

0:00 / 0:05

P0vsP1_density0

And finally the partial density of material 1 p = 0 and p = 1 (black and red lines resp.). Note the different scale here (material 1 is the lower (thermodynamic) density material.

0:00 / 0:05

P0vsP1_density1

Edited by tevoth 6 months ago

Alan Stagg @akstagg · 6 months ago Owner

Adding exact Riemann solution data for single material Sod problem (1000 data points) at t=0.2:

density.csv
pressure.csv
velocity.csv

initial conditions:
rho_left = 1, rho_right = 0.125
vel_left = 0, vel_right = 0
p_left = 1.0, p_right = 0.1
gamma_left = 1.4, gamma_right = 1.4
domain extent = [0,1]
contact location = 0.5

Data can be imported into Paraview for comparison within PlotOverLine:

first load data: % paraview density.csv
then: use TableToStructuredGrid filter. Whole Extent is 0 to 999 for X and 0 for other entries. Set X column to xcoord, and Y and Z columns to zero. Then create PlotOverLine, etc.

Sample comparison to Flexo p0 solution with 1000 elements:

Alan Stagg @akstagg · 6 months ago Owner

Two-material Sod problem calculation compared to exact Riemann solution. Same initial conditions as above, but with left and right initial states corresponding to different materials (and with gamma_left = 2.0).