Material Models and the Uintah Computational Framework

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equation of state. The deviatoric response is determined either by an elastic constitutive equation or using a plastic flow rule in combination with a yield condition.

2.1 Hypoelastic-plastic Stress Update

This section describes the current implementation of the hypoelastic- plastic model.

The elastic response is assumed to be isotropic. The material constants that are taken as input for the elastic response are the bulk and shear modulus. The flow rule is determined from the input and the appropriate plasticity model is created using the `PlasticityModelFactory`

2.2 Hyperelastic-plastic Stress Update

The stress update used for the hyperelastic-plastic material is a return mapping plasticity algorithm based on a multiplicative decomposition of the deformation gradient and the intermediate configuration concept. The algorithms has been taken from Simo and Hughes (1998) [2].

The variables that are evolved locally in the Hyperelastic-plastic stress update algorithm are the de(v)20iatoric part of the left Cauchy-Green tensor and a scalar damage variable.

The plasticity, damage and equation of state models are initialized and called in exactly the same way as in the hypoelastic-plastic model. Therefore, the stress update algorithm and the plasticity, damage and equation of state

```
<material>

  <include href="inputs/MPM/MaterialData/MaterialConstAnnCopper.xml"/>
  <constitutive_model type="hypoelastic_plastic">
    <tolerance>5.0e-10</tolerance>
    <include href="inputs/MPM/MaterialData/IsotropicElasticAnnCopper.xml"/>
    <include href="inputs/MPM/MaterialData/JohnsonCookPlasticAnnCopper.xml"/>
    <include href="inputs/MPM/MaterialData/JohnsonCookDamageAnnCopper.xml"/>
    <include href="inputs/MPM/MaterialData/MieGruneisenEOSAnnCopper.xml"/>
  </constitutive_model>

  <burn type = "null" />
  <velocity_field>1</velocity_field>

  <geom_object>
    <cylinder label = "Cylinder">
      <bottom>[0.0,0.0,0.0]</bottom>
      <top>[0.0,2.54e-2,0.0]</top>
      <radius>0.762e-2</radius>
    </cylinder>
    <res>[3,3,3]</res>
    <velocity>[0.0,-208.0,0.0]</velocity>
    <temperature>294</temperature>
  </geom_object>

</material>
```

The general material constants for copper are in the file `MaterialConstAnnCopper.xml`. The contents are shown below

```
<?xml version='1.0' encoding='ISO-8859-1' ?>
<Uintah_Include>
  <density>8930.0</density>
  <toughness>10.e6</toughness>
  <thermal_conductivity>1.0</thermal_conductivity>
  <specific_heat>383</specific_heat>
  <room_temp>294.0</room_temp>
  <melt_temp>1356.0</melt_temp>
</Uintah_Include>
```

The elastic properties are in the file `IsotropicElasticAnnCopper.xml`. The contents of this file are shown below.

```
<?xml version='1.0' encoding='ISO-8859-1' ?>
<Uintah_Include>
  <shear_modulus>45.45e9</shear_modulus>
  <bulk_modulus>136.35e9</bulk_modulus>
</Uintah_Include>
```

The constants for the Johnson-Cook plasticity model are in the file `JohnsonCookPlasticAnnCopper.xml`. The contents of this file are shown below.

```
<?xml version='1.0' encoding='ISO-8859-1' ?>
<Uintah_Include>
  <plasticity_model type="johnson_cook">
    <A>89.6e6</=o
```

```
  </plasticity_model>
</Uintah_Include>
```