目 录

主要材料模型及参数

1基本的状态方程

1.1EOS_JWL

1 3 5 #

Vatihte	EOD	A	H	风1	M1	FF	E	vo
Ty=	1	F	千	F	P	F	F	F

Remarks

The JWL equition of state defines the pressure as

$$p = A\left(1-\frac{\omega}{R_1 V}\right)e^{-R_1 V} + B\left(1-\frac{\omega}{R_2 V}\right)e^{-R_2 V} + \frac{\omega E}{V}$$

and is usually nsed for detonation products of high explosivex.

2.2EOS_GRUNEISEN

2 4 4 s 省 T

VattNe	to[D	C	Si	2	$3	GAHAO	A	Ea
1yie			F	P	F	F	F	P

Caid1

Vatb	Vo							
Tyr	F							

Remarkst

The Gruoeisen eqation of sate wab cuhie shock velocity-particle velocty defimes pressure fot compressed materials as

$$p = \frac{\rho_0 C^2 \mu\left[1+\left(1-\frac{\gamma_0}{2}\right)\mu-\frac{a}{2}\mu^2\right]}{\left[1-\left(S_1-1\right)\mu-S_2\frac{\mu^2}{\mu+1}-S_3\frac{\mu^3}{(\mu+1)^2}\right]^2}+\left(\gamma_0+a\mu\right)E$$

ant fur expanded materials as

$$P=AC'\mu+(X\%+\mu)E$$

where C is the intercepe of theyseYp curve:Si.Sz.und Sy are the coefficients of the slope of the e Vp urve:To is the Gruneisen gummat u is the firt erdet volume correcion 1o and $\mu=\frac{\rho}{\rho_0}-1$.

2.3EOS_LINEAR_POLYNOMIAL

(对 EOS_GRUNEISEN 进行线性化)

Cand 1 1 2 J 1 5 6

Veiahls	EOSD	C0	C1	C	C3	C4	C5	Cn
Trp	1		F	扩	节	F	F	

Canl2

Vataht	BP	w						
7yp		F						

Remarks

1.The linear polynomial equation of state is linear in intcmal energy.The pressure is given by;

P=C+Cμ+Gμ²+Gμ¹+(G+Cμ+C,μ)E,

where terms C2u?and Con²are se to zero irf $\mu < 0, \mu = \frac{\rho}{\rho_0} - 1$ md $\frac{\rho}{\rho_0}$ itheratie of curent density to initial deasity.

2.材料模型

2.1MAT_HIGH_EXPLOSIVE_BURN

Canl Parnat

Cad 1 2 J 4 5 1

Vwiahia	MID	RO	D	PCJ	BETA	K	G	SIOY
T)pe	1	F	F	F	F	卡	F	F

Burn fractions,F,which multiply the equations of states for high explosives,control the release of chemical energy for simulating detonations.At any time,the pressure in a high explosive element is given by:

p=Fp(V,E)

where /,is the pressure from the equation of state(either types 2 or 3),V is the relative volume, and E is the internal energy density per unit initial volume.

In the initialization phase,a lighting time t is computed for each element by dividing the distance from the detonation point to the center of the element by the detonation velocity D.If multiple detonation points are defined,the closest detonation point determines tt The burn fraction F is taken as the maximum wnere

$$F_1 = \begin{cases} \dfrac{2\left(t - t_l\right) D A_{e_{max}}}{3 v_e} & \text{if } t > t_l \\ 0 & \text{if } t \le t_l \end{cases}$$

$$F_2 = \beta = \frac{1 - V}{1 - V_{CJ}}$$

where V is the Chapman-Jouguet relative volume and t is current time.IfF exceeds I,it is reset tt 1.This calculation of the burn fraction usually requires several time steps for F to reach unity,thereby spreading the burn front over several elements.After reaching unity,F is held constant.This burr fraction calculation is based on work by Wilkins [1964]and is also discussed by Giroux [1973].

If the beta burn option is used,BETA=1.0,any volumetric compression will cause detonation and

$$F = F_2$$

and is not computed.

If programmed bum is used,BETA=2.0,the explosive model will behave as an elastic perfectly plastic material if the bulk modulus,shear modulus,and yield stress are defined. Therefore,with this option the explosive material can compress without causing detonation.

As an option,the high explosive material can behave as an elastic perfectly-plastic solid prior to detonation.In this case we update the stress tensor,to an elastic trial stress, $^{*}s_{ij}^{n+1}$

$$^{*}s_{ij}^{n+1} = s_{ij}^{n} + s_{ip}\Omega_{pj} + s_{jp}\Omega_{pi} + 2G\dot{\varepsilon}'_{ij}\, dt$$

where G is the shear modulus,and e is the deviatoric strain rate.The von Mises yield condition is given by:

$$\phi = J_2 - \frac{\sigma_y^2}{3}$$

where the second stress invariant,/₂,is defined in terms of the deviatoric stress components as

$$J_2 = \frac{1}{2} s_{ij} s_{ij}$$

and the yield stress is o.If yielding has occurred,ie.,φ>0,the deviatoric trial stress is scaled to obtain the final deviator ic stress at time n+1:

$$s_{ij}^{n+1} = \frac{\sigma_y}{\sqrt{3J_2}} \, {}^{*}s_{ij}^{n+1}$$

If φ≤0,then

^{1} =*

Before detonation pressure is given by the expression

$$p^{n+1} = K\left(\frac{1}{V^{n+1}} - 1\right)$$

where K is the bulk modulus.Once the explosive material detonates:

$$s_{ij}^{n+1} = 0$$

and the material behaves like a gas.

RDX

密度；1.69E+3 kg/m³: D:8310m/s: Pci:30.45 G

A:850 Gpa: B;18 Gpa: R_1:4.6: R_2;13: $w_0$38: E_0:10MJ/kg

For(g-cm-us):

```
*MAT_HIGH_EXPLOSIVE_BURN
          1       1.69     8.310     0.3015     0
*EOS JWL
                  8.50     0.18      4.6      1.3     0.38    10 e-02     1.00
```

HMX

密度：1.891E+3 kg/m³ D:9910m/s, Pcj:42Gpa

: aBp:G7.31.GβaΓ7:R:₁A:4.1;R_2:1.00; wo:30; E_0:10.5 M

For(g-cm-us):

```
*MAT_HIGH_EXPLOSIVE_BURN
          1       1.89     9.910
*EOS JWL                             0.42     0
          1      7.783     0.071
                                      4.2      1.0
                                                      0.30    10.5 e-02    1.00
```

TNT

密度：1.63 E+3 kg/m³ D:6930 m/s; Pci:27 Gpa:

A:371.2 Gpa; B:3.21 Gna; R:4.1 5; R,:0.9 5; wo:30 $E_0$4.29 MJ/kg

For(g-cm-us):

```
*MAT HIGH EXPLOSIVE BURN
     1    1.63    6.930    0.27    0
*EOS JWL
     1    3.713    0.0743    4.15    0.95    0.30    7.0 e-02    1.00
```

1.2MAT_NULL

Cmd1		2	3		3	6		
Vaniahe	MID	RO	Pe	MU	1EROO	CFROD	VM	PR
Tba*	1	F	F	F	P	F	F	
Dfangs		P	0. a	40	0北	. 0	核林	y.

The null material must be used with an equation of-state.Pressure cutoff is negative in tension. **A(deviatoric)viscous stress of the form**

$$\sigma=\mu e'。$$

$$\left[\frac{N}{m^2}\right]\approx\left[\frac{N}{m^2}s\right]\left[\frac{1}{S}\right]$$

is computed for nonzero μ where e'is the deviatoric strain rate.μ is the dynamic viscosity with unit of [Pascal*second].

2. The null material has no shear stiffness and hourglass control must be used with great care.In some applications,the default hourglass coefficient might lead to significant energy losses.In general for fluid(s),the hourglass coefficient QM should be small(in the range 1.0E-4to L.0E-6 in the SI unit system for the standard default IHQ choice).

3. The Null material has no yield strength and behaves in a fluid-like manner.

4. The pressure cut-off,PC,must be defined to allow for a material to "numerically"cavitate.In other words,when a material undergoes dilatation above certain magnitude,it should no longer be able to resist this dilatation.Since dilatation stress or pressure is negative,setting PC limit to a very small negative number would allow for the material to cavitate once the pressure in the material goes below this negative value.

空气

***MAT NULL**

RO=1.25 kg/m³　PC=-1.0pa(<0)　MU=1.7456E-5（动力粘性系数）

***EOS_LINEAR_POLYNOMIAL**

1,0　Gpa,0Gpa,　0 Gpa,　0,　0. 4 ,　0. 4

253312.5,　　1.0

For(g-cm-us):

```
*MAT_NULL
          30.125e-02
                         -1.0E-121.749E-7      00000         0000          00          00
*EOS_GRUNEISEN
          3     0.3444
                          00000       0000      00000      1.40      00
                                                                 00
```

```
        00
/* EOS  LINEA R _POLYNOMIAL
        3         0
                          0         0         0       0.4       0.4       0
 2.5000E-6        1
```

水

***MAT_NULL**

1. RO=998.21kg/m³ , PC=-10.0 pa, MU=0.8684E-3   0, 0, 0, 0

C:1480m/s, SL:2.5 1 83 0.2268 0.4934 A:0.27 E_0;Q

Y_0;1

For(g-cm-us):

```
*MAT_NULL
        1    0.998
                         -1.0E-11   0.8684E-5  00000     0000     00     00
*EOS  GRUNEISEN
        1    1.65
       00
                          1.92     -0.096     00000     0.350     00     00
```

1.3MAT_JOHNSON_COOK

Cant.I	1	1	1	4	S	[illegible]	T	[illegible]
Vsise	MtD	Rn	a	五	FR	DTF	VP	
Dm	1	开	F	F	F	F	护	
Defadt	mmc	*	8i		nime	0.0	0.0	

Cant 2

WaiHe	A	b	N	c	M	TM	TR	EYSO
Tye	F	F	F	F	F	F	F	F
Delt	me	0,0	0.0	0.0	nooe	none	mne	be

Cand3

VmtsHe	CF	PC	SFAL.1.	π	Di	2	33	D4

Pye	F	g	F	F	F	F	g	F
Dasdt	ncne	0,0	2.0	0.0	0.0	0.0	0.0	