A Computational Method to Predict Fluid-Structure Interaction of Pressure Relief Valves

,   ,   ,

103-16

(Blowdown)

.

6DOF (Six Degree OF Freedom)   , Chimera

(Overset)   .

,   CFD-RC   CFD-Fastran   1"

.

Abstract

An effective CFD (Computational Fluid Dynamics) Method to predict important performance parameters, such as blowdown and chattering, for pressure relief valves in NPPs is provided in the present study. To calculate the valve motion, 6DOF (Six Degree Of Freedom) model is used. A chimera overset grid method is utilized to this study for the elimination of grid remeshing problem, when the disk moves. Further, CFD-Fastran which is developed by CFD-RC for compressible flow analysis is applied to a 1" safety valve. The prediction results ensure the applicability of the presented method in this study.

1.

,

.

KEPIC MNX 7000

Code   .

　　　　　　　　,

　　　　　　　　　　　　　　　(Blowdown)   .

                                                                                                        .

                                                                                                        .

　　　,

                                                                                        .

                                                                               ,

                                                                                        .

                                            ,

                                                                                                        .

                              [1]-[3].

                                                                                            1

                              2   .   [1]   [2]
RELAP5

                                                            [1]

                                                                                    .

                                                            Reich   [3]
　　　.

　　Reich   Flutter
                                                                            .

                                    6DOF (Six Degree Of Freedom)
Chimera   (Overset Grid)
                                                            .

            Riech

                                                                                        .

    2.

CFD-Fastran . CFD-Fastran

, Chimera (Overset) 6DOF (Six Degree OF Freedom) .

Chimera (Overset) ,

.

(minor) , ,

. 6DOF (Six Degree OF Freedom)

, .

$$\vec{F} = m\frac{d\vec{v}}{dt}$$

$$\overrightarrow{M} = \frac{\partial \vec{h}}{\partial t} + \vec{w} \times \vec{h}$$

$\vec{F} =$

$\overrightarrow{M} =$

$m =$

$\vec{v} =$

$\vec{h} = \tilde{I}\,\vec{w},$

$\vec{w} =$

(Itanium Workstation) ,

, ,

CFL number .

CFL number ,

,

.

3.

CFD-RC CFD-Geom .

, , Figure 1 .

, , ,

. , 2D

, 59,634 . , ,

,

, .

1   Figure 2   3   ,
            Table 1   .
                        ,   Table 2   .

Table 1

	0.025m
	0.043m
	0.0076m
	0.287m

Table 2   (   )

-0.0036m	-0.0057m
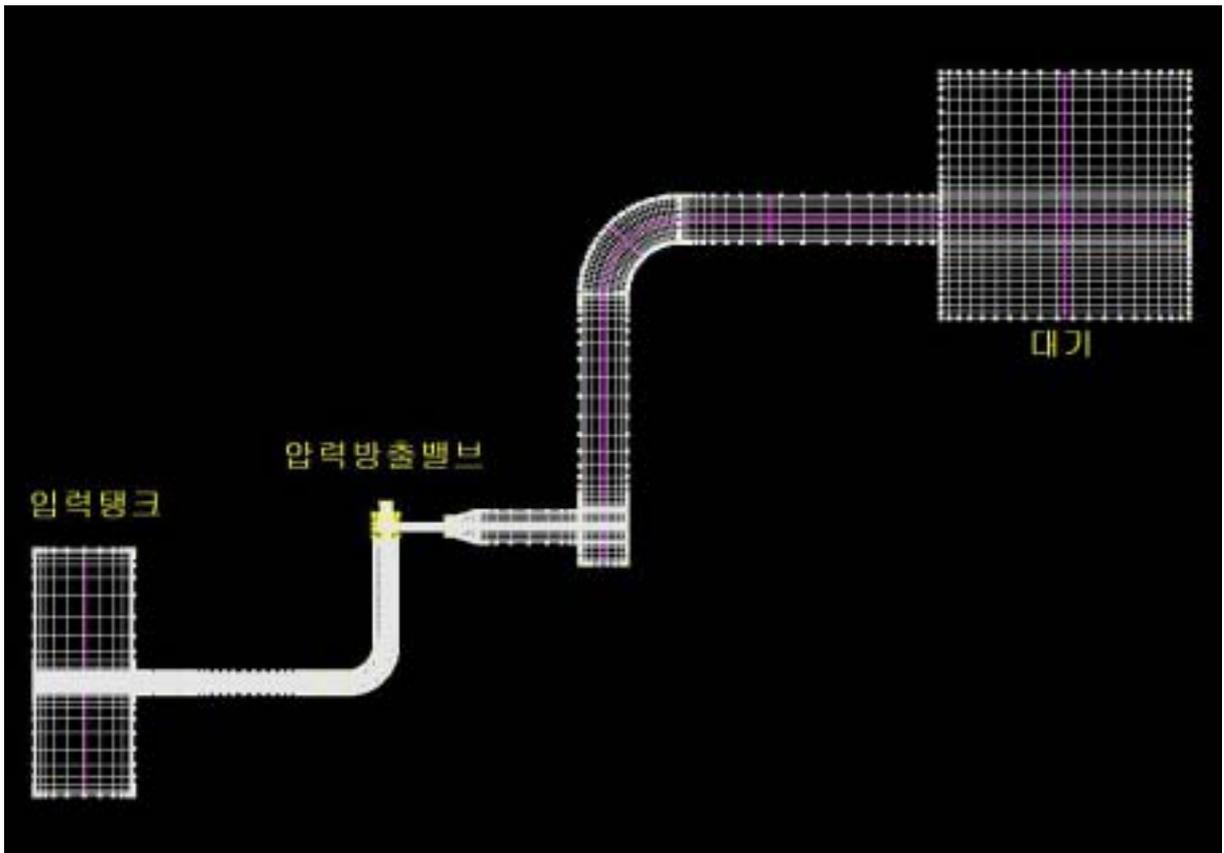
Figure 1

,

.   Chimera   (Overset)

, 6DOF (Six Degree OF Freedom)   .

                                        Chimera   (Overset)   ,

Figure 4   Chimera   (Overset)   . Chimera   (Overset)

                                        Chimera   (Overset)

                                        ,

                                                                        Chimera

(Overset)

.

    y   Chimera   (Overset)

                                , Figure 4   ,   .

            2,572   Chimera   (Overset)

  Figure 5   Chimera   (Overset)

        ,   .

            Chimera   (Overset)

  ,

                                        .

  6DOF (Six Degree OF Freedom)   ,

                            .   Chimera   (Overset)   ,

            6DOF (Six Degree OF Freedom)   (point force)

        .   289,247N/m,   105,200N

              ,   9.07Mpa(92.5kgf/cm^2)   .

                                        7.6mm   , Chimera

(Overset)   0.1mm   ,   0

    7.5mm   ,   .

4.

                                (Inflow-outflow)   ,

(101,325Pa),   (288K)   ,   (adiabatic wall)

            .   Chimera   (Overset)   overset

                                    .

              9.4MPa, 579K   ,   ,   .

Figure 2   3
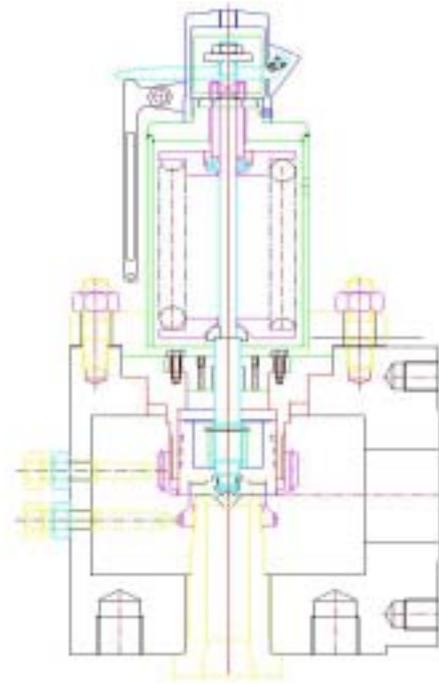
Figure 3

Figure 4   Chimera   (Overset)

Figure 5   Chimera   (Overset)

5.

,

,

.

Figure 6   . 1.38msec
                          105,200N   ,

                                                ,   Figure 8

.

                                          . 8msec

                                ,   . 12.23msec

                                                ,

                                                      , 12.7msec

     , Figure 8   .
Figure 7   .

                              105,200N   ,

                                                      .

                    7.5mm   2,169N(0.0075m×289,247N/m)

          107,369N   .   2msec

                                                                                                    .

Figure 8   ,

                                                                              .

Figure 9   . 1.39msec

                                                                                      .

     , Figure 9(b)   .

                                                                          .

                ,   Figure 9(c), (d)   .
Figure 10   .
1.39msec   ,

                                                      Figure 10(b)   .

                                                                                                          ,

Figure 10(c)   .

            Figure 10(c), (d)   .
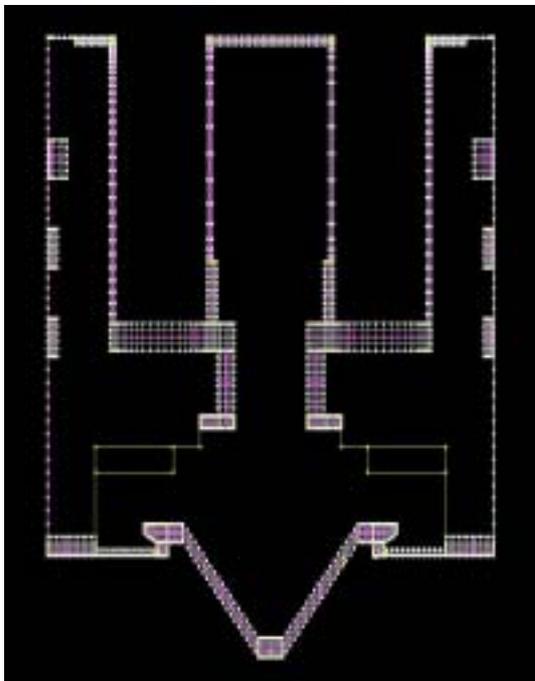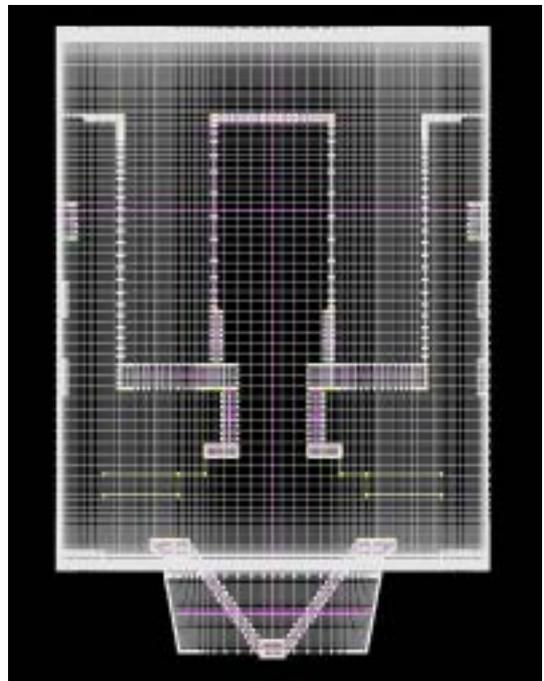
6.

CFD-Fastran   Chimera   (Overset)   6DOF (Six Degree OF Freedom)
                                                           .

                    Chimera   (Overset)   ,   ,   ,
        6DOF (Six Degree OF Freedom)
    .   ,
                                        .   Chimera
(Overset)   6DOF (Six Degree OF Freedom)
                    .
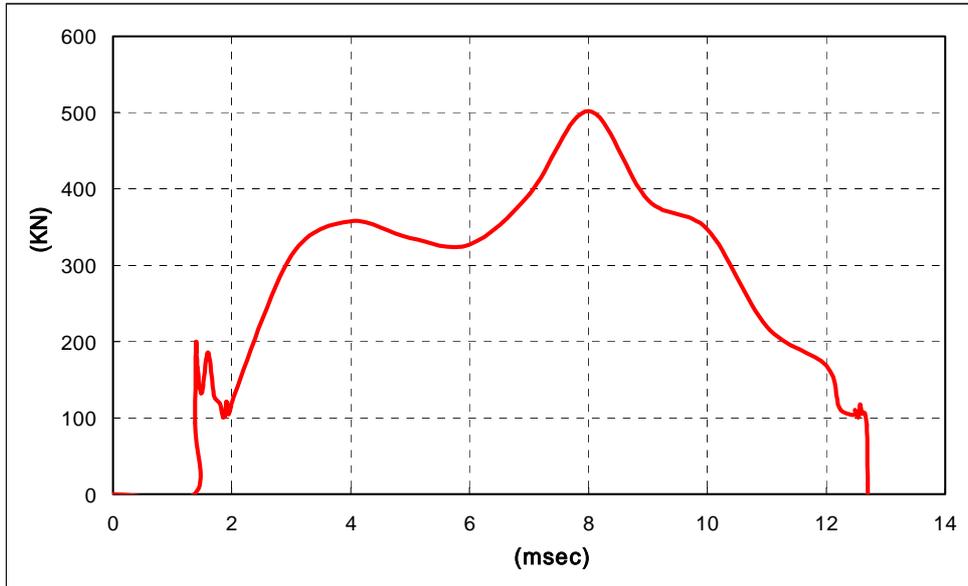
Figure 6
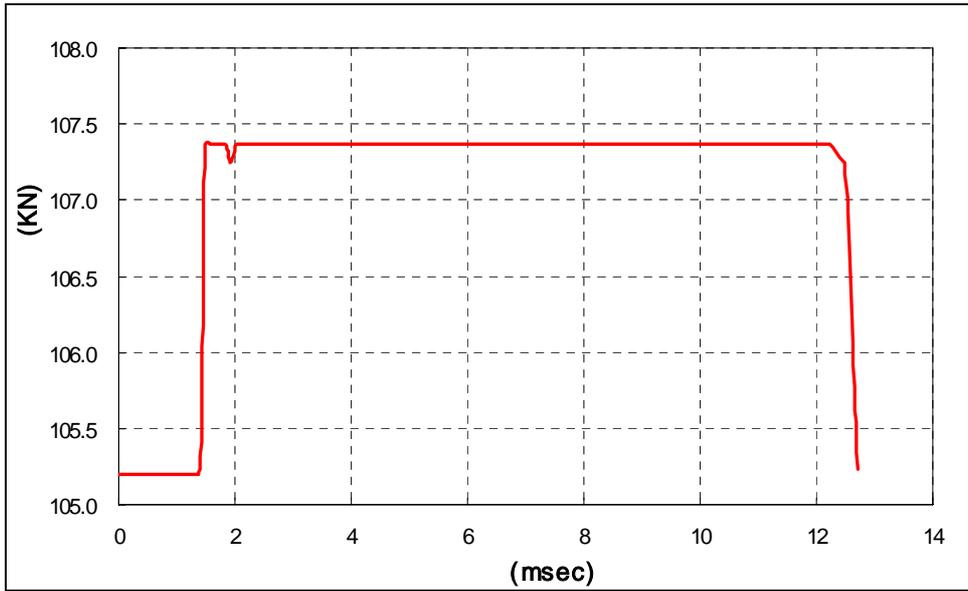
Figure 7
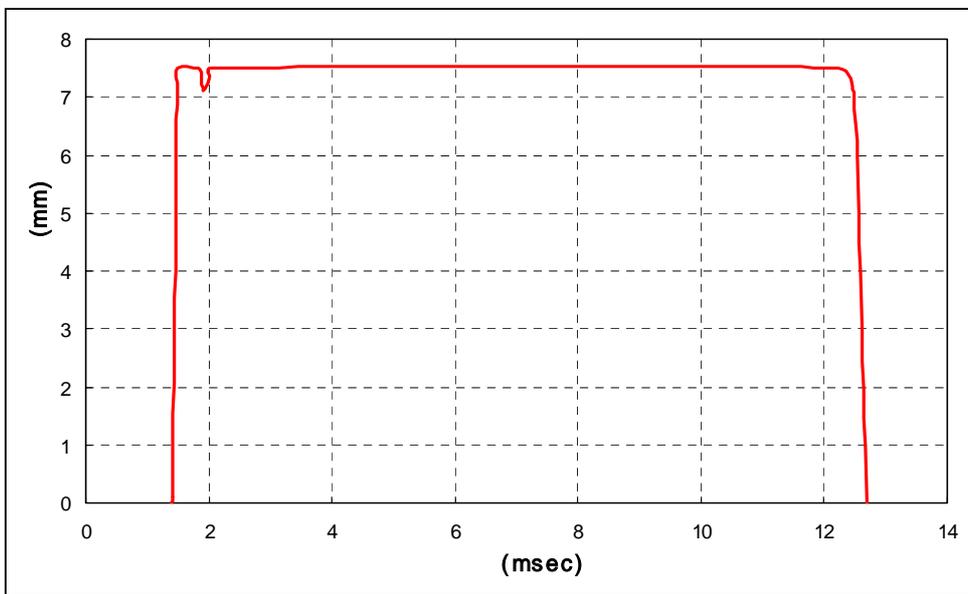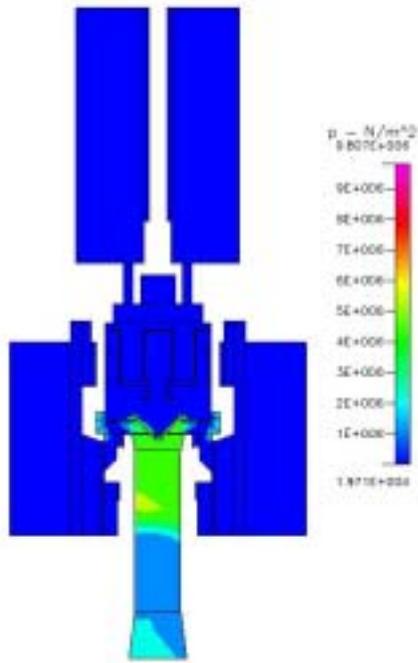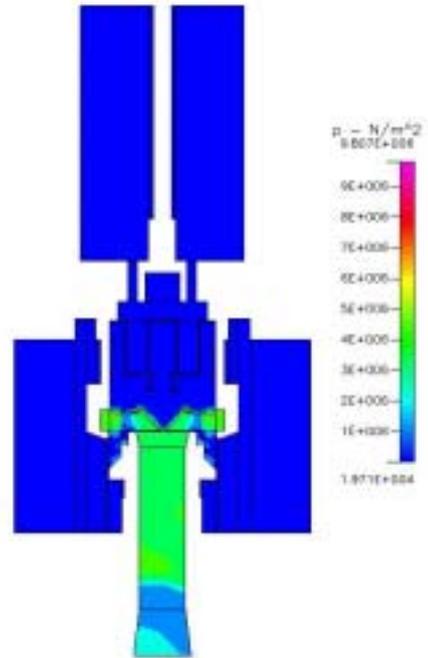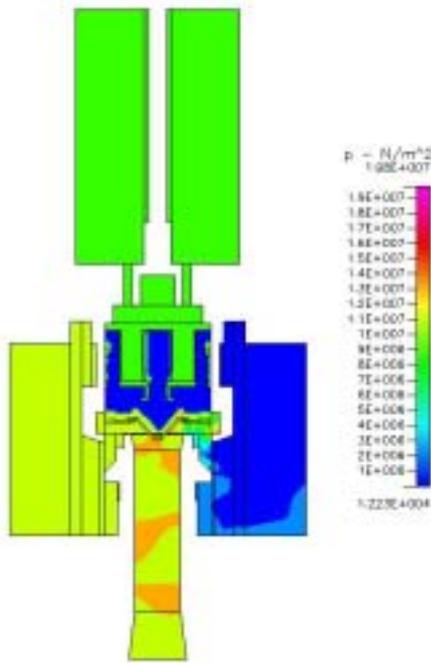
Figure 8
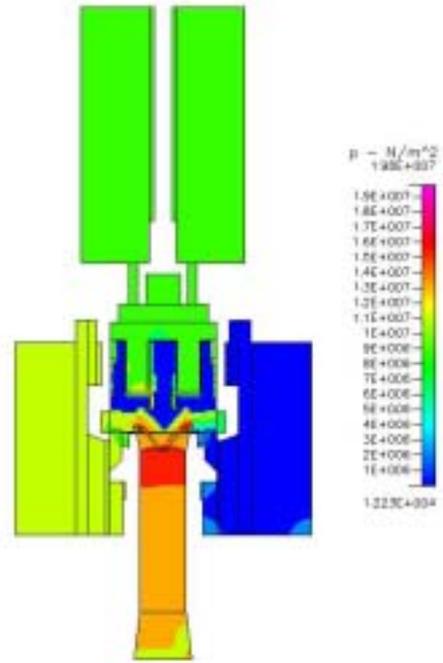
(a)   , t =1.46msec   (b)   , t = 1.51msec
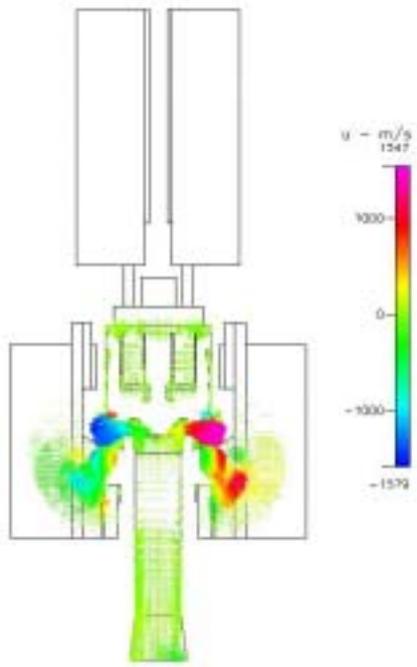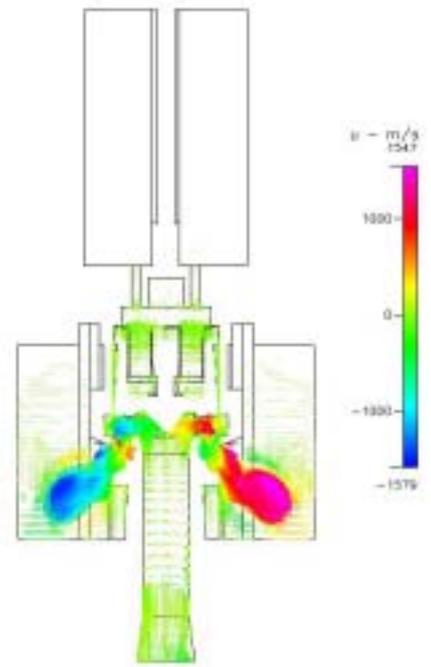
(c)   , t =12.58msec   (d)   , t =12.7msec
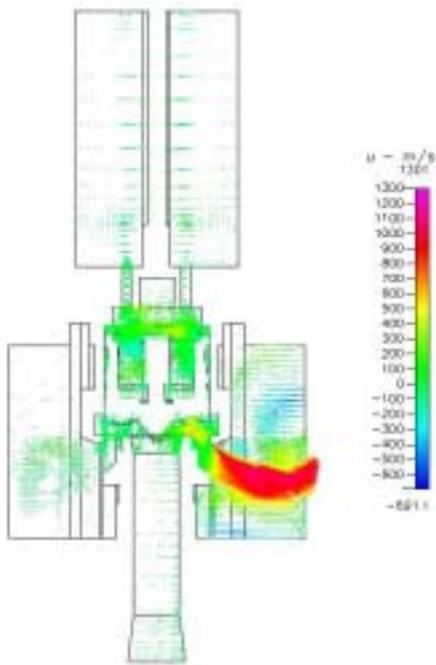
Figure 9
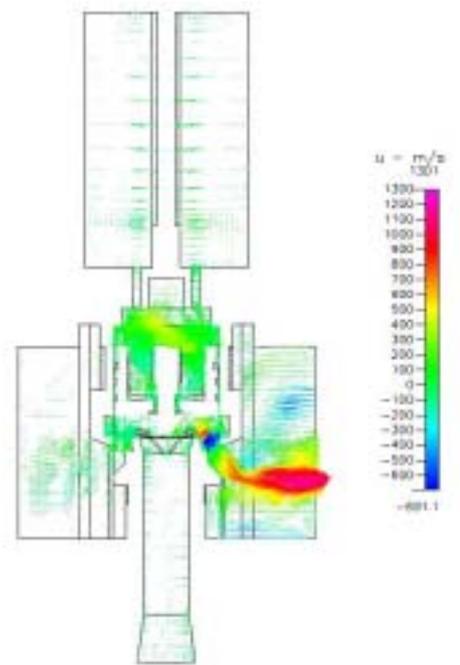
(a)   , t =1.46msec   (b)   , t = 1.51msec

(c)   , t =12.58msec   (d)   , t =12.7msec

Figure 10

7. References

［1］　　　，　　　，　　　，　　　，　　　，" RLAP5/MOD3

　　　　　　　　　　," 　　　　　　　　　　　　　　　　　, 2003

［2］ M. A. Langerman " An Analytical Model of a Spring- Loaded Safety Valve", in Testing and Analysis of Safety/Relief Valve Performance, ASME, 1983

[3] A. J. Reich, V. Parthasarathy and A. DiMeo, "Coupled Fluid-Structure Interaction Simulation of the Opening of the Target Rock Vacuum Relief Valve," ASME Pressure Vessels and Piping Conference, 2001