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**Thermal Analysis of Clamp Using MARS Analysis Heat Generations**

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The MARS program has been used to find the heat generations in the upstream and downstream horn clamp. Two clamp geometries were considered. The first, shown in Fig. 1a, contains no special holes or slots to improve convective cooling. The second, shown in Fig. 1b, contains several small circular holes, and a thru-slot in the uppermost aluminum block, all attempts to improve convective cooling.

The finite element models of the clamps were broken up into the approximately the same volumes used in the MARS work, and heat generations were assigned. The generations for the downstream clamp were chosen because they are higher than those of the upstream clamp.

The surface of the clamp that will be in contact with the outer shell of the horn was constrained to remain at 30 C. All free surfaces were given a convective film coefficient of 10 $W/m^2$-C, based on forced convection correlations for flat plates with constant heat flux, and an air velocity of 10 m/sec.

The FE models are shown in Fig. 1. The finite element volumes corresponding to the MARS volumes is shown in Fig. 2. The volume numbering for MARS data input is shown in Figs. 3 and 4. Table I shows the heat fluxes input to the model.

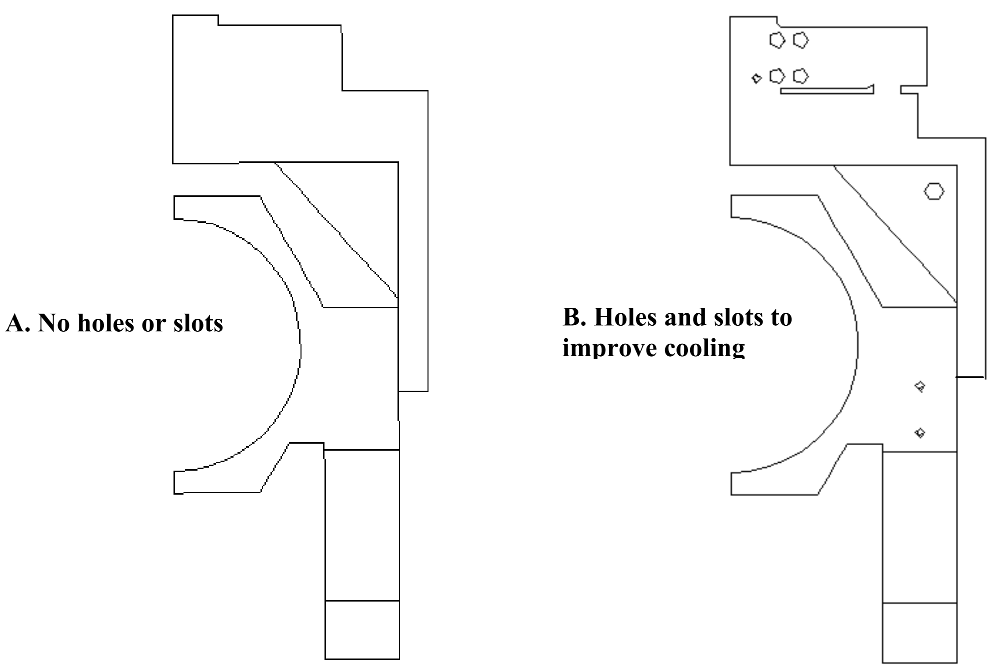



**Figure 1. Clamp Geometries**

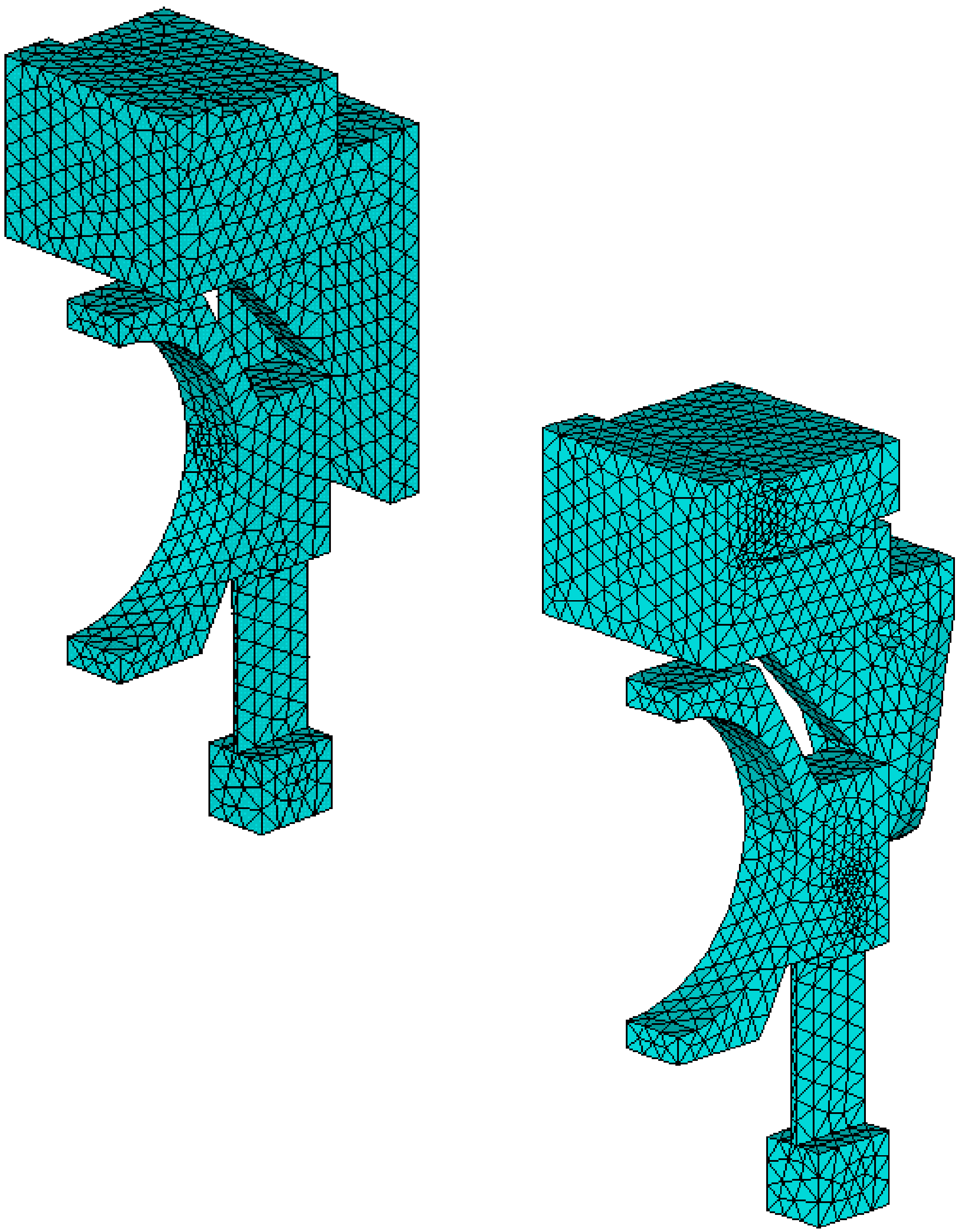


**Figure 2. Finite Element Models**

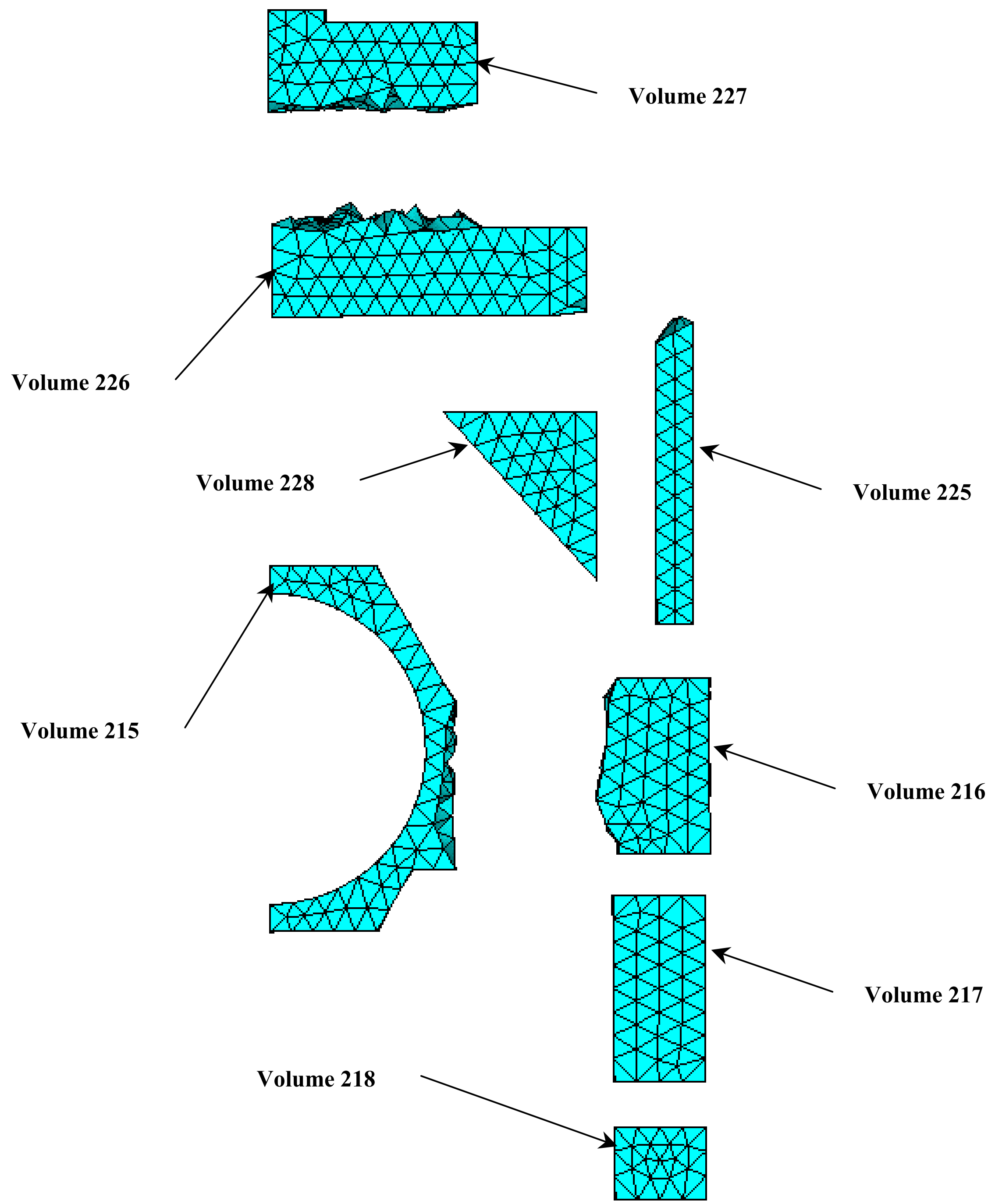



**Figure 3. Finite Element Volumes corresponding to MARS Volumes (clamp without holes or slots)**

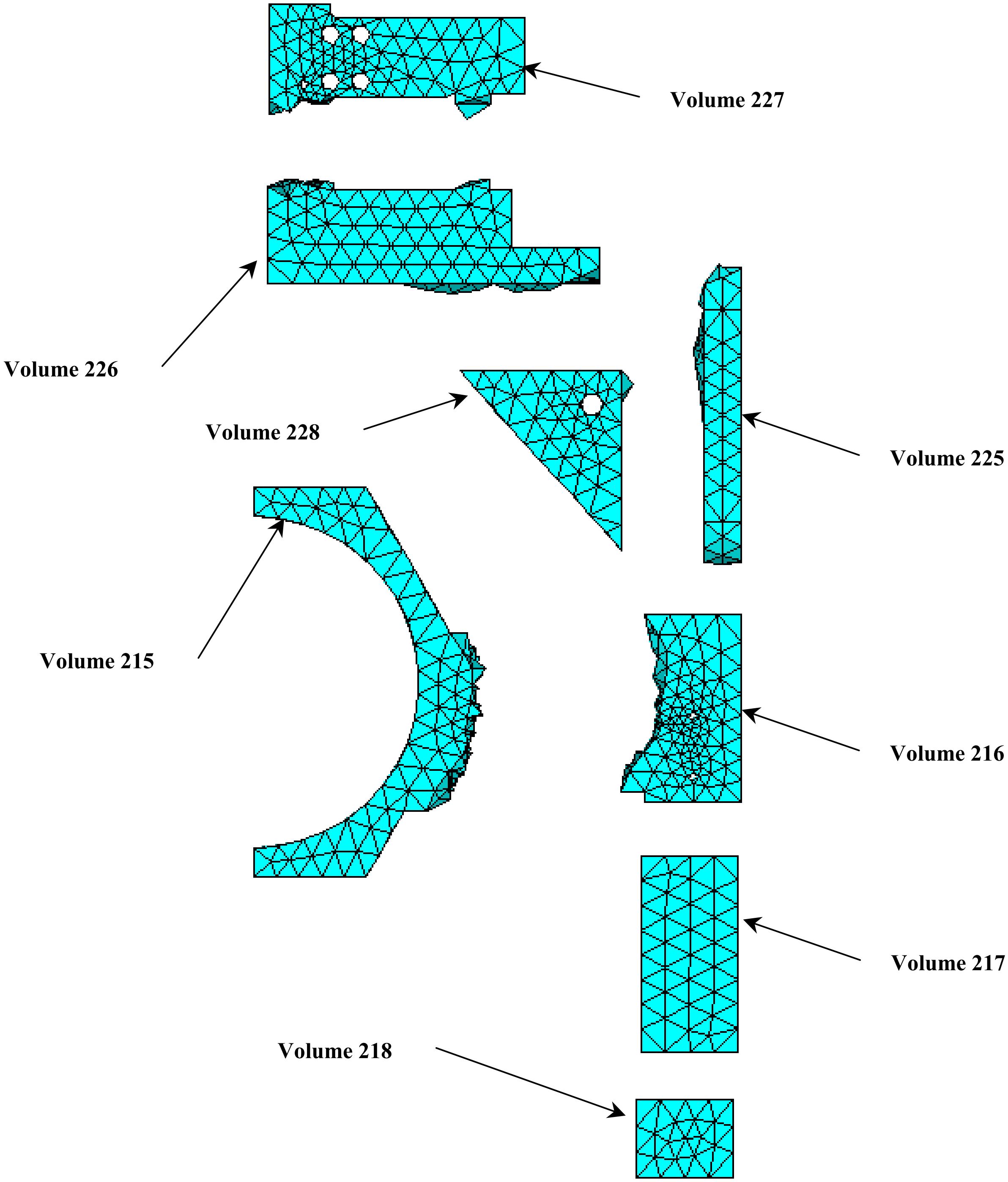


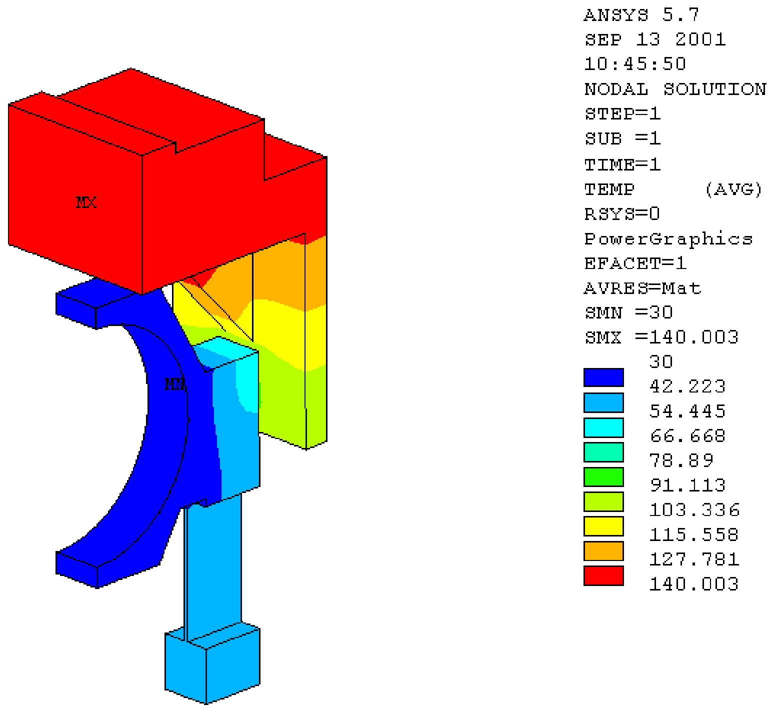

**Figure 4. Finite Element Volumes corresponding to MARS Volumes (clamp with holes and slots)**

**Table I. Heat Generations from MARS Analysis**

| Volume | Heat Generation $W/m^3$ |
|---|---|
| 215 | 128000 |
| 216 | 86200 |
| 217 | 34500 |
| 218 | 26300 |
| 225 | 91800 |
| 226 | 55200 |
| 227 | 39400 |
| 228 | 66900 |

The temperature distribution in both models is shown in Fig. 5. The maximum temperature for the clamp with no slots or holes is 140 C. The maximum temperature for the clamp with slots and holes is 120 C. Substantial temperature drop is achieved by adding the additional convective area, and additional ground is gained because the overall mass of the upper volumes is reduced, both by the holes, and by other modifications in dimensions.

The temperature distributions were input to structural models, and the displacements calculated. These results are shown in Fig. 6. The vertical displacement of the center of the clamp ring is 0.85 mm and 0.64 mm, for the unslotted and slotted models, respectively. The goal is a maximum vertical displacement of 0.33 mm. Neither design appears to meet this goal.



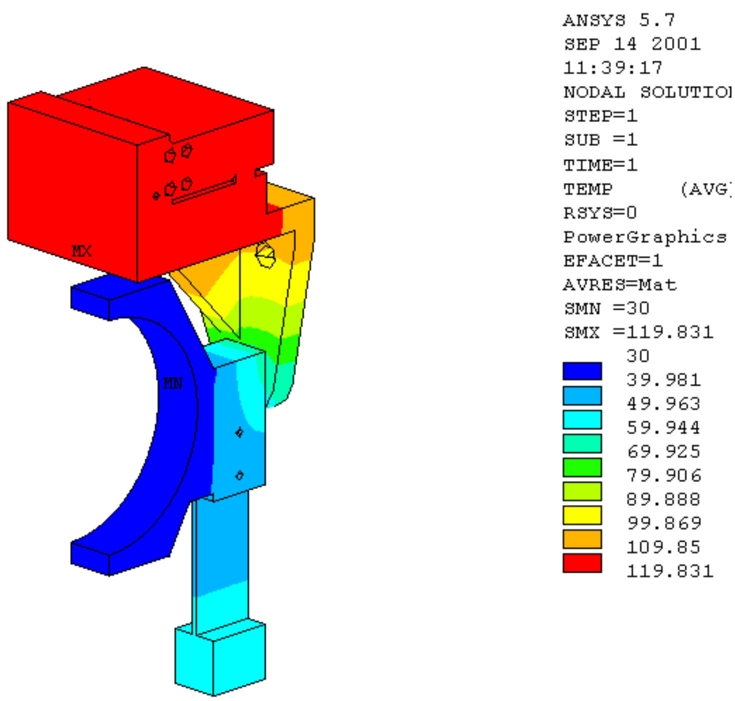




**Figure 5. Temperature Distribution in Clamps**

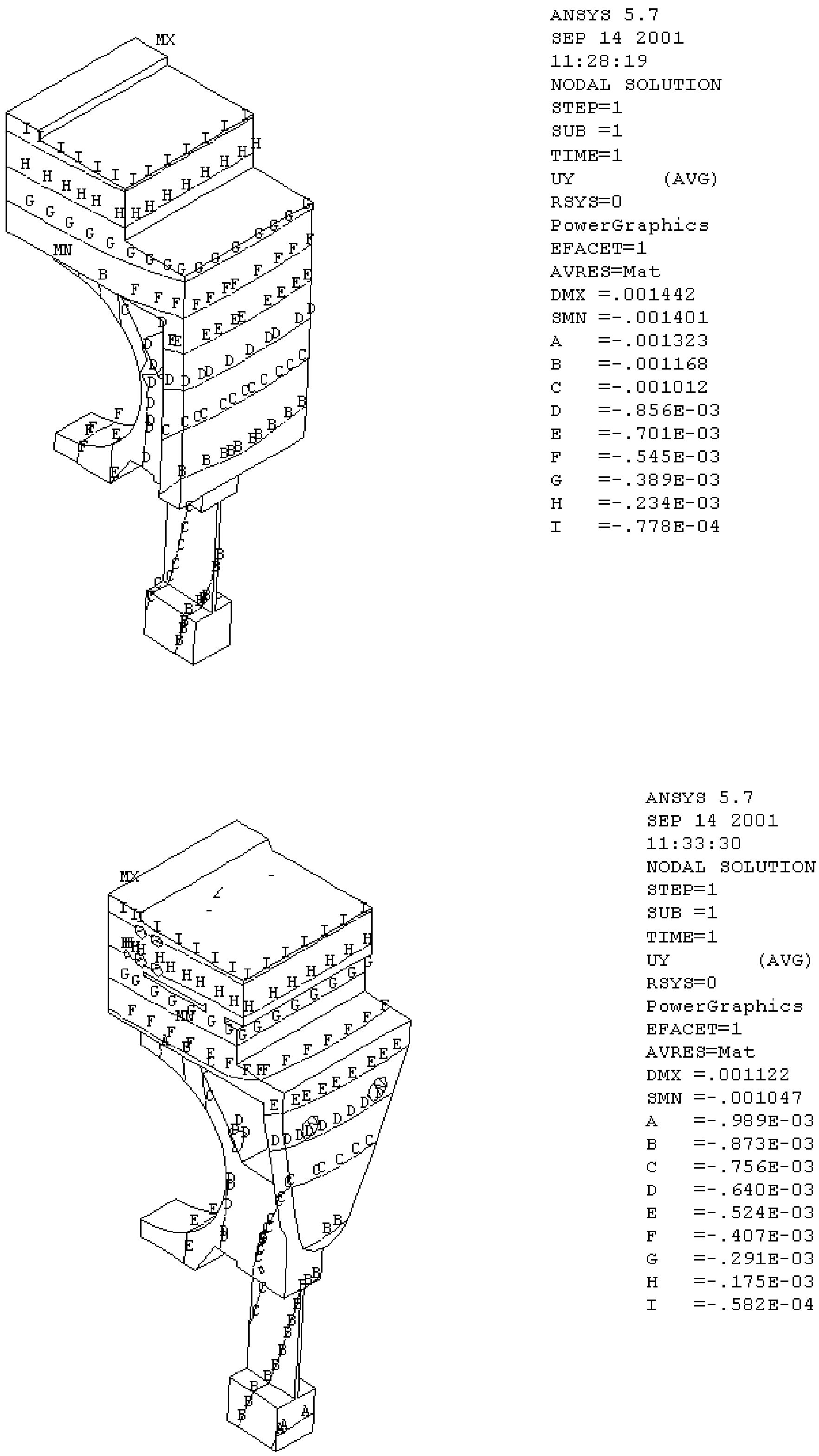



**Figure 6. Vertical Deflection of Clamps (units are meters)**