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Introduction

The Monte Carlo N-Particle (MCNP)[1] transport code version 6 (also known as MCNP6) has the capability for tracking particles on unstructured mesh (UM) geometry models embedded into constructive solid geometry (CSG) cells [1]. A UM geometry is a collection of elements representing a solid geometry. The first step of MCNP UM modeling is using other software packages to create a finite element mesh representation of a solid 3D geometry. Computer-aided design (CAD) or computer-aided manufacturing (CAM) software is typically used to create a solid geometry model, which is later imported into mesh generation software to create a UM model. The MCNP UM feature was originally designed for models generated by the Abaqus/CAE software. The MCNP code version 6.0 and later can process UM models formatted as Abaqus input files. MCNP can process a UM model consisting of several different element types including linear tetrahedral or hexahedral elements and calculate quantities of interest such as flux and energy deposition at elements. An MCNP UM simulation provides high-fidelity elemental edit (i.e., tally) outputs, which can be further used in multiphysics calculations. The MCNP UM feature was used for multiphysics simulations where quantities of interest calculated by MCNP are used as inputs for heat transfer calculations in Abaqus [2]. MCNP6.3 can produce two types of elemental edit output (EEOUT) file formats: ASCII and HDF5. An EEOUT file type must be requested on an EMBED card while output type (flux or energy deposition) must be requested on an EMBEE card. We wrote Python3 scripts to extract energy deposition values in an ASCII or HDF5 EEOUT file and compute a heat flux profile for an Abaqus heat transfer calculation.

Processing ASCII EEOUT File

A Python script eeeou_to_inp.py is for processing an ASCII EEOUT file. Since element numbers from an Abaqus input are not written an ASCII EEOUT file, element numbers in each part in an Abaqus input file must start from 1 and increase by 1 in order to use a heat flux profile for an Abaqus heat transfer calculation. A previous version of this script was developed in 2020 [3]. The command line *python eeout_to_inp.py --help* or *python eeout_to_inp.py -h* can be used to display the command line options:

```
usage: eeout_to_inp [-h] [-o heatFlux.inp] [-e 6] eeout_filename power_level_in_watts

Process an MCNP ASCII EEOUT file and produces a body heat flux for an Abaqus
heat transfer calculation.

positional arguments:
  eeout_filename        MCNP EEOUT file name
  power_level_in_watts  A power level in Watts

optional arguments:
  -h, --help            show this help message and exit
  -o heatFlux.inp, --output heatFlux.inp
                        A heat flux file name
  -e 6, --embee 6       An EMBEE number for energy depostion [must end with 6]
```

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Click to download this Python script.

Processing HDF5 EEOUT File

A Python script h5eeeou_to_inp.py is for processing an HDF5 EEOUT file. A previous version of this script was developed in 2022 [4]. The command line *python h5eeout_to_inp.py --help* or *python h5eeout_to_inp.py -h* can be used to display the command line options:

```
usage: h5eeout_to_inp [-h] [-o heatFlux.inp] [-e 6] h5eeout_filename power_level_in_watts

Process an MCNP HDF5 EEOUT file and produce a body heat flux file for an Abaqus
heat transfer calculation.

positional arguments:
  h5eeout_filename      MCNP HDF5 EEOUT file name
  power_level_in_watts  Power level in Watts

optional arguments:
  -h, --help            show this help message and exit
  -o heatFlux.inp, --output heatFlux.inp
                        Heat flux file name
  -e 6, --embee 6       EMBEE number for energy depostion [must end with 6]
```

Click to download this Python script.

References

[1] Joel A. Kulesza et al. *MCNP® Code Version 6.3.0 Theory & User Manual*. Tech. rep. LA-UR-22-30006, Rev. 1. Los Alamos, NM, USA: Los Alamos National Laboratory, Sept. 2022. URL: https://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-22-30006.

[2] V. Mehta et al. "Capturing Multiphysics Effects in Hydride Moderated Microreactors using MARM". In: *Annals of Nuclear Energy* 172 (July 2022), p. 109067. ISSN: 0306-4549. DOI: 10.1016/j.anucene.2022.109067. URL: https://www.sciencedirect.com/science/article/pii/S0306454922001025.

[3] Vedant K. Mehta and Jerawan C. Armstrong. *Processing MCNP Elemental Edit Outputs*. Tech. rep. LA-UR-20-24025. Los Alamos, NM, USA: Los Alamos National Laboratory, June 2020. DOI: 10.2172/1631564.

[4] Divyanshu R. Sharma, Jerawan C. Armstrong, and Vedant K. Mehta. *Developing Python Codes for Processing MCNP Elemental Edit Outputs*. Tech. rep. LA-UR-22-30662. Los Alamos, NM, USA: Los Alamos National Laboratory, Oct. 2022. URL: https://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-22-30662.