

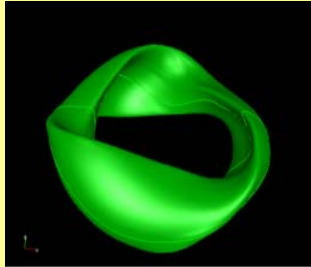


Neutron Wall Loading Profile Using CAD/MCNP Interface

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INTRODUCTION:

Compact Stellarator (CS) is for a commercial power plant fusion device. It is a complicated geometry composed by spline surface. Nuclear analysis is needed. Such as neutron wall loading.



Compact Stellarator

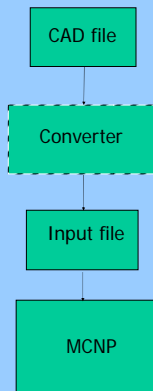
MCNP is widely used Monte Carlo simulation tool.

However, MCNP can not construct this geometry because MCNP only provides limited geometry modeling capabilities.

METHODS:

CAD software focuses on the capabilities of geometry modeling. They have powerful abilities and provide a user-friendly interface. Complex models are usually designed with CAD systems. Then how to take advantage of CAD software?

Converter is not a good idea.



Converter approach

MCNP still supports only limited geometry type.

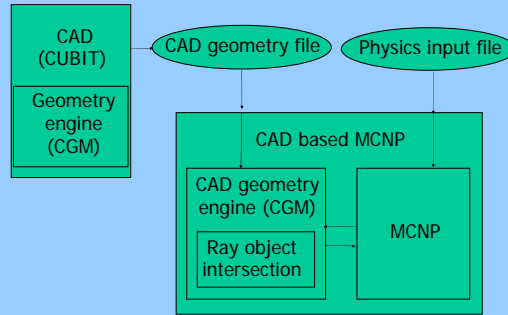
It is impossible to 100% convert a CAD geometry to MCNP because CAD supports more types of geometry than MCNP.

If using approximation to convert a CAD model, it is hard to decide how to make approximation.

Once there is a new geometry type in CAD software, we need to update the converter to support new type.

METHODS:

Our approach: Use CAD software as geometry engine of MCNP. The radiation transport is directly performed through the CAD geometry.



CAD based MCNP approach

Benefits:

Save the time of modeling the complicated geometry for MCNP.

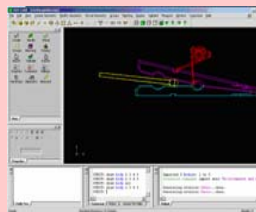
Support all kinds of geometry provided by CAD software. Such as high order surface, spline surface, facet surface.

Obtain some advance features from CAD software. Such as gap/overlap detection, surface area function.

Update easily. The most recent geometry functions are available which will be updated by the CAD software developer.

VALIDATION:

We use a clothespin model to demonstrate CAD based MCNP can be applied to complicated geometries.



(a) Shown by CAD



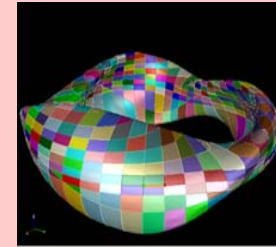
(b) Radiation image simulated by CAD based MCNP

Clothespin model

This model would be very difficult to analyze with MCNP alone because of the helical surface of the spring.

APPLICATION:

The first real application of the CAD-MCNP coupling approach is to calculate the neutron wall loading distribution (Γ) in the Z and toroidal directions of the ARIES-CS design.

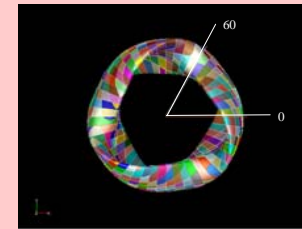


Subdivision of CS model

We subdivide the plasma in horizontal and toroidal direction.

The toroidal subdivision is 7.5 degree each.

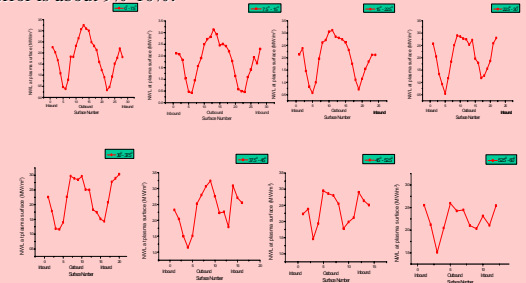
The horizontal subdivision is 0.5 m each.



Tally portion of CS model

By the symmetry, we select portion from 0 to 60 degree toroidally to tally. The other symmetry patch was combined to this portion to reduce relative error.

There are 8 neutron wall loading profiles in this portion. For 1600MW of total neutron power, the average neutron loading is 1.985MW/m² and peak is 3.24MW/m² which occurs at outbound of 0-7.5 degree portion. The computation takes 5 days at a linux station and relative error is about 9%-10%.



Summary:

CAD based MCNP can be applied to complicated geometries.

However, the computational speed is not satisfied.

In the future plan, we will use ray-object intersection acceleration techniques to improve the computational speed.