analysis

June 8, 2018

```
In [1]: import numpy as np
        import matplotlib.pyplot as plt
        import csv
```

1 FIT01 for Fuel Cycle Simulation Reactor Depletion

1.0.1 This Functionality Isolation Test (FIT) is to test MOX fuel fabrication and depletion functionalities in a reactor module given streams of varying plutonium quality (different isotopics). The four streams are:

1.0.2 `ref`, `source_1`, `source_2`, and `source_3`.

1.0.3 ORION is used for this analysis, where a MOX LWR fabrication and reactor module is given four streams with varying plutonium stream.

1.0.4 The Fuel Loading Module (FLM) is the `Fuel Fabrication` facility in ORION, that uses cross sections and nu-bars to calculate how to mix the fissile and fertile stream. The datasets with `_ff` are ones using fixed fractions, which means that the FLM is not utilized.

1.0.5 Depletion is done using cross section data.

1.0.6 The fissile stream is plutonium and americium in different qualities.

1.0.7 The fertile stream is depleted uranium (0.238% U235).

```
In [2]: %%javascript
        IPython.OutputArea.prototype._should_scroll = function(lines) {
            return false;
        }
```

```
<IPython.core.display.Javascript object>
```

```
In [3]: def get_comp_dict(filename):
            with open(filename, 'r') as f:
                lines = f.readlines()
                isotopes = lines[0]
                isotopes = isotopes.split(',')[1:-1]
                isotopes = [x.split('+')[1] for x in isotopes]
```

```
            masses = lines[-1]
            masses = masses.split(',')[1:-1]
            masses = np.array([float(x) for x in masses])
            total_mass = sum(masses)

        comp_dict = {}
        for indx, val in enumerate(isotopes):
            comp_dict[val] = masses[indx] / total_mass * 100

        return comp_dict
```

In [4]:
```
def show_fracs(comp_dict, search_list):
    filtered_dict = {}
    for key, val in comp_dict.items():
        for keyword in search_list:
            if keyword.upper() in key:
                if val < 1e-5:
                    continue
                filtered_dict[key] = val
    return filtered_dict
```

In [5]:
```
def get_am_pu(filtered_dict):
    am_pu = 0
    for key, val in filtered_dict.items():
        if 'AM' in key or 'PU' in key:
            am_pu += val
    return am_pu
```

In [6]:
```
def main(file_list):
    data = {}
    for file in file_list:
        comp_dict = get_comp_dict(file)
        frac_dict = show_fracs(comp_dict, ['U', 'NP', 'PU', 'AM'])
        am_pu = get_am_pu(frac_dict)
        filename = file.split('/')[-1]
        filename = filename.split('.csv')[0]
        data.update({filename:{'fraction': frac_dict, 'AM+PU': am_pu}})
    return data
```

In [7]:
```
from os import listdir
from os.path import isfile, join
file_list = [f for f in listdir('./results') if isfile(join('./results', f))]
file_list =['./results/' + x for x in file_list]
```

In [8]:
```
data = main(file_list)
```

In [9]:
```
# show all
def show_data(data, must_word=''):
    for key, val in data.items():
```

```
                if must_word not in key:
                    continue
                print('========================')
                print(key)
                for key2, val2 in val.items():
                    if key2 == 'fraction':
                        for key3, val3 in val2.items():
                            print('%s = %f' %(key3, val3))
                    else:
                        print('%s = %f' %(key2, val2))
                print('========================')
                print('\n')
```

In [10]:
```
# show all -> show_data(data)
# show discharge only -> show_data(data, '_discharge')
# show charge only -> show_data(data, '_charge')
# show fixed fraction only -> show_data(data, '_ff')
show_data(data)
```

```
========================
pu_ref_charge_ff
U235 = 0.221340
U238 = 92.778666
PU238 = 0.280000
PU239 = 2.697098
PU240 = 1.719198
PU241 = 1.112999
PU242 = 0.894599
AM241 = 0.296100
AM+PU = 6.999994
========================


========================
source_3_charge_ff
U235 = 0.221340
U238 = 92.778666
PU238 = 0.200900
PU239 = 3.289297
PU240 = 2.373698
PU241 = 0.317800
PU242 = 0.764399
AM241 = 0.053900
AM+PU = 6.999994
========================


========================
```

source_3_discharge_ff
U234 = 0.003576
U235 = 0.195332
U236 = 0.000580
U238 = 81.785093
NP237 = 0.000271
PU238 = 0.173356
PU239 = 2.899316
PU240 = 2.091838
PU241 = 0.246001
PU242 = 0.673820
AM241 = 0.081057
AM+PU = 6.165387
==========

==========
pu_ref_charge
U235 = 0.221340
U238 = 92.778666
PU238 = 0.138600
PU239 = 4.357496
PU240 = 1.574999
PU241 = 0.559999
PU242 = 0.350000
AM241 = 0.018900
AM+PU = 6.999994
==========

==========
source_1_discharge
U234 = 0.003887
U235 = 0.195354
U236 = 0.000416
U238 = 81.785429
NP237 = 0.000492
PU238 = 0.188457
PU239 = 3.183152
PU240 = 1.500257
PU241 = 0.636678
PU242 = 0.496110
AM241 = 0.159846
AM+PU = 6.164501
==========

==========

```
pu_ref_discharge
U234 = 0.002467
U235 = 0.195402
U236 = 0.000385
U238 = 81.784640
NP237 = 0.000197
PU238 = 0.119597
PU239 = 3.840850
PU240 = 1.387969
PU241 = 0.433479
PU242 = 0.308524
AM241 = 0.076058
AM+PU = 6.166477
=========================


=========================
source_2_discharge_ff
U234 = 0.003576
U235 = 0.195332
U236 = 0.000580
U238 = 81.785093
NP237 = 0.000271
PU238 = 0.173356
PU239 = 2.899316
PU240 = 2.091838
PU241 = 0.246001
PU242 = 0.673820
AM241 = 0.081057
AM+PU = 6.165387
=========================


=========================
10000w_g
U234 = 0.003995
U235 = 0.195355
U236 = 0.000420
U238 = 81.784715
NP237 = 0.000502
PU238 = 0.188455
PU239 = 3.183124
PU240 = 1.500244
PU241 = 0.636673
PU242 = 0.496106
AM241 = 0.160593
AM+PU = 6.165196
=========================
```

```
========================
diff_pow_dens
U234 = 0.003995
U235 = 0.195355
U236 = 0.000420
U238 = 81.784715
NP237 = 0.000502
PU238 = 0.188455
PU239 = 3.183124
PU240 = 1.500244
PU241 = 0.636673
PU242 = 0.496106
AM241 = 0.160593
AM+PU = 6.165196
========================


========================
3_modified
U235 = 0.221340
U238 = 92.778666
PU238 = 0.280000
PU239 = 2.697098
PU240 = 1.719198
PU241 = 1.112999
PU242 = 0.894599
AM241 = 0.296100
AM+PU = 6.999994
========================


========================
source_1_charge_ff
U235 = 0.221340
U238 = 92.778666
PU238 = 0.218400
PU239 = 3.611297
PU240 = 1.702398
PU241 = 0.822499
PU242 = 0.562799
AM241 = 0.082600
AM+PU = 6.999994
========================


========================
```

```
source_3_charge
U235 = 0.221340
U238 = 92.778666
PU238 = 0.280000
PU239 = 2.697098
PU240 = 1.719198
PU241 = 1.112999
PU242 = 0.894599
AM241 = 0.296100
AM+PU = 6.999994
========================


========================
source_1_discharge_ff
U234 = 0.003887
U235 = 0.195354
U236 = 0.000416
U238 = 81.785429
NP237 = 0.000492
PU238 = 0.188457
PU239 = 3.183152
PU240 = 1.500257
PU241 = 0.636678
PU242 = 0.496110
AM241 = 0.159846
AM+PU = 6.164501
========================


========================
source_1_charge
U235 = 0.221340
U238 = 92.778666
PU238 = 0.218400
PU239 = 3.611297
PU240 = 1.702398
PU241 = 0.822499
PU242 = 0.562799
AM241 = 0.082600
AM+PU = 6.999994
========================


========================
casmo_discharge
U234 = 0.003968
U235 = 0.195356
```

```
U236 = 0.000416
U238 = 81.785360
NP237 = 0.000493
PU238 = 0.188457
PU239 = 3.183150
PU240 = 1.500256
PU241 = 0.636678
PU242 = 0.496110
AM241 = 0.159846
AM+PU = 6.164496
=========================


=========================
source_2_charge
U235 = 0.221340
U238 = 92.778666
PU238 = 0.200900
PU239 = 3.289297
PU240 = 2.373698
PU241 = 0.317800
PU242 = 0.764399
AM241 = 0.053900
AM+PU = 6.999994
=========================


=========================
source_2_discharge
U234 = 0.003576
U235 = 0.195332
U236 = 0.000580
U238 = 81.785093
NP237 = 0.000271
PU238 = 0.173356
PU239 = 2.899316
PU240 = 2.091838
PU241 = 0.246001
PU242 = 0.673820
AM241 = 0.081057
AM+PU = 6.165387
=========================


=========================
pu_ref_discharge_ff
U234 = 0.004984
U235 = 0.195296
```

```
U236 = 0.000420
U238 = 81.786515
NP237 = 0.001344
PU238 = 0.241615
PU239 = 2.377369
PU240 = 1.515079
PU241 = 0.861559
PU242 = 0.788606
AM241 = 0.378092
AM+PU = 6.162321
=========================


=========================
source_3_discharge
U234 = 0.004984
U235 = 0.195296
U236 = 0.000420
U238 = 81.786515
NP237 = 0.001344
PU238 = 0.241615
PU239 = 2.377369
PU240 = 1.515079
PU241 = 0.861559
PU242 = 0.788606
AM241 = 0.378092
AM+PU = 6.162321
=========================


=========================
source_2_charge_ff
U235 = 0.221340
U238 = 92.778666
PU238 = 0.200900
PU239 = 3.289297
PU240 = 2.373698
PU241 = 0.317800
PU242 = 0.764399
AM241 = 0.053900
AM+PU = 6.999994
=========================


=========================
casmo_charge
U235 = 0.221340
U238 = 92.778666
```

```
PU238 = 0.218400
PU239 = 3.611297
PU240 = 1.702398
PU241 = 0.822499
PU242 = 0.562799
AM241 = 0.082600
AM+PU = 6.999994
========================
```

1.1 major errors spotted:

1. The charge fuel composition does not change
    - the Pu composition changes, obviously becasue the input stream is different.
    - but the U composition does not, which means that the fuel fabrication is mixing the fuel at the same ratio
        - Maybe it's a cross section thing, so I tried using CASMO mox cross section file, still the same.
2. The depleted composition is different from excel
    - U238 drops down to ~80 percent
        - tried power density 10.13 W/g
        - 104.5 W/cc
    - very minor differences across diff pu streams
    - the AM+PU is higher than excel