**VIPRE LAB. 5 PROBLEM SOLUTIONS:**

**Problem-1:**

| Property | Value |
|---|---|
| MDNBR | 2.2 (Channel-3 on Rod-4) |
| Hot Channel Exit Quality (%) | 0.0 |
| Peak Fuel Temperature (°C) | 1212 |
| Peak Clad Temperature (°C) | 348 |
| Core Pressure Drop (kPa) | 140 |
| Pumping Power (MW) | 3.5 |

**Problem-2:**

22 % power uprate is possible. The MDNBR is 2.1. Peak Fuel Temperature is 1400 °C (limit). Pumping power is 5.3 MW. Therefore, the peak fuel temperature (fission gas release) is the limiting factor. We may perhaps increase the plenum height and decrease the fuel height (volume) to accommodate more fission gases and increase the power density further. Another way of doing it is to design new materials that can retain the fission gases up to higher temperatures or materials with high thermal conductivity.

**Problem-3:**

This question can be solved considering only the three design criteria given in the problem statement. Typically we have many other limitations such flow induced vibrations, neutronics and clad fast fluence and temperature limits.

Since we are limited with the peak fuel temperature, we need to find a way to increase the power density while keeping the linear heat rate constant (peak fuel temperature can typically be referred to the linear heat rate). Since there is the large margin in pumping power, the coolant flow area can be reduced and equivalent diameter can be decreased with a tighter lattice arrangement. So, while keeping the linear heat rate constant, the power density can be increased significantly.

This is not direction the utilities follow because this arrangement may lead to (1) harder neutron spectrum which may hurt the cladding integrity at high burnups, (2) Requires higher enrichment for the criticality since we operate now at the epithermal region, (3) The flow induced vibrations can cause increased cladding breaches due to higher coolant velocity.

Another possibility could be to go smaller diameter fuel pins. This time, we can keep the coolant flow velocity constant; the neutron spectrum can also be similar to the reference PWR. However, the thinner fuel pins are much more susceptible to the flow induced vibrations.