Adam Butt
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Sonofusion Lab 2004 Summer Activities

1. Lab setup and Construction
    a. Moved equipment from Pharmacy lab to INOK lab
    b. Setup concrete and paraffin shielding around Sonofusion test area
    c. Setup pressurized air system
        i. Bolted air tank to the floor
        ii. Mounted filter and regulator setup
        iii. Design, constructed, and installed supply lines
        iv. Performed numerous leak checks to asses system
    d. Designed and constructed polycarbonate shielding for the high pressure chamber
    e. Acquired necessary tools, fittings, and various other supplies from many trips to local vendors
    f. Selected and purchased television
    g. Selected and installed purified water filter for drinking water

2. Sonofusion test work
    a. Installed and helped verify functionality of Sonofusion/freezer station
    b. Performed numerous days test work with Sonochamber using normal acetone at nominal conditions in order to understand how the system works and trying to achieve resonance and cavitation.

3. Preliminary control system design
    a. Went through the preliminary work to determine how to create a control system to keep the chamber in resonance
    b. Determined that a LabView controlled loop to adjust the frequency of the PZT such that the recorded decibel level caused by the cavitating liquid would remain in the same general vicinity would be the easiest near term solution
    c. Will be looking into the necessary hardware required to have the microphone as the input and frequency adjust as the output

4. FEMLAB
    a. Began the long process of understanding how to use Femlab and what is required to generate useful models and how to analyze them
    b. Went through the Structural Mechanics Module tutorial which consisted of literature background and an example problem of each of the following stress analyses:

        i. Static
        ii. Quasi-static transient
        iii. Eigenfrequency
        iv. Frequency response
        v. Time dependant
        vi. Parametric
    c. Learned how to use the built in CAD program to generate models
    d. Designed an accurate 2D cross-sectional model of the actual Sonofusion test chamber

5. Library Research
    a. Spent many hours in the Potter Engineering Library doing background research on,
        i. Sonoluminecsence and Sonofusion
        ii. Fusion
        iii. Nuclear propulsion
        iv. Various electric propulsion schemes
        v. Direct energy conversion methods
        vi. Structural mechanics and dynamics

6. Manaz's NASA paper
    a. Helped Manaz with her paper for NASA concerning the use of sonoluminescent fusion for space power and propulsion

7. Generated my topic outline and schedule for thesis research (see attached)

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7/23/2004

Sonofusion and its Applications in Space Propulsion

1. Sonofusion Reactor Modeling
    a. Analytical problem to obtain known solution – 8/6/04
    b. Simple Femlab models to match analytical solutions – 8/6/04
    c. Femlab modal analysis – 8/20/04
        i. Find Eigenfrequencies
        ii. Find Resonance Frequencies
    d. Harmonic Response Analysis – 9/8/04
        i. See at which driving freq. the chamber is in resonance (including accurate damping and materials)
        ii. Verify results with experimental results
        iii. Check results against material failure criteria
    e. Parametric Analysis varying: - 9/24/04
        i. Structural Materials
        ii. Reactor geometry
        iii. Fluid
        iv. Driving frequency/amplitude
        v. Temperature
        vi. Vacuum pressure (lower pressure)
        vii. Etc.
    f. Determine pressure fluctuations possible and needed to obtain desired reaction rates (ex. 100 atm → Net power?) – 10/8/04
        i. Implosion dynamics simulation
            1. Raleigh-Plesset simulation
            2. Estimate internal bubble temperature
        ii. Calculate DD and DT reaction rates (using Maxwellian distribution) necessary for net power
        iii. Include analysis on multi-bubble fields
2. Sonofusion Experimentation – 11/26/04
    a. Testing using various neutron sources
    b. Iterative testing based on Femlab results
    c. High speed photography
    d. Control System to keep reactor in resonance
3. Energy Conversion Analysis – 10/29/04
    a. For direct propulsion applications
        i. Heat transfer from high energy neutrons – Heat (thermalized blanket, etc) from the reactor used to vaporize and potentially ionize propellants
            1. Include 1^{st} order MCNP analysis
        ii. Ionization source – Neutrons from reactor are used to ionize atoms to be used in a propulsion system
    b. For indirect propulsion applications (Electrical energy source)

        i. Thermionic energy conversion (thermal energy added to conductor until electrons are freed, free electrons then travel to a cooler facing electrode, thus setting up an E-field)
            1. Useful because system would be solid state (be able to function reliably in space for a long time)
        ii. Thermoelectric – electric energy produced from thermal energy using bound electrons in a solid
4. Propulsion Candidate Analysis – 11/5/04
    a. High energy ion engines
    b. Plasma Thrusters
    c. Magnetohydrodynamic (MHD)
    d. Etc.
5. Sonofusion comparison to other power sources and systems for space applications – 11/12/04
    a. Trade off matrix
6. Other Topics – 11/26/04
    a. Mating of reactor/conversion system/propulsion system
    b. Sonofusion reactor design for space application (structure, material, fluids, orientation, etc)
    c. Using more than one reactor – possible interactions
    d. Sizing necessary for various missions (manned Mars mission, outer planets lander, lunar transport, etc.)