

GUJARAT TECHNOLOGICAL UNIVERSITY
Chandkheda, Ahmedabad
Affiliated



LUKHDHIRJI ENGINEERING COLLEGE
MORBI



A
Project Report
On
Nuclear Reactor

Under subject of
DESIGN ENGINEERING – I
B. E. II, Semester – III
CHEMICAL ENGINEERING

Submitted by:

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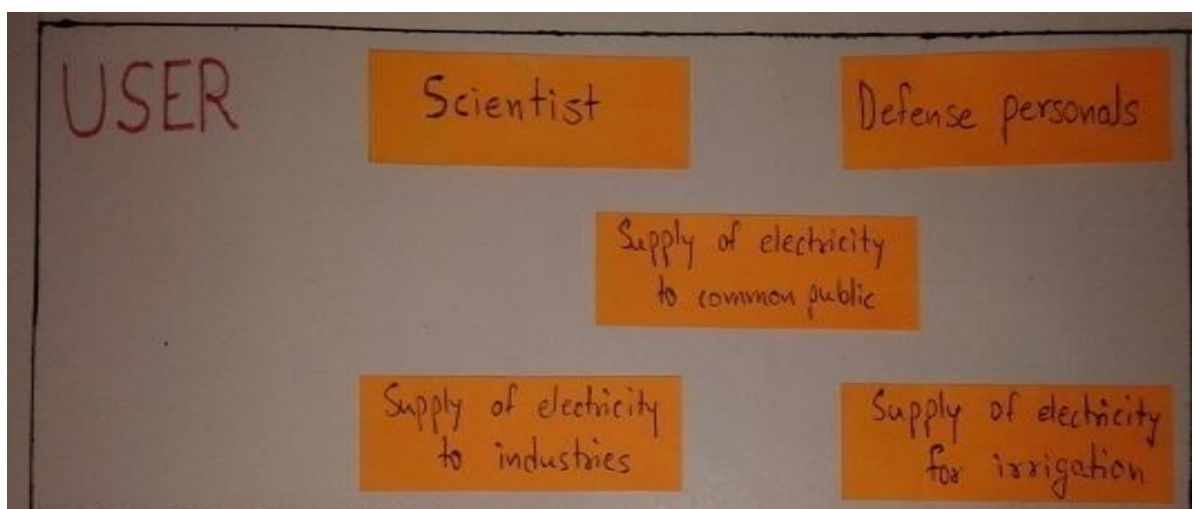
INTRODUCTION:

Design Engineering is concerned with the creation of systems, devices, and processes useful to society. The process by which these goals are achieved is engineering design. A person studying the process/design of a particular thing, and creating or adding something new into it, is a design engineer.

EMPATHY MAPPING:

USER:

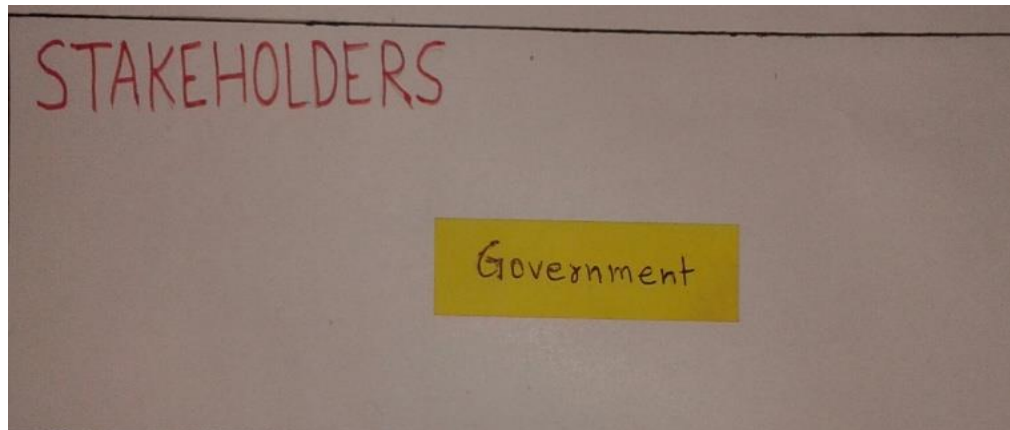
- **Scientist:** In this era of automation and robotics, there is a huge requirement for an alternative source of energy which can able to harness power many other things. Scientists work on nuclear reactor for performing various experiments on inventing the new scope for nuclear energy.
- **Defense personals:** Nuclear reactors are also used in the military and defense for the safety purposes of the nation. The use of it depends on the status of war and peace.
- **Others:** A large amount of electricity is produced from nuclear reactors at a comparatively cheap cost which can be used for various purposes like for household use to common people, to industries and for irrigation.





STAKEHOLDERS:

- ❖ **Government:** Government only put their own bodies over any such matters which contain nuclear matter, as such nuclear lab/reactor and power plants. Other private bodies are neither allowed to hold a right or legal share of nuclear materials like uranium and thorium nor any financial involvement with something of this sort.



ACTIVITIES:

User does the following activities:

- ✓ Management gathers the required fueling materials which are rare and expensive.
- ✓ Scientists start the nuclear fission process safely.
- ✓ Moderators are being placed to slow down the speed of neutrons.
- ✓ Control rods are adjusted.
- ✓ Operators look after the proper circulation of coolants.
- ✓ Researchers look after the proper disposal of the radioactive waste.
- ✓ Supervisors look after the safety of the workers.
- ✓ Steps are taken to avoid the mixing of heated coolants in the natural water systems.



STORY BOARDING:

1) Happy:

Government of India established a Russian backed 2000 MW Kudankulam Nuclear Power Plant in Tamil Nadu and found it to be powerful and efficient as it could generate a large amount of electricity from a single plant. They also found it to be reliable because it could be operated even in the cases of rough weather conditions unlike solar and wind power plants. This plant was also noted low on greenhouse gas emissions as it didn't release any gases like CO₂ or CH₄ which are largely responsible for greenhouse effect.

2) Happy:

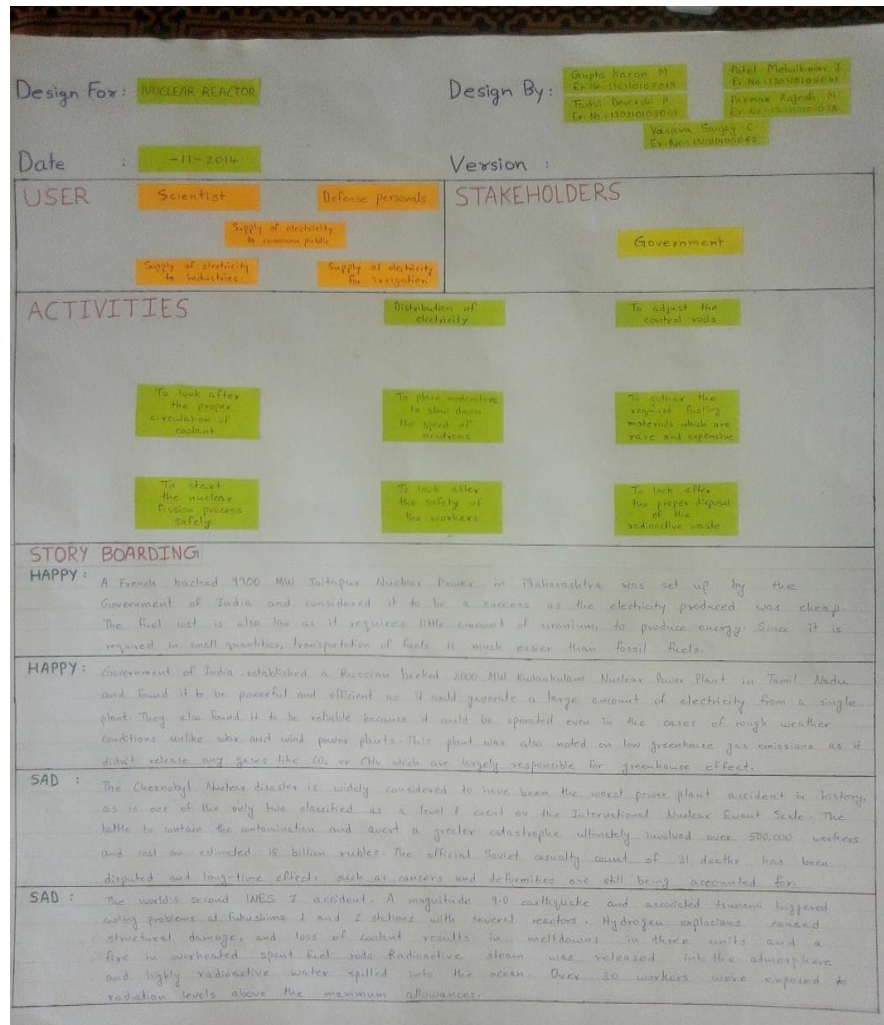
A French backed 9900MW Jaitapur Nuclear Power Project in Maharashtra was set up by the Government of India and considered it to be a success as the electricity produced was cheap. The fuel cost is also low as it requires in small quantities, transportations of fuel is much easier than fossil fuels.

3) Sad:

The Chernobyl nuclear disaster is widely considered to have been the worst power plant accident in history and is one of only two classified as a level 7 event on the International Nuclear Event Scale. The battle to contain the contamination and avert a greater catastrophe ultimately involved over 500,000 workers and cost an estimated 18 billion rubles. The official Soviet casualty count of 31 deaths has been disputed and long-term effects such as cancers and deformities are still being accounted for.

4) Sad:

The world's second INES 7 accident. A magnitude 9.0 earthquake and associated tsunami triggered cooling problems at Fukushima 1 and 2 stations with several reactors. Hydrogen explosions cause structural damage, and loss of coolant results in meltdowns in three units and a fire in overheated spent fuel rods. Radioactive steam was released into the atmosphere and highly radioactive water spilled into the ocean. Over 30 workers were exposed to radiation levels above maximum allowances.



Conclusion from Empathy Canvas:

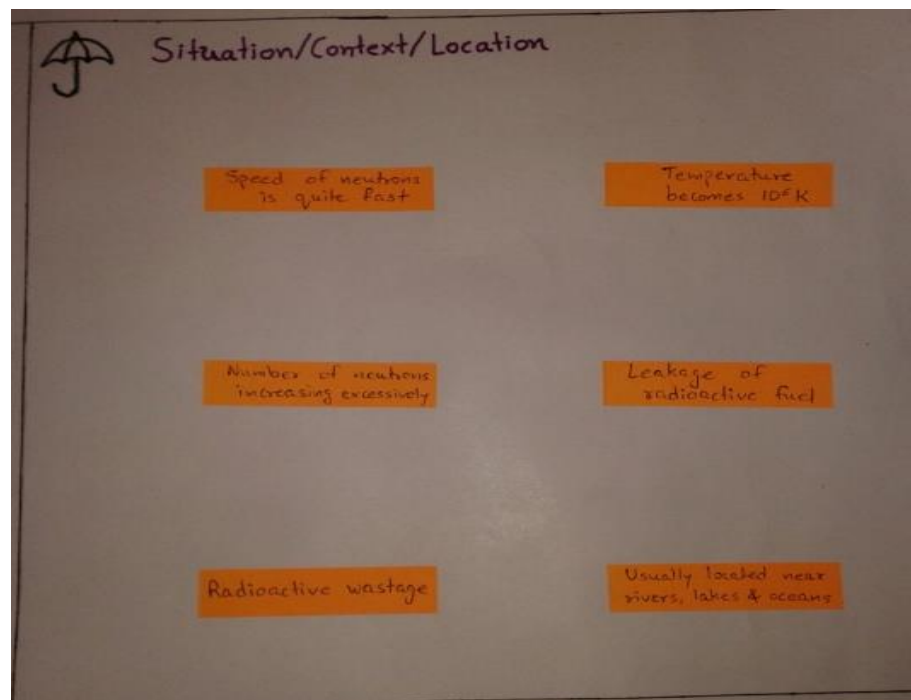
There are many advantages of nuclear reactor like the electricity is produced in bulk from a little amount of raw materials and was even cheaper than the conventional sources of energy. Nuclear reactors don't even cause pollution and are reliable. But its major disadvantage is that the disposal of waste products and the harm it causes when it gets exposed to atmosphere. So some steps should be taken for overcoming these serious issues.

IDEATION CANVAS:

- ***Situation/Context/Location:***

Following situations may occur at a nuclear lab/reactor:

1. Sometimes the speed of neutrons gets too fast.
2. Neutrons increase to an excessive number.
3. The temperature of the reactor may increase up to 10^6 K.
4. There may be a chance of leakage of radioactive fuels.
5. The problem of radioactive wastage always comes out to be a serious issue.
6. Nuclear reactors are usually located near the rivers, lakes or oceans.



- ***Props/Possible Solutions:***

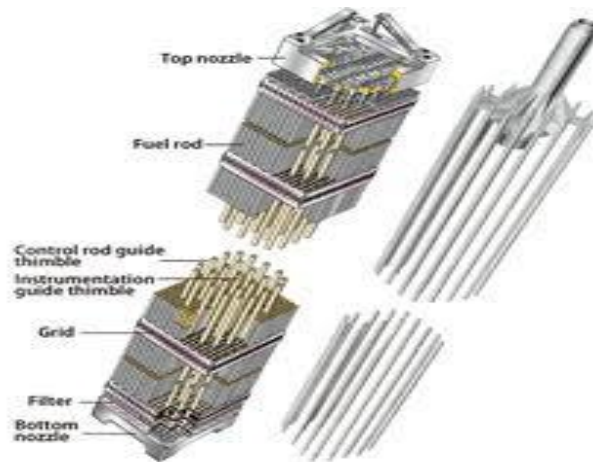
- ✓ Use of coolants:

Coolants are the substances that are used to remove heat from the system. As the temperature of the reactor becomes almost 10^6 K, the circulation of coolants like water, molten sodium metal and other gases is very essential.



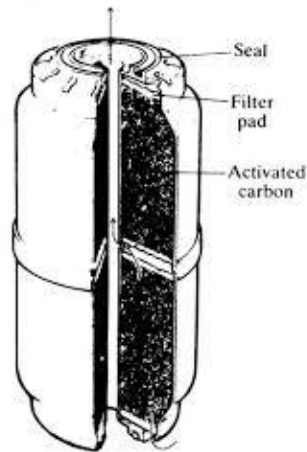
✓ Use of control rods:

As the number of neutrons in a nuclear reactor increase excessively which may also result into a blast, rods of a neutron-absorbing substance is used to vary the output power of a nuclear reactor, called the control rods. The control rods essentially contain neutron absorbers like boron, cadmium or indium.



✓ Use of activated charcoal:

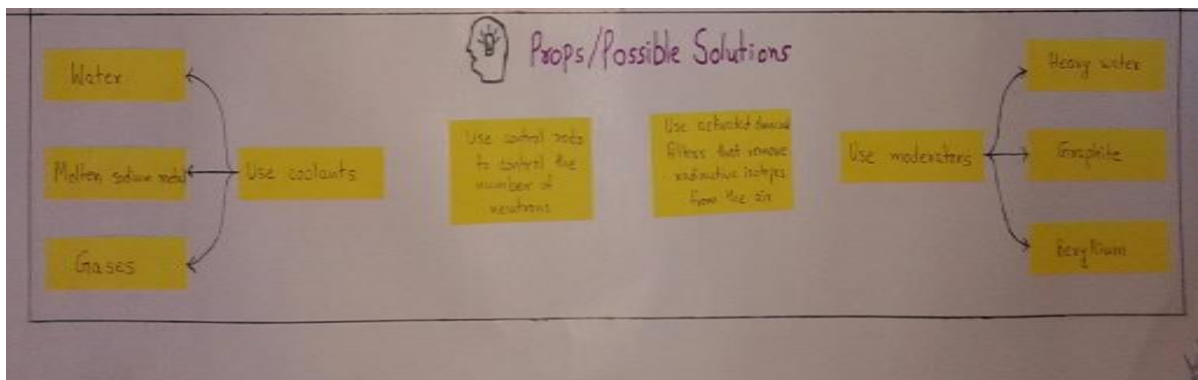
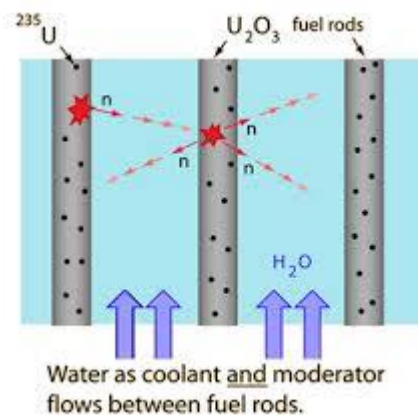
Activated charcoal absorbs any type of gases within its pore space. So in a nuclear power plant, activated charcoal filters are used that remove radioactive isotopes from the air.



Activated carbon water filter.

✓ Use of moderators:

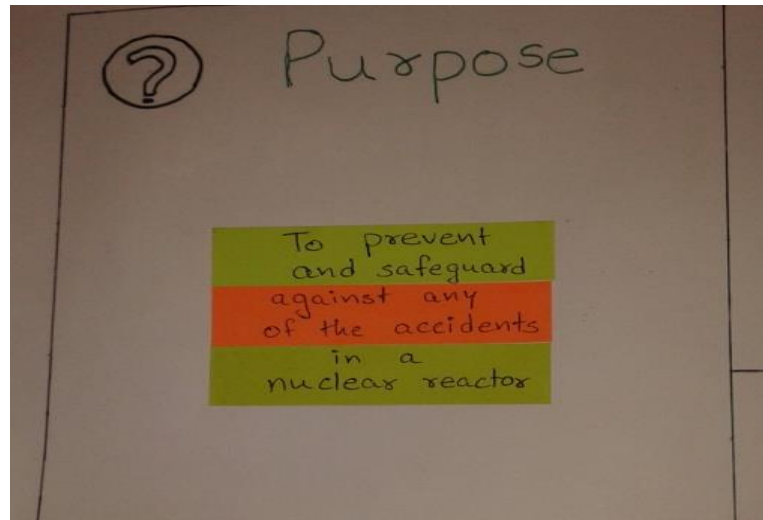
The speed of neutrons in a nuclear reactor sometimes becomes excessively fast and to maintain it, moderators are used. Some of the moderators used in a nuclear reactor are normal water (H_2O), heavy water (D_2O), graphite and beryllium.



PRODUCT DEVELOPMENT CANVAS:

✚ Purpose:

- The purpose of designing this concept is to solve the problem of preventing and safeguarding the health of workers, scientists and other staff working in a nuclear reactor/lab against any of the accidents in a nuclear reactor.



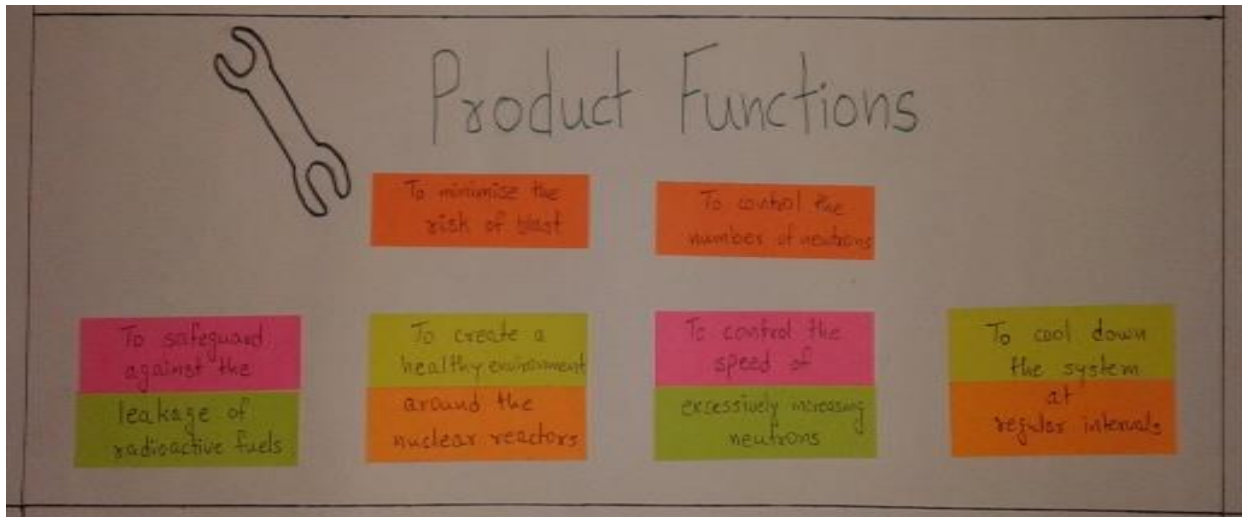
✚ People:

The people involved or attached, directly or indirectly with the good/adverse effects of a nuclear reactor are researchers, scientists, manager, workers, operator, supervisors, common public and other living organisms.



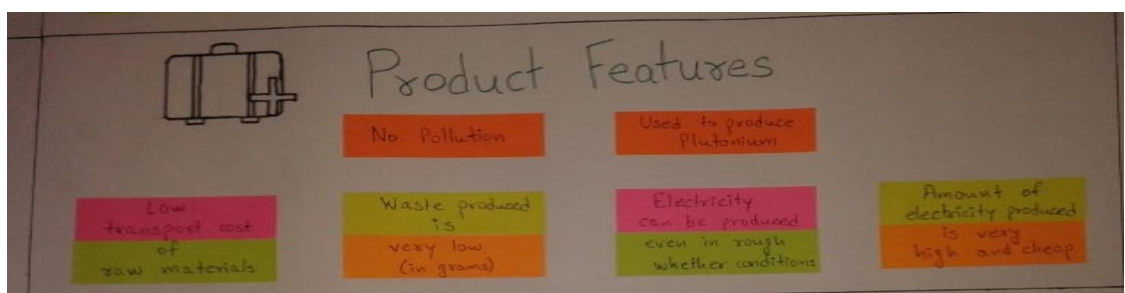
Product Functions:

- To minimise the risk of blast in the reactor.
- To control the number of excessively increasing neutrons.
- To control the speed of fast moving neutrons.
- To create a healthy environment around the nuclear reactor.
- To safeguard humankind against the leakage of radioactive fuels.



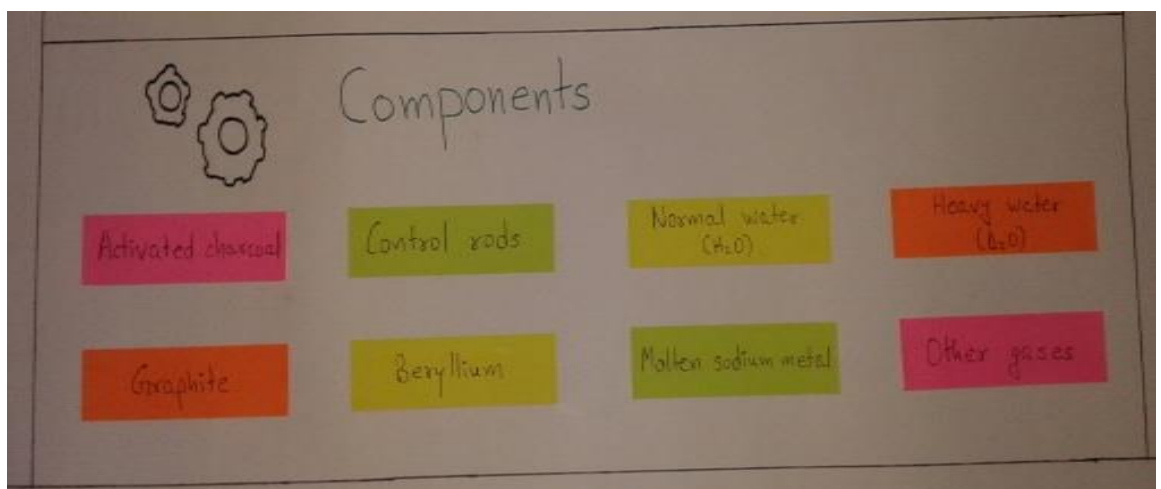
Product Features:

- No pollution is created in producing electricity by nuclear reactors in a nuclear power plant.
- A nuclear reactor is also used to produce plutonium.
- Amount of electricity produced by nuclear reactors is very high and cheap.
- Electricity can be produced even in rough whether condition.
- Waste produced by the nuclear reactors in producing electricity is very low (in grams).
- There is a low transport cost of raw materials for producing electricity in a nuclear power plant.



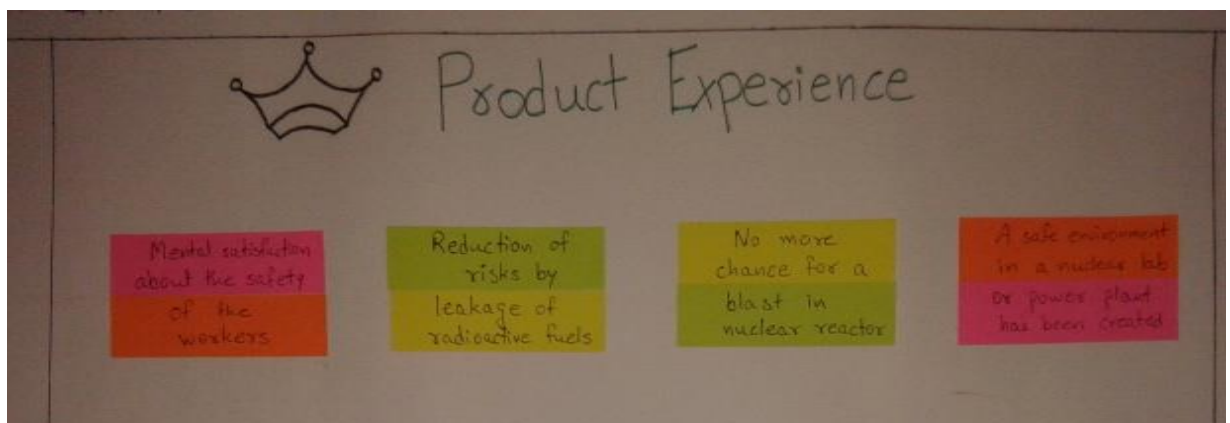
Components:

- Activated charcoal- they are used in activated charcoal filters which are able to absorb the harmful radioactive substances in the case of leakage.
- Graphite- it is used as a moderator.
- Control rods- they are used to control the number of excessively increasing neutrons.
- Beryllium- it is used as a moderator.
- Normal water (H_2O) - it is used as a moderator as well as in coolants.
- Molten sodium metal- it is used as a coolant.
- Heavy water (D_2O) - it is used as a moderator.
- Other gases- they are used in coolants.



Product Experience:

- Workers were mentally satisfied about their safety.
- The risk of leakage of radioactive fuels was reduced.
- There was no more chance for a blast nuclear reactor.
- A safe environment in a nuclear lab or power plant has been created.



Customer revalidation:

The system after being installed got the following reviews/ suggestions from the workers/staff working with nuclear reactor and from other experts:

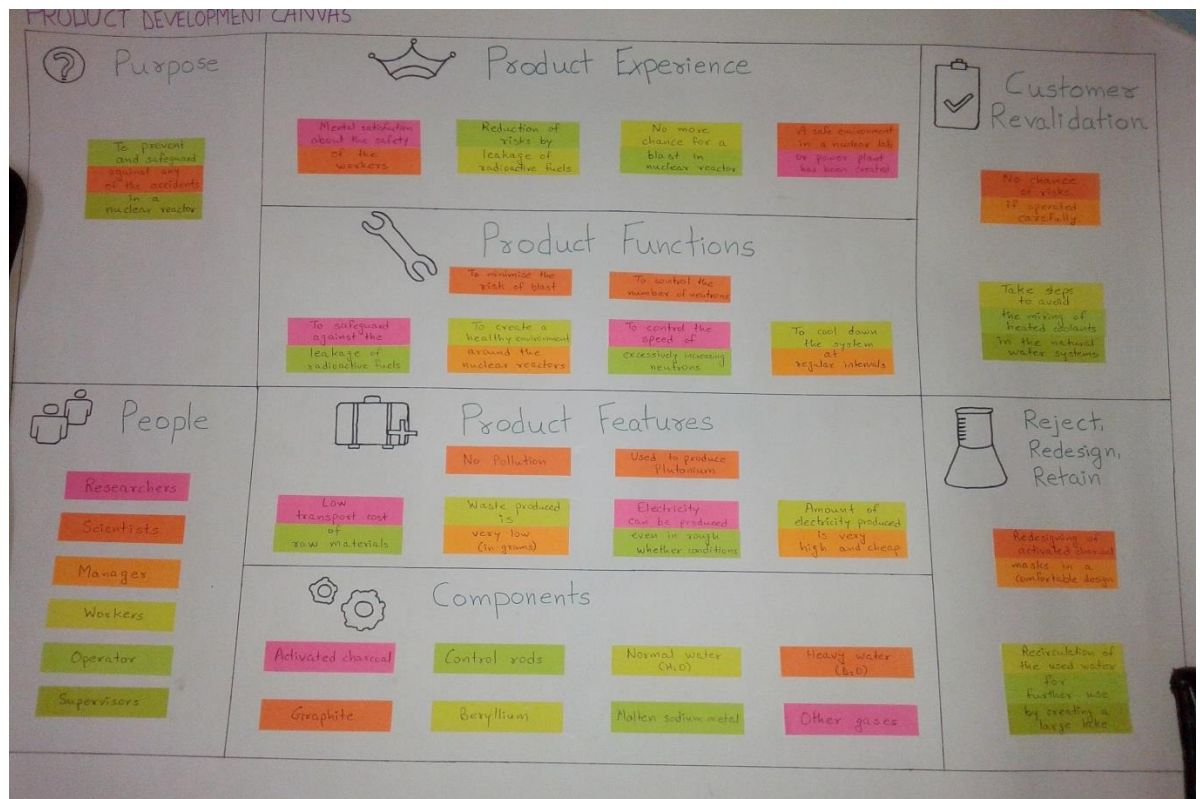
- There is no chance of risk if the nuclear reactor with mentioned specifications is operated carefully.
- Take steps to avoid the mixing of heated coolants in the natural water systems which causes the evaporation of the dissolved oxygen present in it, resulting in the rise of number of deaths/reduction of aquatic life.



Reject, Redesign, Retain:

None of the features/specifications made in the design of the nuclear reactor were rejected. The post customer validations are as follows:

- Redesign the activated charcoal masks for the working staff and others in a comfortable design.
- Recirculation of the used water for further use by creating a large lake: The mixing of heated coolants in the natural water systems causes the evaporation of the dissolved oxygen present in it, resulting in the rise of number of deaths/reduction of aquatic life. So for the solution of this problem, a large lake is to be created for the purpose of storing the heated coolants and circulating the already cooled coolants again in to the reactor.



FINAL PRODUCT SOLUTION:

Looking to the present scenario of the usage of nuclear power plants, it became a need of the hour for developing some techniques, solutions or design to overcome the serious issues regarding the leakage and waste disposal of hazardous substances. Apart from using control rods, moderators and coolants in the nuclear reactor, activated charcoal masks can be used which can absorb the radioactive isotopes from the air in case of leakage. Another solution found for waste disposal is the recirculation of the used water for further use by creating a large lake.

