Project Synopsis

Department: Mechanical	**Project Title:**
Name of Project Group Members	**3d Printer for Cake Icing**
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A) Categorize your Project/Activity and justify your answer (200)

(Give brief description, include sketch or photo of your model)

1.Innovation /New Development /Modification in existing solution

This study introduces the first-generation food printer concept designs and workable prototypes that target to revolutionize customized 3D printing (3DP) technology .Our project objective is to print 3D objects with the help of materials that can be consumed as food, although a wide range of viscous materials can be printed using this machine, but for now, we have primarily focused our attention on generation of 3D objects using chocolate as a raw material. Our main aim was to build a cost-effective 3D printer which can print using chocolate as its filament. Some of these kinds of printers are existing in the market but are way too costly for the customers.

For this purpose, we have ourselves build a 3D Printer and instead of using a traditional extruder we have used a peristaltic pump which can serve the purpose of an extruder.these kind of pumps are used in medical uses too. The purpose of using peristaltic pump ia that they offer the ultimate in purity because the media being pumped only touches the tube. Another advantage is that they are available in so many different configurations. This allows them to pump a wide variety of fluids.

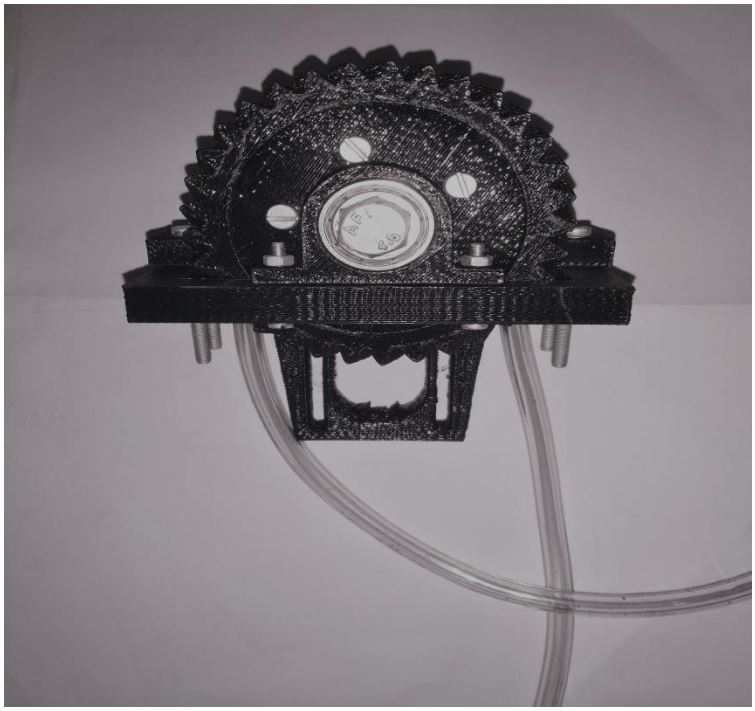


Fig peristaltic pump

Fig Parts of pump

2. Perfecting skills of manufacturing by creating usable prototype / Implementation of existing technology with better reliability and manufacturing aspects.

There is an increasing market need for customized food products, most of which are currently designed and made by specially trained artisans. The cost for such a limited number of pieces is relatively high. Preparing a Chocolate printer is a challenging task and may require extensive knowledge of basics of engineering to solve the numerous problems that come along in the way.

Building a viscous material based 3D printing machine can be a challenging task and might require troubleshooting of issues in the temperature control of material or machine components, developing an efficient extrusion mechanism, tweaking the software based parameters in the firmware, designing the machine components. . These issues might arise as a result of high dimensional precision and accuracy required in the framework design including printer components and extruder parts.

B) Define & justify your problem statement (100)

1. Describe what problem you are solving through this activity?

- Through this project we aim to can reduce wastage by using only the required amount of raw materials
- To open the door to food customization and therefore tune up with individual needs and preferences.
- To reduce human effort
- Use it as mass production for effective functioning

2. What are consequences in current situation?

Only certain plastics are safe enough to be used to contain or manipulate food. ABS and PET-G are such materials. The 3d printing process however is not food safe because, it creates crevices in the printed part into which bacteria and other contaminants can cling to. A printed part would need to be coated in a silicone rubber to render the surface both inert (can't grow anything) and smooth (no crevices). Further, the type of plastic you use must be able to be sterilized in boiling water. PLA softens in boiling water. PET-G variants can as well (think clear plastic bottles). This is why most food handing utensils are either glass or stainless steel.

If you are going to use a 3d printing process to produce parts that are to be used for food, you also have to consider containment from the machine itself. The brass nozzle, the teflon tube, the extruder gears etc. The filament itself may not have come from the factory as clean as it would need to be to be used around food.

If you are able to coat the heat resistant part in silicone and you only use it a few times (ensuring that it is properly washed and sterile) then it can be used for food prep purposes.

3. How your solution helps to resolve/minimize mentioned consequences?

In the current food printing scenario the most vital problem is maintaining quality of food while printing . considering the above situation we deciding to a peristaltic pump for extruding the paste material where he food material is only in contact with the food graded pipe and is aloof from all the mechanical parts.The working principle of peristaltic pump is shown below

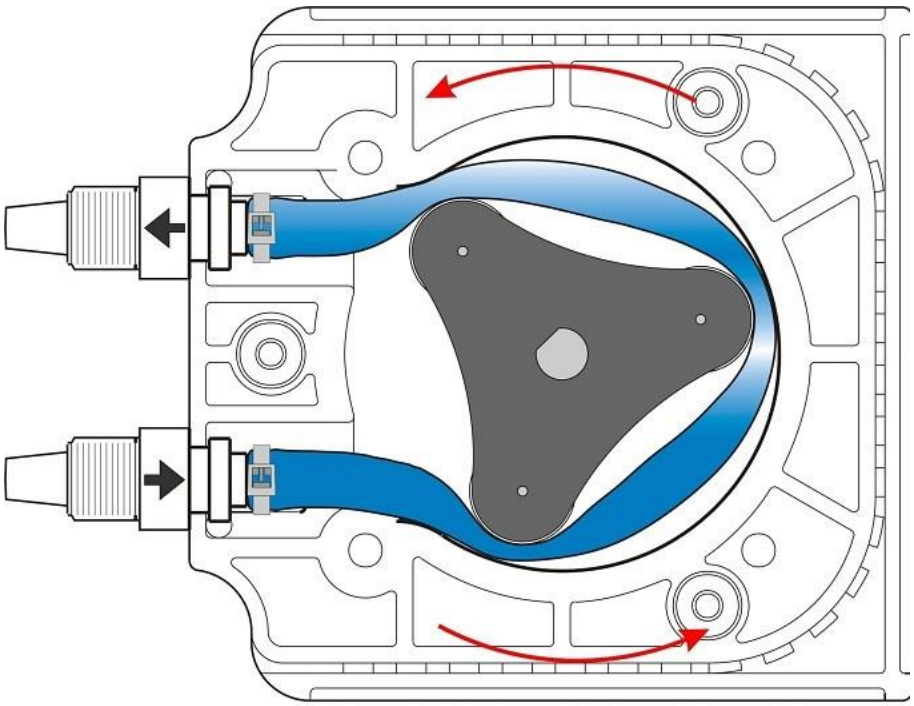


Fig PERISTALTIC PUMP WORKING

- the tubing is continuously squeezed by the rollers which push the liquid in the direction of the revolving rotor
- The rollers on the revolving rotor move across the tubing
- The tubing behind the rollers recovers its shape, creates a vacuum and draws liquid in behind it.

Avantages of using a peristaltic pump

- no contact of the liquid with mechanical parts
- tube is only part to wear
- service and maintenance costs are minimal
- easy to clean and sanitize
- multi-channel systems available
- Ismatec pumps available up to 24 channels
- insensitive to dry-running
- self-priming
- excellent suction height
- use tubing with small i.d., thick wall and stiff material
- no siphoning effect when pump is stopped

- immune to many chemicals
- depends on the tubing material
- suspensions and sludge can be pumped
- with a solid content of up to 60%
- virtually immune to abrasive media
- liquids of high viscosity can be delivered
- gentle delivery due to very low shearing forces

C)Technology, platform used in project/activity (100)

1. What resources does your project/program require? (hardware &/or software requirement)

   The hardware required is mentioned below

RAMPS 1.4, AURDINO MEGA 2560, A4988 STEPPER MOTOR DRIVER, 12864 SMART LCD (comprising of single electronic unit)
POWER SUPPLY 12V/20A
NEMA 17 STEPPER MOTOR
ENDSTOP SWITCH
MECHANICAL PARTS
GT2 20 TEETH PULLEY &TIMING BELT
STEPPER MOTOR COUPLER 5MM TO 8MM
T8 8MM LEAD SCREW
8MM DIAMETER STEEL ROD
ACRYLIC SHEETS
ALUMINIUM SECTION PIPE
SC8UU LINEAR MOTION BEARING
SK8 8MM RAIL SUPPORT

Software required

3D Slicing software

Slicing is dividing a 3D model into hundreds or thousands of horizontal layers and is done with slicing software.Some 3D printers have a built-in slicer and let you feed the raw .stl, .obj or even CAD file.When your file is sliced, it's ready to be fed to your 3D printer. This can be done via USB, SD or internet. Your sliced 3D model is now ready to be 3D printed **layer by layer**.Cura is the most commonly used slicing software.

Marlin Software

Marlin is an open source firmware in which any of RepRap family to replicate in Rapid prototyping and it is popularly known as a 3D printer. Marlin runs in 8-bit microcontrollers the chips are at the center of open source reference platform for marlin Arduino Mega2560 with RAMPS 1.4. Marlin is firmware can be used in any of single-processor electronics, like supporting for ultimaker, ramps, and several other Arduino2570-based on 3D printers. It supports printing over USB or from SD cards with folders and uses look-ahead trajectory planning. Marlin is licensed under the GNU GPL v3 or later. It is based on sprinter firmware, licensed under GPL v2 or later. Marlin Firmware runs through a 3D printer's main board, to manage all the real-time activities on the machine. It coordinates the heaters, buttons, sensors, steppers, LCD display, lights and everything will be involved in the 3D printing operation. Marlin implies on additive manufacturing process called as FUSED DEPOSITION MODELING. In this process a motor pushes the thermoplastic filament into a hot nozzle which melts and extrudes the material while the nozzle is moved under computer control. After several minutes it start laying layer by layer to form a physical object. The control-language for Marlin is used to derivative of G-code. G-code gives commands about machine to do simple things like to "set heater 1 to 210°," or "move to XY at speed F." To print a model through Marlin, it must be converted to G-code using a program called a "slicer." Since every printer is different, but we won't find G-code files from download we should need to slice by yourself. As Marlin receives movement of all commands it

allows themselves into a movement queue to be executed in the order received. The stepper will interrupt the processes for queue and they start converting linear movements into precisely-timed electronic pulses to the stepper motors. Even at modest speeds Marlin needs to generate thousands of stepper pulses every second. Since CPU speed limits how fast the machine can be moved, we're always looking for new ways to optimize the stepper interrupt! Heaters and sensors are managed in a second interrupt that executes at much slower speed, while the main loop handles command processing, updating the display, and controller events. For safety purpose in Marlin firmware it will actually reboot the CPU gets too overloaded to read the sensors.

2. What all skillsets you have learned to complete your project work?

This project helped us knowing different softwares such as cura , pronterface , marlin firmware. We also got our hands on arduino. And the overall project helped us knowing about 3d printers inside out.

3. What was your selection criteria for particular hardware &/or software?

HARDWARE

SELECTION OF MOTOR

Assumptions:

Constant speed of the motor = 400rpm=6.667rps

$v = r$

$\omega = [2\pi N]/60$

$= 41.908 rad/s$

Therefore;

$400 = r*41.908$

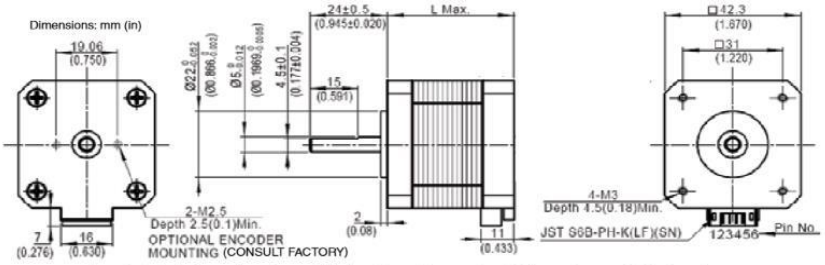
$r = 9.547mm$

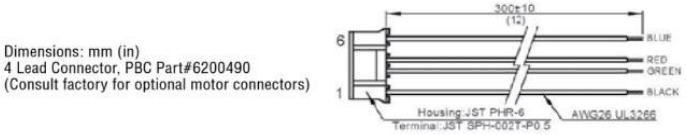
Torque = Force*Radius

Force = 41.87N (considering NEMA 17 stepper motor having torque = 0.4Nm)

Conclusion for motor design

4.2 kg can be pulled over a distance of 500mm in 1second using NEMA 17.





SOFTWARE

The cura 3d software is selected as a slicing software as it is open source and comparatively easy to use. Marlin is an open source firmware in which any of RepRap family to replicate in Rapid prototyping and it is popularly known as a 3D printer Marlin runs in 8-bit microcontrollers the chips are at the center of open source reference platform for marlin Arduino Mega2560 with RAMPS 1.4. Hence we selected marlin firmware.

5. What will be approximate costing of your project? Illustrate with bill of material (BOM)

Electronics Part	UNIT	COST
RAMPS 1.4, AURDINO MEGA 2560, A4988 STEPPER MOTOR DRIVER, 12864 SMART LCD (comprising of single unit)	1	2799
POWER SUPPLY 12V/20A	1	800
NEMA 17 STEPPER MOTOR	5	3990
ENDSTOP SWITCH	3	295

MECHANICAL PARTS		
GT2 20 TEETH PULLEY &TIMING BELT	1	399
STEPPER MOTOR COUPLER 5MM TO 8MM	2	300
T8 8MM LEAD SCREW	2	1000
8MM DIAMETER STEEL ROD	4	400
ACRYLIC SHEETS	1	70
ALUMINIUM SECTION PIPE	1	740
SC8UU LINEAR MOTION BEARING	6	1440
SK8 8MM RAIL SUPPORT	2	198
OTHERS		498
PUMP PART		
608ZZ BALL BEARING	4	126
624ZZ BALL BEARING	20	466
PLA FILAMENT1.75MM	1	960
		TOTAL COST
		RS 14481

D) Project/Activity/Work Outcome & its evaluation (Need assessment) (600)

1. What are the underlying assumptions of the project/ program?
    - Project costs will stay the same as initially budgeted costs
    - Arduino 2560 & ramps 1.4 to be used for interface other components
    - Peristaltic pump to be used as a extruder

2. Include a brief on previous attempts to solve similar problem or similar products/services already in the market .

1.ZMorph VX

The ZMorph VX Full Set ($4,399) comes with 5 different extruders/toolheads: single, dual, CNC, laser cutting, and thick paste extruder. And yes, the thick paste extruder can print not only chocolate but any similar substance as well, such as icing or cookie dough.

On the website, it's specified that objects printed with the thick paste extruder are not certified as eatable, so it may be best to take caution, especially when switching toolheads. Also, this printer is best for printing flatter chocolate patterns that aren't too tall.

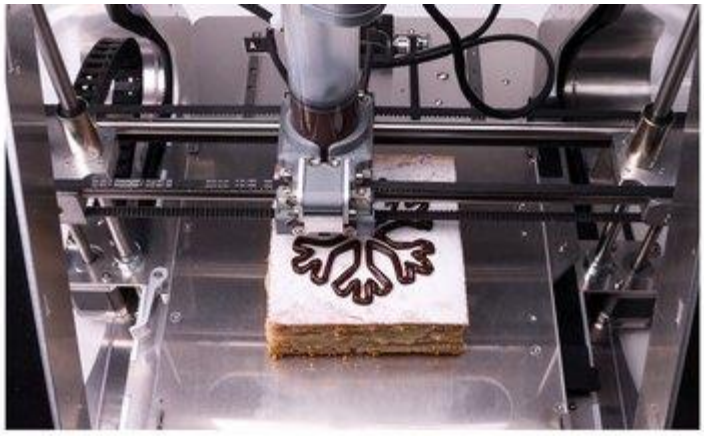


Fig ZMorph 3DPrinter

2. Procusini 3.0

This Germany-based company offers a very similar package at the more affordable price of about $2,250 per printer. Touted as a "universal plug and play printing solution", the Procusini 3.0 prints in pasta, marzipan, fondant, and of course chocolate. Technically speaking, there's no limit to what it can print, as you can load your own mixtures into the printer to print with — just makes ure they are the right consistencies!

What makes this chocolate 3D printer special is that you can buy it with dual extruders. With double the nozzles, batches of objects can be printed twice as fast. It also allows for more innovative food creations, as you can match different colors and materials.

Fig Procusini 3D Printer

3.The Choc Edge Choc Creator V2.0 Plus

It is a food 3D printer able to 3D print chocolate. The Choc Creator is made by Choc Edge, a manufacturer from the UK.

This food 3D printer targets mostly professionals in the confectionery industry, but also suits all chocolate lovers.

Choc Creator V2.0 edible 3D printing technology

The Choc Creator V2.0 Plus works with a syringe loading system. Users must manually insert tempered and heated chocolate into the 3D printer's 30-mL syringe. It is possible to heat the barrel containing the syringe, to keep the chocolate warm.

After 3D printing food, a cleaning process is necessary: users must remove the syringe, squeeze out the remaining chocolate and clean the syringe and nozzle with soap and water.

Choc Creator V2.0 main features

- Mobile apps: the CHOC DRAW, MIX & MATCH and CHOC TEXT apps help users to draw and write on their chocolate 3D prints.
- Proprietary software: a slicing program, the ChocPrint, is also available.
- Large touchscreen: provides an intuitive user experience.

Choc Edge Choc Creator V2.0 Plus price

The Choc Edge Choc Creator V2.0 Plus is available at the manufacturer price of £2,380.

FIG CHOCO EDGE CHOC CREATOR

4.The PancakeBot 2.0

It is a food 3D printer able to 3D print pancakes designed by Miguel Valenzuela, an inventor from Norway.

PancakeBot 2.0 3D printing technology

The PancakeBot 2.0 uses a special batter dispensing system, allowing to **3D print the liquid pancake batter onto the griddle**. By using a combination of compressed air and a vacuum system, the PancakeBot controls where the batter is dispensed. Then, the heated griddle turn the batter into edible pancake.

PancakeBot 2.0 3D printing steps

Users must follow three steps to 3D print pancakes with the PancakeBot 2.0:

- Firstly, users **design their own pancake model** with the PancakePainter, PancakeBot's proprietary software.
- Secondly, they **insert their SD card** with the loaded 3D model into the food 3D printer.
- Then, they **load the bottle-like extruder with pancake batter** and can start the 3D print.

A **cleaning process is also necessary** at the end of the operation, for the extruder and the griddle.

PancakeBot PancakeBot 2.0 price

This pancake 3D printer is available at the manufacturer price of $299.

Fig PANCAKEBOT 2.0

3. What are the outputs, outcomes, objectives, and goals of the project?
    - The objective and goal of our project is to optimize the available resources and make a 3D PRINTER for cake icing costing around Rs 16000.
    - Also to open the door to food customization and therefore tune up with individual needs and preferences.
    - And to reduce human effort.

4. Are outcomes, objectives, and goals achieved? if yes how, if not why not?
   As our prototype is not yet fully developed we are not certain if our objectives would be surely achieved.

5. What is the project/activity outcome?

Building a fully functional viscous material based 3D printing machine which can able to print customized design with the help of peristaltic pump as an extruder. Reduce the printing time and human effort

6. Who will use outcome from your activity /work/solution? (describe customer segment, users, industry segment)
   It will be mostly used in baking industries As big cake manufacturers can use this technology for mass production and with some changes they also can print different designs . Also local bakeries and small cake manufacturing businesses can also use this technology for their products

7. How does the target population/customer/user interact with the system you created?
   We have interacted with some local bakers about this technology , they were positive about the idea but they were also sceptical if they actual needed a machine to print designs and for icing.

8. What do they think of the services? Are they satisfied?
   This is very new technology and use of a 3d printer might sound crazy but We are thinking very positively because further development of this technique will lead to the printer being more economical and will reach the mass production of industrial-size

3D printer will give rise to a new industry which caters to the personalised need of consumers where consumers can give their designs over the internet and the company will print their concept with specified material, followed by professional refinement of the print produced and eventually delivering it to the consumer's footstep.Other viscous materials printing may be achieved by varying these parameters: Temperature control of extruder and conditioned region (depending on the melting and solidification points of material), extruder nozzle diameter (depending on viscosity of material to be printed).

9. Have you verified and validated customer /user views/feedback.

   Yes we have verified the customers feedback as they were sceptical about the degradation of food material.

10. Why your solution should be preferred?

    We used peristaltic pump as a extruder and has various advantages. We made our own 3d printer made changes accordingly, and also introduced a foreign system it its core. We had an idea and we worked on that . We built the whole system and its working. Its a very unique technology combining electronic ,mechanical and food industry. We think this as one of its kind.

11. Conclusion and future scope of your work

    Our conclusion is Preparing a Chocolate printer is a challenging task and may require extensive knowledge of basics of engineering to solve the numerous problems that come along in the way. These issues can be easily resolved if we follow the scientific methodology of problem solving. Chocolate 3D printer has multiple advantages over traditional and conventional processes involved in manufacturing of chocolate items.
    It allows us to create personalized and customized items. It has several applications in confectionary industry. Other viscous materials can also be used in the same framework with minimal changes.
    As we know the 3D printing machine has high cost in the market, so we tried to optimize its cost in every possible manner and made a 3D printer which cost around

Rs. 16000/- which is much lower than market price.

Our 3D printer has accuracy of up to 100 microns. This optimization will be helpful in society and in the field of manufacturing. In future it may be possible that the 3d printer can be easily installed in household at cheaper cost. Since this technology growing day by day, it creates great impact in today's world and their might be huge scope in this field

Future scope

Refinement of the printing mechanism, material composition, temperature control means will lead to better result output from the machine and hence enhance the reputation of practicability achieved by 3D printer.Further development of this technique will lead to the printer being more economical and will reach the masses.Introduction of industrial-size 3D printer will give rise to a new industry which caters to the personalised need of consumers where consumers can give their designs over the internet and the company will print their concept with specified material, followed by professional refinement of the print produced and eventually delivering it to the consumer’s footstep.Other viscous materials printing may be achieved by varying these parameters: Temperature control of extruder and conditioned region (depending on the melting and solidification points of material), extruder nozzle diameter (depending on viscosity of material to be printed).

12. Limitations of your activity/work

1. Nozzle movement speed and extrusion rate affect the quality of 3D food printing
2. The extruder assembly should be as rigid as possible, especially for chocolate 3D printing
3. A effective active cooling system is needed for chocolate 3D printing
4. Maintaining the shape of cholocate due to effect of gravity.
5. Inconsistent occlusion of paste from peristaltic extruder.

E) Assessment of efficiency (100)

1. Is the cost of the services or activities reasonable in relation to the benefits?

Yes, as we know if we want to buy a good quality 3D printer we would probably have to spend around 24000-25000 on it and if we want to buy a 3D food printer it costs about 3,00000 in the market. Instead our printer would just cost 16000 Rs and could be less if produced in bulk. The main purpose of building this printer is that we could print various designs which are difficult to be made by a worker or require high skills. So instead of paying to the skilled worker eventually the cost of buying a printer itself would be more cost effective.

2. Are there any alternative approaches that could have the same outcomes with less cost?

Probably there isn't any such an alternative that is more cost effective than our prototype. As in our prototype we have build most of the part by ourselves and also have 3D printed the peristaltic pump using a 3D printer which was the only most expensive part in this prototype so we have reduced the cost there also.

3. Is your solution cost effective. Justify your answer.

Yes, then prototype is definitely cost effective since the 3 D printer is build from a scratch and using cheap but good quality material and saved some money on the materials by comparing it before buying and if necessary have produced the components by ourselves like the aluminium frame and peristaltic pump.

F. Sustainability & Commercialization (400)

1. Do you think this project work has potential to commercialize/ scale up, if yes specify the industrial segment where your work can be forwarded.

Yes, This project has potential to commercialize. Food presentation and food appearance customization for individuals is a big trend in the food industry. So far food customization and creative designs have required hand-made skills, which results in low production rate and high cost. 3D food printing can overcome this problem by providing the necessary tools for creative food design even for home users. So in the Food industry segment this project work can be forwarded.

2. Is your prototype ready if yes, send link of video illustrating /demonstrating working of your prototype model

   No the prototype is not yet ready.

3. Any possibility of IPR and patent filing, if yes? Justify

   No

4. Have you checked for sustainability of your solution, if yes? What all parameters you considered?

   Yes, We have considered economical , social and environmental parameters for sustainability of project