Temporary Registration No. : TPN / 73809

सत्यमेव जयते
Ministry of Science & Technology
Government of India

Project Proposal On

"A 3D-PRINTED ENJOYABLE FOOD FOR DYSPHAGIA PATIENTS THROUGH ADDITIVE MANUFACTURING"

Submitted to

Division :SEED

Programme or Scheme : Scheme for Young Scientists and Technologists

Submitted by

Project Investigator:

Dr. Anjibabu Merneedi

ADITYA COLLEGE OF ENGINEERING, SURAMPALEM-SURAMPALEM

Part 1 : General Information

General Information:

1.Name of the Institute/University/Organisation submitting the Project Proposal :

ADITYA COLLEGE OF ENGINEERING, SURAMPALEM

2. State	Andhra Pradesh
3. Principal Investigrator Name:	Dr. Anjibabu Merneedi
4. Category:	General
5. Type of the Institue :	Academic Institutions (Private)
6. Project Title :	A 3D-PRINTED ENJOYABLE FOOD FOR DYSPHAGIA PATIENTS THROUGH ADDITIVE MANUFACTURING
7. Division :	SEED
8. Programme Or Scheme :	Scheme for Young Scientists and Technologists
9. Academic Area :	Food and Nutrition, Medical Sciences, Mechanical Engineering,
10. Application Area :	Food and agriculture, Health,
11. Goverment National Initiative :	Make in India, Swasth Bharat, Startup India,
12. Type of Proposal :	Proposal Against Call
13. Project Duration :	2 Years and 9 Months
14. Proposal Submit Date :	30/11/2021
15. Project Keywords :	Extrusion-based Additive manufacturing, 3D Fruit Printer, Dysphasia

16. Project Summary :

Objectives
1.To provide a joyful food for people suffering from Dysphasia using 3D printing technology.
2.To prepare and analyse for mechanical properties of an advanced composite materials like functionally graded materials through a gradient method.
3.To implement Lithography-based Additive Manufacturing Technology on photosensitive materials.
American Society for Testing Materials ASTM specifies a broad classification of Additive manufacturing AM techniques according to the deposition and solidification methods. Among these techniques, the Extrusion-based Additive manufacturing EAM by material extrusion is the most cost-efficient and widely diffused technology for a wide variety of applications.
Methodology
The multistep process of EAM involves preparation of a powder-binder mixture feedstock, extrusion deposition of the feedstock in a controlled manner to build the 3D object, and post processing debinding and sintering to obtain the finished product. The EAM process is divided into three distinct operations feedstock preparation, deposition 3D printing, and post treatments. The starting material the feedstock is a homogeneous mixture of powder and binder constituents. This mixture is prepared using a compounding equipment, an extruder, and a pelletizer for homogenization and easy feeding to the EAM machine . The 3D deposition is accomplished by synchronizing the feeding of the feedstock material with the moving table or extrusion head. The shape obtained green state after the freeform deposition is not the final part as the part characteristics are modified during subsequent operations. Post treatments that include debinding for the removal of binder constituents, sintering for powder consolidation to near full density, and optional finishing are used to obtain the final usable part. The EAM operations and the components shown in Fig.

Another recently developed extrusion-based system uses a parallel kinematic and controlled acceleration of actuators for generating path trajectories of the work table. Three translational and two rotational degrees of freedoms allow efficient deposition of material on given trajectories. A robot having 5 degrees of freedom DoFs was developed for movement of worktable for extrusion-based. The ratio between the extrusion velocity and the x–y movement of the nozzle should be maintained at 1.0 to obtain a quasi-constant diameter of the extruded wire for better geometrical accuracy and interlayer bonding.

Most of the current 3D food printing experiments have however used extrusion-based printers. 3D food printers operate based upon a number of different additive fabrication techniques including i high and low temperature extrusion, ii selective hot air sintering and melting, selective laser sintering, liquid binding, and iii inkjet printing, among others.
The health problem of dysphagia was selected because a as populations age, problems with ensuring seniors have safe and enjoyable meals increase and b malnutrition, poor health related to aspiration pneumonia, and preventable death from choking are common in older people and people with lifelong disability.
In the technique EAM , product is fabricated in a layer-by-layer approach in which each printed layer supports the succeeding layers. In addition to generic 3D printers, several purpose-built 3D printers have been developed specifically for food printing namely ChefJet, Foodini, f3d, NASA printer, Choc Creator, Cake and Chocolate Extruder, Discov3ry Extruder, 3D Fruit Printer, 3D Everything Printer, Palatable-Looking Goop Printer, and Original Food Printer.

Out-comes
1. The ultimate goal will be to have a 3D printer that could be placed in the kitchen and operated with minimal effort - by choosing a meal from a list of options, filling the printer with the chosen ingredients, and pressing a print button to get a meal with the desired texture, nutrients, smell, and visual appearance that can also be consumed by people having health problem of dysphagia.
2. Through a gradient method an advanced functionally graded material can be prepared.
KEY QUESTIONS
1. Which Foods Can Be 3D Printed
2. Do Food 3D Printers Cook the Food
3. Is It Safe Consuming A 3d Printed Food..

Hypothesis Using of same methodology EAM preparation of 3D printed food and functionally graded materials.

Part 2: Particulars of Investigators

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3. Name:	Dr. DVSSSV Prasad
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Part 3: Suggested Refrees

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Application Area:	
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Part 4: Financial Details

Financial Details:

A. Non - Recurring

Equipment

S.	Equipments	Qty.	Justification	1 Year	Total
1 .	3D printer (metal)	1	3D printer can be customized to print 3D food through an extrusion	1208910	1208910
			Total	**1208910**	**1208910**

Other NonRecurring

S.	Description	Justification	1 Year	2 Year	3 Year	Total
1 .	metal 3D printer can be attached with food cans	so that through an extrusion 3D food print can be done. fabrication cost	0	189000	0	189000
		Total	**0**	**189000**	**0**	**189000**

B. Recurring

Project Staff

S.	Project Staff	No.	Justification	1 Year	2 Year	3 Year	Total
1 .	Project Scientist	2	AN EXPERT VISITING IS NEEDED.	40000	40000	40000	120000
			Total	**40000**	**40000**	**40000**	**120000**

Consumables

S.	Items	Qty.	Justification	1 Year	2 Year	3 Year	Total
1 .	food cans	35	pasted food cans	0	28000	28000	56000
			Total	**0**	**28000**	**28000**	**56000**

Budget Head Summary in (INR)

Budget Head	Year-1	Year-2	Year-3	Total
1- Non-Recurring				
Equipment	1208910	0	0	**1208910**
Other NonRecurring	0	189000	0	**189000**
Subtotal (Capital)	1208910	189000	0	**1397910**
2- Recurring				
Project Staff	40000	40000	40000	**120000**
Consumables	0	28000	28000	**56000**
Subtotal (General)	40000	68000	68000	**176000**
Total Project Cost (Capital + General)	**1248910**	**257000**	**68000**	**1573910**

Part 5: PFMS Details

PFMS Unique Code Available: Yes

PFMS Unique Code : APEG00008296

Part 6: Current Ongoing Project

Current Ongoing Project: NA

List of Uploaded Documents:-

1. Complete Project proposal
2. Biodata
3. Certificate from PI
4. Conflict of interest
5. Endorsement from head of Institute
6. Quotation for Equipments

A 3D - PRINTED ENJOYABLE FOOD FOR DYSPHAGIA PATIENTS THROUGH ADDITIVE MANUFACTURING

Project proposal

Submitted to

Scheme for Young Scientist and Technologist (SYST)

in

FACULTY OF MECHANICAL ENGINEERING

By

Dr ANJIBABU MERNEEDI

(Principal Investigator)
With the collaboration of

Co- Principal Investigator-1
Dr YKS Subbarao
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ME Department
Aditya College of Engineering

Co- Principal Investigator-2
Dr A Ramesh
Professor
EEE Department
Aditya College of Engineering

Co- Principal Investigator-3
Dr DVSSSV Prasad
Professor
ME Department
Aditya College of Engineering

सत्यमेव जयते
Department of Science and Technology (DST)
DST

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1. Introduction:

A 3D food printing is known within the field of engineering as a type of additive manufacturing or food layering manufacture. Additive manufacturing is "well suited to produce customized products, it is expected to play a significant role in personalized healthcare to improve the safety, quality, and effectiveness of healthcare for the general population. The rapid growth in 3D printer technologies and applications with non-food items has led to optimism and an expectation of benefit when it comes to 3D printing of food materials. Reflecting its relatively recent appearance in 3D printing literature, 3D food printing is still considered to be at the prototyping research and development stage. A narrow range of food types - chocolate and sugar - have been produced commercially, and further expansion in relation to 3D printing of these foods is expected to be driven at least in part by a growing 'maker' movement, of 'prosumers' (i.e., consumers who produce).

An important element of 3D food printing development is its aim to develop the printing of a wider range of natural and nutritious foods, including foods that contain carbohydrates, proteins, and fats which could be put to a range of uses. While development of 3D printed foods is aimed at the general population, it might also be driven, at least in part, by a motivation to address significant food problems, including:

(i) Provision of safe and enjoyable meals for people with dysphagia; and
(ii) Provision of large scale individually-tailored foods for people with special nutritional requirements related to age, setting (e.g., in hospital, residential care), health conditions, or other requirements (e.g., gluten-free, high protein, low salt, diabetic diet).

The health problem of dysphagia was selected because (a) as populations age, problems with ensuring seniors have safe and enjoyable meals increase; and (b) malnutrition, poor health related to aspiration pneumonia, and preventable death from choking are common in older people and people with lifelong disability (e.g., cerebral palsy, severe intellectual disability).

2. Literature:

Apart from noting the potential significance of 3D food printing in addressing world food problems, to date the 3D food-printing literature is not well grounded in the relevant research literature for each of these health-related problem areas. Additionally, there is a lack of information demonstrating how future 3D food printing technology could address these problems. There is, however, an awareness that any efforts to provide solutions will require a systematic approach and plan for all stages of food design, supply, and provision on a large scale. Therefore, the aim of this review was to identify the problems, solutions, and problem-solving capacity of 3D food printing research towards the provision of foods for people with specific dietary requirements related to swallowing disorders (dysphagia). People with severe swallowing disorders, as assessed by health professionals, often require 'smooth food' or puree textures for safe swallowing. In this review, a 'research as problem solving' approach based on the work of Larry Laudan's philosophy of scientific progress was applied to the 3D food printing literature. Laudan's 'research as problem solving' philosophy considered problems as 'absence of knowledge', solutions as 'knowledge', and the problem-solving capacity of the research as the adequacy of the solution to address the significant problem. From literature 3D food printing could address both conceptual and constructive problems with standardization of the appropriate food texture, according to a prescription model (e.g., being prescribed safe and appropriate food textures by an expert in swallowing disorders such as a speech pathologist). Dysphagia management is moving towards the more inclusive bio-psycho-social models of health and disability that take account of the social impact of swallowing disorders and the environmental factors that impact upon mealtime enjoyment and safety, as reflected in the International Classification of Functioning, Disability and Health (ICF).

Currently, the literature on 3D food printing is primarily concerned with the environmental factors of the 3D printer tools and technologies, with little attention to the role of food scientists and applied health scientists including speech pathologists and occupational therapists.

Reviewing the design of 3D food constructs via additive manufacturing technology, Godoi proposed a model outlining the connections between the properties of food printing material, and factors which have to be considered in 3D food printing. This classification allows for easy identification of the appropriate material property to modify if specific printing properties are desired. The model presents "materials properties and factors to consider for the rational design of 3D food structures" considering applicability, printability, and post-processing, and taking into account properties of food substrates (physical chemical properties, rheological properties, and structural and mechanical properties). Godoi examined the interactive factors essential for rational choice of 3D printing techniques in the design of food, providing detail on (a) food properties and binding mechanisms of constituents of foods and feasibility for food printing: carbohydrates, proteins, and fats; (b) additive manufacturing techniques, and (c) choices of techniques, including models of printability, applicability, and post-processing reality. Liquid-based deposition techniques were found to be more suited for printing of foods with a combination of carbohydrates, proteins and fat.

These printers operate based upon a number of different additive fabrication techniques including: (i) high and low temperature extrusion, (ii) selective hot air sintering and melting, selective laser sintering, liquid binding, and (iii) inkjet printing, among others. Most of the current 3D food printing experiments have however used **extrusion-based printers**. In this technique, product is fabricated in a layer-by-layer approach in which each printed layer supports the succeeding layers.

3. OBJECTIVES:

i) To provide a joyful food for people suffering from Dysphasia using 3D printing technology.

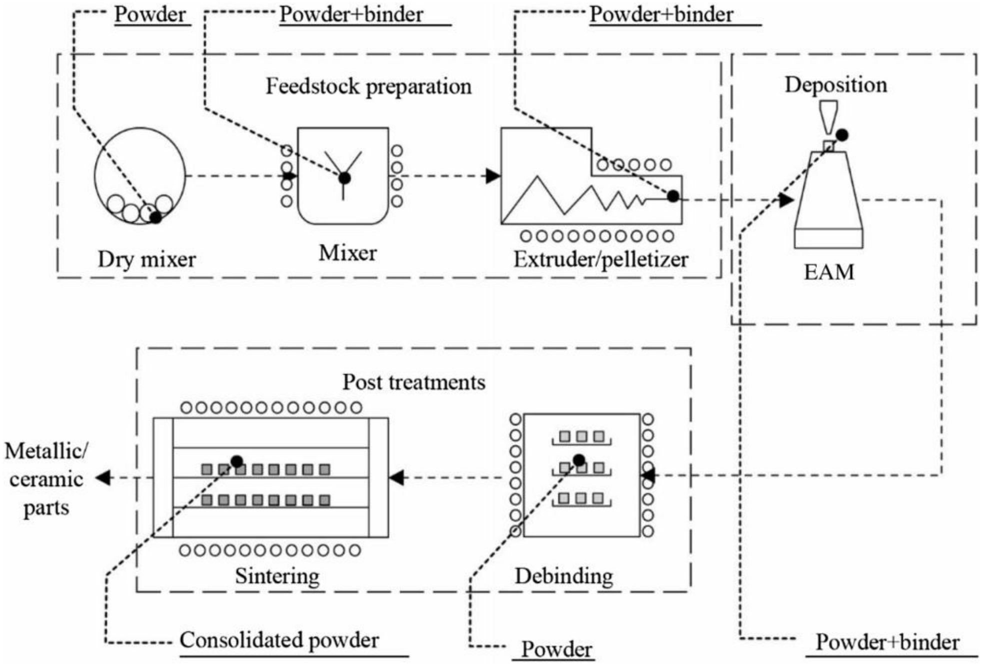
ii) To prepare and analyse for mechanical properties of an advanced composite materials like functionally graded materials through a gradient method.

iii) To implement Lithography-based Additive Manufacturing Technology on photosensitive materials.

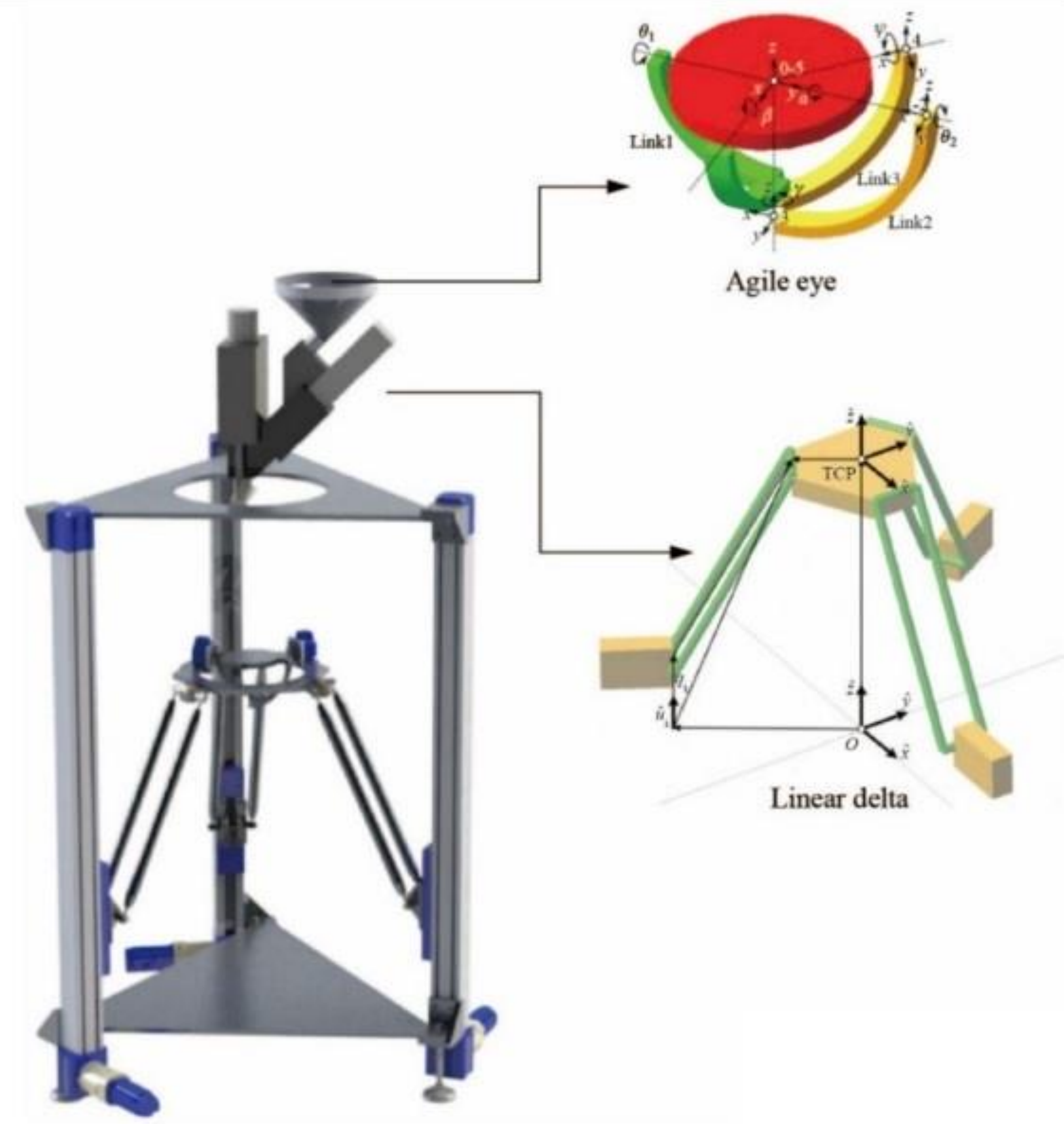
4. METHODOLOGY:

American Society for Testing Materials (ASTM) specifies a broad classification of Additive manufacturing (AM) techniques according to the deposition and solidification methods. Among these techniques, the **Extrusion-based Additive manufacturing (EAM)** by material extrusion is the most cost-efficient and widely diffused technology for a wide variety of applications. The multistep process of EAM involves preparation of a powder-binder mixture (feedstock), extrusion deposition of the feedstock in a controlled manner to build the 3D object, and post processing (debinding and sintering) to obtain the finished product.

The EAM process is divided into three distinct operations: **feedstock preparation, deposition & 3D printing, and post treatments**. The starting material (the feedstock) is a homogeneous mixture of powder and binder constituents. This mixture is prepared using a compounding equipment, an extruder, and a pelletizer for homogenization and easy feeding to the EAM machine. The 3D deposition is accomplished by synchronizing the feeding of the feedstock material with the moving table or extrusion head. The shape obtained (green state) after the freeform deposition is not the final part as the part characteristics are modified during subsequent operations. Post treatments that include debinding for the removal of binder constituents, sintering for powder consolidation to near full density, and optional finishing are used to obtain the final usable part. The EAM operations and the components shown in Fig.



Another recently developed extrusion-based system uses a parallel kinematic and controlled acceleration of actuators for generating path trajectories of the work table. Three translational and two rotational degrees of freedoms allow efficient deposition of material on given trajectories. A robot having 5 degrees of freedom (DoFs) was developed for movement of worktable for extrusion-based. The ratio between the extrusion velocity and the x–y movement of the nozzle should be maintained at 1.0 to obtain a quasi-constant diameter of the extruded wire for better geometrical accuracy and interlayer bonding.

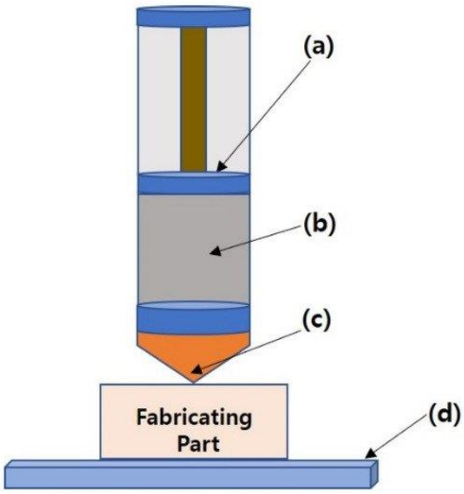


Most of the current 3D food printing experiments has however used **extrusion-based printers.** 3D food printers operate based upon a number of different additive fabrication techniques including: (i) high and low temperature extrusion, (ii) selective hot air sintering and melting, selective laser sintering, liquid binding, and (iii) inkjet printing, among others.

In the technique **EAM**, product is fabricated in a layer-by-layer approach in which each printed layer supports the succeeding layers. In addition to generic 3D printers, several purpose-built 3D printers have been developed specifically for food printing namely: ChefJet, Foodini, f3d, NASA printer, Choc Creator, Cake and Chocolate Extruder, Discov3ry Extruder, 3D Fruit Printer, 3D Everything Printer, Palatable-Looking Goop Printer, and Original Food Printer. The ultimate goal will be to have a 3D printer that could be placed in the kitchen and operated with minimal effort - by choosing a meal from a list of options, filling the printer with the chosen ingredients, and pressing a print button to get a meal with the desired texture, nutrients, smell, and visual appearance that can also be consumed by people having health problem of dysphagia.

Extrusion-based printing has a wide range of food materials that are simultaneously extruded to create an entire meal. However, it requires a material with the capability to easily extrude out of the nozzle tip and support the weight of the next printed layers without deformation. The SLS method refers to a technique in which powder-type materials are applied to the bed, and then the laser is illuminated to solidify only the desired part. As only the part, exposed to the laser, hardens, it forms a shape. Typical powder materials include thermoplastic, metal, and ceramic powders. It is a method of thinly layering powder-type raw materials and shooting laser or resin onto them before the hardening process. Thermoplastics, metals, ceramics, etc., are used as ordinary powder raw materials in extrusion-based printing technology. In the case of food, powder ingredients such as sugar and starch are used in the SLS method, and the output of various colors and flavors can be produced by adding food additives such as artificial pigments and fragrances. The principle of operation of a printer using the SLS method is shown in **Fig** . The color jet printing (CJP) method uses a print head to selectively distribute the binder into a powder layer. This technology is cheaper than other 3D printers and utilizes rollers to spread thin powders on the tray, as in the SLS system. The print head scans the powder tray and provides a continuous dispensing solution to the powder solution while touching the powder particles. Supporting structures are not required during prototyping because the surrounding powders support unconnected parts. Then, the remaining ambient powder is inhaled, and the cyanoacrylate-based material penetrates the prototype surface before hardening. CJP printing technology enables the manufacture of complex geometries, such as partitioning inside cavities without artificial support structures.

Depending on the additive method of 3D food printing technology, it can be divided into material extrusion or powder bed fusion. The extrusion method includes fused deposition modeling (FDM)/fused filament fabrication (FFF), while powder-bed technology uses multi jet fusion (MJF) or selective laser sintering (SLS). FDM/FFF requires thermoplastic material to be heated up to the processing temperature, while the extrusion technique from **Figure** resembles more liquid additive manufacturing (LAM), especially if materials such as mashed potatoes or meat paste are considered.



Fused deposition modeling (FDM) 3D printing technology is currently widely used in 3D food printers, where slurry, such as liquid materials or paste, is continuously protruding from the moving nozzle and stacked while cooling. Extrusion-based printing technology mainly uses soft ingredients such as chocolate, dough, mashed potatoes, cheese, and meat paste. Although FDM technology has been applied to the deposition of various soft materials, it is limited to deposition in complex and delicate forms because it is inherently prone to distortion. The extrusion process using soft materials should print delicate and complex forms with additional structures that support the product geometry. However, it is a time-consuming process to manually remove support components at the last stage, slowing down printing, and increasing material costs. Therefore, it is necessary to increase the printing precision and accuracy by considering the extrusion mechanism, material properties, extrusion speed, and machining factors such as glass transition temperature (T_g), nozzle height, and nozzle diameter. The extrusion mechanism applied to 3D printing technology consists of screw-based extrusion, pressure-based extrusion, and syringe-based extrusion. In the screw-based extrusion process, food materials (3D printing inks) are inserted into the sample supply unit and transported to the nozzle tip by moving screws. During the extrusion process, food materials can be continuously injected into the hopper, allowing continuous 3D food printing process to be performed. However, screw-based extrusions are not suitable for high-viscosity and high-mechanical-strength food slurry, so printed samples do not reach the appropriate mechanical strength required to support the sedimentary layer and reduce compression deformation and resolution. In air-based extrusion, food ingredients are pushed into the nozzle by the air pressure. These methods are suitable for printing liquids or low-viscosity materials. Syringe-based extrusion devices are suitable for printing highly viscous and mechanical-intensity food materials. Therefore, they can be used to produce complex 3D structures with high resolution. However, barometric pressure-based extrusion, such as syringe-based extrusion, makes it difficult to continuously supply food materials during printing. As described above, it is a type of compression method, and in the case of food, it is suitable for printing viscous materials such as dough.

Selective laser sintering (SLS) can be easily printed in foods with more diverse colors and flavors by using sugar-like powders and adding food additives such as artificial pigments and fragrances. SLS for 3D printing can successfully form complex-shaped products by selectively sintered powders, controlling laser irradiation locations using computers, and successfully sintering powders layer by layer. The SLS method is carried out by melting powder particles, which can be formed and bound by forming a solid layer using fresh food material powder until the desired structure is created. For example, an SLS-type 3D food printer, called Candy Fab, selectively sintered and melted a layer of sugar using a flow of slow heat. Though there are several obstacles to using SLS in the food sector, the SLS procedure was carried out by creating a colorful and detailed edible object with a laser spot diameter of 0.6 mm and specific process parameters, i.e., 0.1 mm layer distance, 1250 mm/s writing speed, 50 mm laser power, and 0.3 mm layer thickness. The SLS method is dangerous when exposed externally because of machine operating errors during the process. There are four major hazard classes (I to IV) of lasers according to the Food and Drug Administration (FDA), including three subclasses (IIa, IIIa, and IIIb). The higher the class, the more powerful the laser, and the potential to pose more danger if used improperly. The labeling for Classes II–IV should include a warning symbol stating the class and output power of the product. Approximate IEC equivalent classes are included for products labeled under the classification system of the International Electrotechnical Commission. However, it is difficult to find any regulations in the FDA for the safety of food products using a 3D food printer (SLS) using a laser beam, even if a high class of laser beam could lead to chemical reactions or transformation of the food ingredients.

Color jet printing (CJP) uses food ingredients (powder) and adhesives (liquids) with various edible colors. Sugar powder and food ingredients mixed with sugar and starch can be utilized as powder-conditioned ingredients. Liquid food adhesives have been developed with many colors and flavors. CJP is usually applied to the field of surface filling and decoration in the case of low-viscosity materials. In standard binder injection technology employing color jet printing in 3D systems, each layer of powder is evenly sprayed on the manufacturing platform, while liquid binder spray combines two consecutive layers of powder. Powder materials are usually stabilized by water mist to minimize the disturbance caused by binder spraying. In the Edible 3D Printing Project, Walters used a mixture of sugar and starch as a powder material and used a Z corporation powder/binder 3D printer as a platform to create a customized product with complex structures. Sugar Lab used sugar and various flavoring binders to create custom cakes for special occasions such as weddings. Binder dispensing has the disadvantages of rough surface finish and high cost of printing facilities, although it has the advantages of requiring less production time and the low cost of food ingredients. Post-treatment is required, such as curing at high temperatures, to strengthen the bonding. Inkjet food printing sprays streams/droplets from syringe-type printing heads in an on-demand manner, which is layered for customized food products and includes pre-patterns of food items in multilayer processing. For example, FoodJet Printer, an inkjet food printer, used pneumatic membrane nozzle jets to deposit selected material drops on pizza bases, biscuits, and cupcakes. The ejected stream/drop was then dropped by gravity, impacting the substrate, and dried through solvent evaporation. Finally, the drop enables the formation of a two-dimensional image to fill the decoration or surface.

5. Available Infrastructures:

The following infrastructure is available at Aditya college of engineering to carry out the project

- **ARTEC Space Spider-Industrial 3D scanner:**

ARTEC Space Spider is a high-resolution 3D scanner based on blue light technology**.** It is perfect for capturing small objects or intricate details of large industrial objects in high resolution**,** with steadfast accuracy and brilliant color. The scanner's ability to render complex geometry, sharp edges and thin ribs sets our technology apart. It is an ideal industrial 3D scanner for high resolution capturing of objects such as molding parts, PCBs, keys, coins or even a human ear, followed by the export of the final 3D model to CAD software. Space Spider offers almost unlimited possibilities in areas such as reverse engineering**,** quality control, product design and manufacturing

- **Extrusion 3D Printer:**

Advantages of the material extrusion process include use of readily available ABS plastic, which can produce models with good structural properties, close to a final production model. In low volume cases, this can be a more economical method than using injection moulding. However, the process requires many factors to control in order to achieve a high quality finish. The nozzle which deposits material will always have a radius, as it is not possible to make a perfectly square nozzle and this will affect the final quality of the printed object. Accuracy and speed are low when compared to other processes and the quality of the final model is limited to material nozzle thickness.

When using the process for components where a high tolerance must be achieved, gravity and surface tension must be accounted for. Typical layer thickness varies from 0.178 mm – 0.356 mm.

One method of post processing to improve the visual appearance of models is through improving material transmissivity. Methods have been explored by Ahn et all, include increasing temperature and the use of resin. Experiments using cyamo acrylate resin, often used to improve the strength of parts, resulted in a 5% increase in transmissivity after 30 seconds and sanding. As with most heat related post processing processes, shrink- age is likely to occur and must be taken into account if a high tolerance is required.

MODEL	Fabforge PX4
Technology	PDM (Paste Deposition Modeling)
Gantry Setup	Cartesian
No. Of Heads	4 (Inline Extruder Setup)
System	HEAD A, B, C & D – Pneumatic combined with auger drive
Build Size	150 x 150 x 150 in mm
Nozzle Size	0.6 mm to 1.8 mm
Power Consumption	360W or Higher
Static UV Lamp	Available
Supported Materials	All kind of Paste, Gel, Starch, Protien, Chocolate, Flour, Pastries and Creams Viscosity upto 20000PS
Heaters	HEAD A & B (Upto 80°C working temperature) Two of the material tanks will be provided with Heater
Head Volume	55 cc Syringe Barrels
Slicer S/W	Licensed Simplyfi 3D
User Interface	Wifi & Web Enabled
Display	5.0” Touch Display

6. **PLAN OF ACTION**:

6.1 For YEAR- 1: FABRICATION OF FGM BY ADDITIVE MANUFACTURING:

Many conventional techniques are available to fabricate FGM with change in composition but only few of them could achieve gradient in porosity and there is precision/shape limitation in controlling the graded porosity with conventional techniques. Complex FGM geometry either with composition change, structural change or porosity change could be achieved by various techniques of additive manufacturing.

Different additive manufacturing processes will be analysed to fabricate FGM. Among them,

i. laser engineered net shaping (LENS),

ii. Selective laser melting (SLM)

iii. Electron beam melting (EBM) are suitable for metal materials.

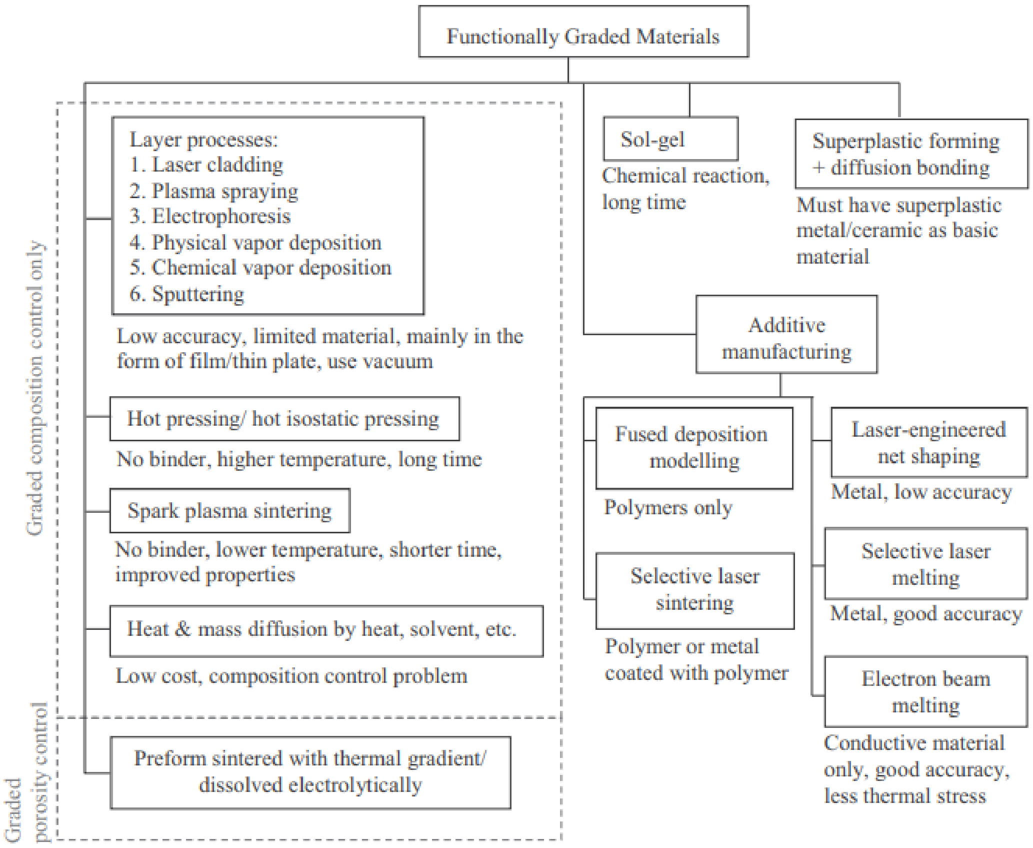


Figure Summary of various FGM fabrication techniques

Challenges in additive manufacturing to be overcome,

- Material and energy consumption of support structure which is required for anchoring fabricated parts to a substrate, and to prevent overhang and floating surfaces from curling up away from the correct geometry.
- Minimum wall thickness and internal geometries with very fine structures below 1 mm still are a technical challenge.
- The manufacturability is an important factor for the selection of the cell type, size, build orientation, and density of cellular structure for specific applications.
- Metal which is cooled from high temperatures to room temperature have a tendency to deform during the process due to thermal stresses gradients generated.
- Thermal stresses could lead to part distortion, initiate fracture, and unwanted decrease in strength of the part.

Step	Process:	
Step 1: Design and modeling	• Product concept generation • Computer aided design for manufacturing and simulation • Topology and infill optimization	The mechanical function of the part is defined by describing the fundamental attributes including the geometry and material composition. Some parts can be optimised by the lattice or cellular structure. Other important attributes include topology optimization,gradient dimension or vector, the geometric of equi-composition or equi-property surfaces, the material characteristics, and mechanical parameters before developing a modeling scheme.
Step 2.1: Materials description	• Material selection and microstructure allocation • Defining optimum material properties distribution • Gradient classification • Analysis of area void density	Material data that concerns the chemical composition and characteristics of the part is modelled. Digital simulation is used to represent the materials, formulate a matching epistemology for the material selection, gradient discretization, volume of support,residual stresses, etc.. The void density needs to be taken into account in the theoretical calculation.
Step 2.2: Product description	• Classification of the part (geometry and material repartition) with mathematical data.	Mathematical data is used to identify an appropriate manufacturing strategy andprocess control.
Step 2.3: Manufacturing description	• Classify information from step 2.2 into slices and build orientation	The manufacturing strategy is determined according to a triptych material-product- manufacturing. The mathematical data from product and material description are used to define the slicing orientation, categorised as planar or complex slices.

Step 3: Additive manufacturing	• Manufacturing strategy and processplan determination. • Paths classification • NC Programming • Process control and monitoring	This type of path strategy is defined and then evaluated according to the geometry and material repartition. Numerical Control (NC) programming involves the generation of paths and modification of process parameters using, but not limited to G-code programming language. The file is sent to the AM machine for the production sequence to commence
Step 4: Post-processing	• Part removal • Heat and pressure treatment • Machining • Surface treatment	Post-processing ensures that the quality aspects (e.g. surface characteristics, geometric accuracy, aesthetics, mechanical properties) of the printed part meets its design specifications. AM post-processing methods include, but not limited to, tumbling, machining, hand-finishing, micromachining, chemical post- processing, electroplating and laser
		micromachining
Step 5: Final Product	• Quality assurance • Validation	Experimental analysis such as non-destructive testing, stress analysis or microscopic imaging are carried out to validate the final product and resultant part properties.

6.2 **For YEAR- 2: To overcome Challenges in 3D food printing**

Three-dimensional food printing technology can be applied to various food ranges based on the advantages of designing existing food to suit one’s taste and purpose. Currently, many countries worldwide produce various 3D food printers, developing special foods such as combat food, space food, restaurants, floating food, and elderly food. Many people are unaware of the utilization of the 3D food printing technology industry as it is in its early stages. There are various cases using 3D food printing technology in various parts of the world. Three-dimensional food printing technology is expected to become a new trend in the new normal era after COVID-19. Compared to other 3D printing industries, food 3D printing technology has a relatively small overall 3D printing utilization and industry size because of problems such as insufficient institutionalization and limitation of standardized food materials for 3D food printing. In this review, the current industrial status of 3D food printing technology was investigated with suggestions for the improvement of the food 3D printing market in the new normal era.

From a 3D printing point of view, we see a series of rather difficult challenges that must be worked through by anyone venturing into the 3D printing of food.

1. **Safety**: Unlike other types of 3D printing, each item of 3D printed food could potentially be eaten. Therefore food safety is a must. But to achieve food safety, a 3D food printer must certify safety along the entirety of the path food material takes through the device – and that is difficult.
2. **Timing**: While you can leave a spool of ABS in your plastic 3D printer for weeks (and perhaps even years) without issue, this will not be the case for many food materials, which could expire within hours. Food materials must be treated very differently.
3. **Structure**: Generally the engineering characteristics of food material are not considered during cooking, but when you're 3D printing them, they are much more important. Food materials tend to be far less strong than even the weakest plastics, meaning 3D printed food can build objects will have some severe build geometry limitations. Consider the chocolate print above, which cannot be made taller without slumping.
4. **Designs**: If there are severe geometry limitations, then the software used to create 3D models for food printing must account for them. We're not aware that such software exists yet, and we suspect it could be quite complex due to the vast number of potential printable food materials.
5. **Taste**: Unlike plastic 3D printing, you (or someone) may have to consume the output. It must taste good, if not at least barely palatable. How this is accomplished after material travels through a machine is a matter for food scientists.
6. **Multiple materials**: Unless it's pretty special, dishes made from a single ingredient tend to be pretty boring. Thus it seems that a successful food printer would likely have to be able to combine multiple foodstuffs into interesting combination dishes. Plastic 3D printers have had great challenges to develop multiple extruder capabilities, and we expect no less with food printers.

6.3 For 9 months:

Dysphagia affects the majority of people with stroke, cerebral palsy, motor neurone disease, Parkinson's disease and many other health conditions. Any conditions that affect the oral preparation of food, or oral movements, or the swallow reflex or movement of the pharyngeal muscles, can affect swallowing. In the management of dysphagia, and to enhance the safety and quality of meals, foods can be modified according to texture (e.g., soft, mashed, puree), and liquids can be thickened to increase their viscosity and give the person more time to co-ordinate the swallow. These strategies are used to prevent aspiration of food or fluid into the lungs, to increase the amount of food managed eaten, and to reduce the time or effort required for meals. Modifying foods and liquids for the daily requirements of people with dysphagia to standard consistencies using the conventional approaches can be challenging. In addition, people on long-term modified food diets may develop a dislike for pureed foods and thickened liquids due to the lack of variety in meals, the unattractiveness of their visual appearance, and the tastes being diluted because of liquids being added. This impacts on both health and quality of life for people with dysphagia, and increases the efforts required on their family members or service providers who must also repeatedly consider their food preparation and safety in provision of meals.

The ingredients used for making the tuna fish print were: 400g of butternut pumpkin, 400g of beetroot, and 425g of canned tuna in springwater. These ingredients will be acquired from Woolworths, Australia. A 3D CAD model has to be created as a physical object using pressure controlled extrusion. Materials that are suitable for use in this printer range from viscous pastes to liquids, and are extruded from a standard 30CC barrel with a piston top and precision tip using pressure from an external nitrogen source. The pressure is applied to the barrel which is moved in three dimensions, this barrel deposits a strand of the print material onto the print bed to produce the object. The size of this strand is controlled by altering the speed of the print-head and the pressure applied to the material in the barrel. Designs are produced in an additive manufacturing manner where the CAD model is sliced into layers of fixed height and then printed one layer at a time with each layer being printed on top of the layer below. Using this method of fabrication, food product can be rapidly produced with a defined outer form and a preselected inner structure.

7. Budget details:

S. N.	Description	Qty.	Unit	Rate	Amount
1	**Fabforge V2 (Custom)** 3D Printer ➢ FFF Technology ➢ 300 x 300 x 300mm Build size ➢ Dual Extruder, Ultrafuse Filament Printable ➢ Max. Extruder Temp. 300°C ➢ 32 bit processor ➢ Wifi and web based ➢ 5.0" Touch display	1	No	572500	572,500.00
2	Electric Muffle (De binding and Sintering) ➢ Max Temp. 1600°C ➢ Working Temp. 1500°C ➢ Thyristor Temp. controller ➢ Control accuracy +/- 5 %	1	No	432000	432,000.00
3	Service charges towards packing and forwarding	1	Box	20000	20,000.00
	Sub Total				**10,24,500.00**
	GST@18 %			18.00%	184,410.00
	Rounded Off				0.00
	Grand Total				**12,08,910.00**

BUDGET HEAD	YEAR-1	YEAR-2	YEAR-3	TOTAL
1- Non-Recurring				0
Equipment	1208910			1208910
Other Non-Recurring		189000		189000
Subtotal (Capital)	1208910	189000	0	1397910
2- Recurring				0
Project Staff	40000	40000	40000	120000
Consumables		28000	28000	56000
Subtotal (General)	40000	68000	68000	176000
Total Project Cost (Capital + General)	1248910	257000	68000	**1573910**

8. Expected out-comes:

1. A joyful more verities food can be provided for people suffering from Dysphasia using 3D printing technology at a reasonable price.
2. Functionally graded materials through a gradient method of various combinations of metal and ceramic can be prepared to explore different mechanical properties.
3. Lithography-based Additive Manufacturing Technology on photosensitive materials can be implemented.

9. End users of out-comes:

The following fields are the end users of 3D printing technologies

1. PROTOTYPING AND MANUFACTURING
2. MEDICINE
3. EDUCATION
4. CONSTRUCTION
5. ART AND JEWELRY

PROFORMA FOR BIODATA OF INVESTIGATOR (Young Scientist & Mentor)

A. Name: **Dr ANJIBABU MERNEEDI**

B. Date of Birth: **28-05-1987**

C. Institution: Aditya College of Engineering

D. Whether belongs to ~~SC/ST~~: **NO**

E. Academic and professional career:

Academic career (From Graduation to highest qualification level indicating subject and area of specialization – Enclose copy of certificate of highest qualification):

DEGREE	***SUBJECT***	***SPECIALIZATION***
Graduation	Mechanical Engineering	-
Post - Graduation	Mechanical Engineering	Machine Design
Doctor of philosophy	Mechanical Engineering	Mechanical Vibrations

Professional career: Total, 8 years of teaching experience among that 3 years of Research & 3 years of post doctorate teaching experience.

F. Award/Prize/Certificate etc. won by the investigator: **NIL**

G. Five best publications in the proposed area of work:

1. Synthesis and characterization of polypropylene/ramie fiber with hemp fiber and coir fiber natural biopolymer composite for biomedical application
2. Optimization on operation parameters in reinforced metal matrix of AA6066 composite with HSS and Cu
3. Experimental investigation on mechanical properties of Carbon Nano Tubes reinforced epoxy composites for automobile application
4. Evaluating the Mechanical and tribological Properties of DLC Nano coated Aluminium 5051 using RF sputtering
5. Experimental investigation on wear behaviour of bio-waste reinforced fusion fiber composite laminate under various conditions

H. Publication (Numbers only): 9 Research papers

Books : 0 Research Papers, reports : 9 General articles : 0
Patents : 0 Others (please specify)

H. (1) List of completed and ongoing projects *NIL*

Sl. No.	**Title of Project**	**Duration From to**	**Total Cost**	**Funding Agency**

(2) List of projects submitted *NIL*

Sl. No.	**Title of the project**	**Name of Organization**	**Status**

ADITYA COLLEGE OF ENGINEERING
Approved by AICTE, Permanently Affiliated to JNTUK & Accredited by NAAC
Recognized by UGC under section 2(f) of UGC Act 1956
Ph: (0884) 2326224, 99631 76662, Email: office@acoe.edu.in, Website: www.acoe.edu.in

CERTIFICATE FROM THE INVESTIGATOR

PROJECT TITLE: **A 3D PRINTED ENJOYABLE FOOD FOR DYSPHASIA PATIENTS THROUGH ADDITIVE MANUFACTURING**

1. We agree to abide by the terms and conditions of the DST grant.
2. We did not submit this or a similar project proposal elsewhere for financial support.
3. We have explored and ensured that equipment and basic facilities will actually be available as and when required for the purpose of the project. We shall not request financial support under this project, for procurement of these items.
4. We undertake that spare time on permanent equipment will be made available to other users.
5. We have enclosed the following materials:

ITEMS		NUMBER OF COPIES
(a)	Endorsement from the Head of the Institution (on letter head)	One
(b)	Certificate from Investigator	One
(c)	Certificate from Investigator regarding conflict of interest	One
(d)	Name and address of experts/institution interested in the subject/ outcome of the project	One
(e)	Copies of the proposals	One hard Copy

1. Dr. Y.K.S. Subbarao
2. Dr. A. Ramesh
3. Dr. D.Y.S.S.S.V Prasad.

Dr. Anjibabu Merneedi

Date : **18-11-2021**

Place: **Surampalem**

Name & Signature of Principal Investigator

Name & Signature Of Co-Investigator(s)

DEPARTMENT OF SCIENCE AND TECHNOLOGY
POLICY ON CONFLICT OF INTEREST

FOR REVIEWER & COMMITTEE MEMBER or APPLICANT or DST OFFICER ASSOCIATED/ DEALING WITH THE SCHEME/ PROGRAM OF DST

Issues of Conflicts of Interest and ethics in scientific research and research management have assumed greater prominence, given the larger share of Government funding in the country's R & D scenario. The following policy pertaining to general aspects of Conflicts of Interest and code of ethics, are objective measures that is intended to protect the integrity of the decision making processes and minimize biasness. The policy aims to sustain transparency, increase accountability in funding mechanisms and provide assurance to the general public that processes followed in award of grants are fair and non-discriminatory. The Policy aims to avoid all forms of bias by following a system that is fair, transparent and free from all influence/ unprejudiced dealings, prior to, during and subsequent to the currency of the programme to be entered into with a view to enable public to abstain from bribing or any corrupt practice in order to secure the award by providing assurance to them that their competitors will also refrain from bribing and other corrupt practice and the decision makers will commit to prevent corruption, in any form, by their officials by following transparent procedures. This will also ensure a global acceptance of the decision making process adopted by DST.

Definition of Conflict of Interest:

Conflict of Interest means "any interest which could significantly prejudice an individual's objectivity in the decision making process, thereby creating an unfair competitive advantage for the individual or to the organization which he/she represents". The Conflict of Interest also encompasses situations where an individual, in contravention to the accepted norms and ethics, could exploit his/her obligatory duties for personal benefits.

1. **Coverage of the Policy:**

a) The provisions of the policy shall be followed by persons applying for and receiving funding from DST, Reviewers of the proposal and Members of Expert Committees and Programme Advisory Committees. The provisions of the policy will also be applicable on all individuals including Officers of DST connected directly or indirectly or through intermediaries and Committees involved in evaluation of proposals and subsequent decision making process.

b) This policy aims to minimize aspects that may constitute actual Conflict of Interests, apparent Conflict of Interests and potential Conflict of Interests in the funding mechanisms that are presently being operated by DST. The policy also aims to cover, although not limited to, Conflict of interests that are Financial (gains from the outcomes of the proposal or award), Personal (association of relative / Family members) and Institutional (Colleagues, Collaborators, Employer, persons associated in a professional career of an individual such as Ph.D. supervisor etc.)

2. **Specifications as to what constitutes Conflict of Interest.**

Any of the following specifications (non-exhaustive list) imply Conflict of Interest if,

(i) Due to any reason by which the Reviewer/Committee Member cannot deliver fair and objective assessment of the proposal.

(ii) The applicant is a directly relative# or family member (including but not limited to spouse, child, sibling, parent) or personal friend of the individual involved in the decision making process or alternatively, if any relative of an Officer directly involved in any decision making process / has influenced interest/ stake in the applicant's form etc..

(iii) The applicant for the grant/award is an employee or employer of an individual involved in the process as a Reviewer or Committee Member; or if the applicant to the grant/award has had an employer-employee relationship in the past three years with that individual.

(iv) The applicant to the grant/award belongs to the same Department as that of the Reviewer/Committee Member.

(v) The Reviewer/Committee Member is a Head of an Organization from where the applicant is employed.

(vi) The Reviewer /Committee Member is or was, associated in the professional career of the applicant (such as Ph.D. supervisor, Mentor, present Collaborator etc.)

(vii) The Reviewer/Committee Member is involved in the preparation of the research proposal submitted by the applicant.

(viii) The applicant has joint research publications with the Reviewer/Committee Member in the last three years.

(ix) The applicant/Reviewer/Committee Member, in contravention to the accepted norms and ethics followed in scientific research has a direct/indirect financial interest in the outcomes of the proposal.

(x) The Reviewer/Committee Member stands to gain personally should the submitted proposal be accepted or rejected.

The Term "Relative" for this purpose would be referred in section 6 of Companies Act , 1956.

3. **Regulation:**

The DST shall strive to avoid conflict of interest in its funding mechanisms to the maximum extent possible. Self-regulatory mode is however recommended for stake holders involved in scientific research and research management, on issues pertaining to Conflict of Interest and scientific ethics. Any disclosure pertaining to the same must be made voluntarily by the applicant/Reviewer/Committee Member.

4. Confidentiality:

The Reviewers and the Members of the Committee shall safeguard the confidentiality of all discussions and decisions taken during the process and shall refrain from discussing the same with any applicant or a third party, unless the Committee recommends otherwise and records for doing so.

5. Code of Conduct

5.1 To be followed by Reviewers/Committee Members:

(a) All reviewers shall submit a conflict of interest statement, declaring the presence or absence of any form of conflict of interest.
(b) The reviewers shall refrain from evaluating the proposals if the conflict of interest is established or if it is apparent.
(c) All discussions and decisions pertaining to conflict of interest shall be recorded in the minutes of the meeting.
(d) The Chairman of the Committee shall decide on all aspects pertaining to conflict of interests.
(e) The Chairman of the Committee shall request that all members disclose if they have any conflict of interest in the items of the agenda scheduled for discussion.
(f) The Committee Members shall refrain from participating in the decision making process and leave the room with respect to the specific item where the conflict of interest is established or is apparent.
(g) If the Chairman himself/herself has conflict of interest, the Committee may choose a Chairman from among the remaining members, and the decision shall be made in consultation with Member Secretary of the Committee.
(h) It is expected that a Committee member including the Chair-person will not seek funding from a Committee in which he/she is a member. If any member applies for grant, such proposals will be evaluated separately outside the Committee in which he/she is a member.

5.2 To be followed by the Applicant to the Grant/Award:

(a) *The applicant must refrain from suggesting referees with potential Conflict of Interest that may arise due to the factors* mentioned in the specifications described above in Point No. 2.
(b) The applicant may mention the names of individuals to whom the submitted proposal should not be sent for refereeing, clearly indicating the reasons for the same.

5.3 To be followed by the Officers dealing with Programs in DST:

While it is mandatory for the program officers to maintain confidentiality as detailed in point no. 6 above, they should declare, in advance, if they are dealing with grant applications of a relative or family member (including but not limited to spouse, child, sibling, parent) or thesis/ post-doctoral mentor or stands to benefit financially if the applicant proposal is funded. In such cases, DST will allot the grant applications to the other program officer.

6. Sanction for violation

3.1 For a) Reviewers / Committee Members and b) Applicant

Any breach of the code of conduct will invite action as decided by the Committee.

3.2 For Officers dealing with Program in DST

Any breach of the code of conduct will invite action under present provision of CCS (conduct Rules), 1964.

7. Final Appellate authority:

Secretary, DST shall be the appellate authority in issues pertaining to conflict of interest and issues concerning the decision making process. The decision of Secretary, DST in these issues shall be final and binding.

8. Declaration

I have read the above "Policy on Conflict of Interest" of the DST applicable to the Reviewer/ Committee Member/ Applicant/ DST Scheme or Program Officer # and agree to abide by provisions thereof.

✓ I hereby declare that I have no conflict of interest of any form pertaining to the proposed grant *
I hereby declare that I have conflict of interest of any form pertaining to the proposed grant *

* & # (Tick whichever is applicable)

Name of the ~~Reviewer/ Committee Member~~ or Applicant or ~~DST Officer~~ Dr. Anjibabu mernedi
(Strike out whichever is not applicable)

18/11/21

(Signature with date)

ADITYA COLLEGE OF ENGINEERING

Approved by AICTE, Permanently Affiliated to JNTUK & Accredited by NAAC
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ENDORSEMENT FROM THE HEAD OF INSTITUTION

PROJECT TITLE: **A 3D PRINTED ENJOYABLE FOOD FOR DYSPHASIA PATIENTS THROUGH ADDITIVE MANUFACTURING**

1. Certified that the Institute welcomes participation of **Dr Anjibabu Merneedi** as the Principal Investigator and **Dr. A Ramesh & Dr YKS Subbarao** as the Co-Investigator for the project and that in the unforeseen event of discontinuance by the Principal Investigator, the Co-Investigator will assume the responsibility for the fruitful completion of the project (after obtaining consent in advance from DST).

2. Certified that the equipment, other basic facilities and such other administrative facilities as per terms and conditions of the grant, will be extended to investigator (s) throughout the duration of the project.

3. Institute assures financial and other managerial responsibilities of the project.

4. Certified that the organization has never been blacklisted by any department of the State Government or Central Government.

Name and Signature of Head of Institution
(Dr. A. Ramesh).

Date: **18-11-2021**

Place: **Surampalem**

REMARKS: In regard to research proposals emanating from scientific institutions/laboratories under various scientific departments the Head of the institution is required to provide a justification indicating clearly whether the research proposals falls in line with the normal research activities of the institution or not and if not, the scientific reasons which merit its consideration by DST.

18th November 2021

To

The Principal,
ADITYA COLLEGE OF ENGINEERING,
Surampalem, Andhrapradesh.

Sub: Proposal for Low cost metal 3D Printer setup reg.

Dear Sir,

We first thanks for giving us an opportunity to serve you.

We have been pioneer in manufacturing of 3D printers for over two years and we do develop customized 3D printers and solutions.

With reference to our discussion regarding requirement of customized 3D Printer, we would like to suggest a new model Low cost Metal 3D Printer with some post process.

This customized 3D printer is supports to print Ultrafuse filaments (Composition of Polymer and Metal) as a component. The 3D printed component will be taken to debinding station which will debind the materials and gives us a metal component output. The metal component will be taken to Sintering process. Finally the component will be in SS316 grade Metal form. Thus this setup will be like a Metal 3D Printer in lower investment.

With reference to our discussion regarding requirement of FDM printer with De binding and Sintering units to your prestigious institution, the quotation is attached herewith and the net value of the product is **Rs. 11,91,210.00** (Rupees Eleven lakhs ninety one thousand two hundred and ten only).

Thanks and hope this is a beginning of a long and prosperous relationship.

For **FABFORGE INNOVATIONS PRIVATE LIMITED**

K. Albert Kennedy
Executive Director
98430 98084

Fabforge Innovations Pvt Ltd
39/1A, RPR Complex, Annur Road, Karumathampatty, Coimbatore – 641 659.
Phone: 0422-4371454. Mobile: 97919 073763. www.fabforge.in. email: fabforgeipl@gmail.com
Corporate ID No: U29309TZ2020PTC034126. GSTIN: 33AAECF1530B1ZH. PAN: AAECF1530B. TAN- CMBF03872B.

Commercial

S. N.	Description	Qty.	Unit	Rate	Amount
1	**Fabforge V2 (Custom)** 3D Printer ➢ FFF Technology ➢ 300 x 300 x 300mm Build size ➢ Dual Extruder, Ultrafuse Filament Printable ➢ Max. Extruder Temp. 300°C ➢ 32 bit processor ➢ Wifi and web based ➢ 5.0" Touch display	1	No	572500	572,500.00
2	Electric Muffle (De binding and Sintering) ➢ Max Temp. 1600°C ➢ Working Temp. 1500°C ➢ Thyristor Temp. controller ➢ Control accuracy +/- 5 %	1	No	432000	432,000.00
3	Service charges towards packing and forwarding	1	Box	20000	20,000.00
	Sub Total				**10,24,500.00**
	GST@18 %			18.00%	184,410.00
	Rounded Off				0.00
	Grand Total				**12,08,910.00**

(Rupees Twelve lakhs eight thousand nine hundred and ten only)

Fabforge Innovations Pvt Ltd
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fabforge™

Product Specification of V2

MODEL	Fabforge-V2 (Custom)
Technology	FFF (Fused Filament Fabrication)
Build size	**200 x 300 x 300 in mm (XYZ)**
Layer Resolution	0.1 to 0.4 mm
Extruders	Dual
Extruder Temperature	Core A – upto 300˚ and Core B – upto 260˚ C
Heated Bed	Yes – Teperature upto 160˚C +
Print Speed	Upto 150 mm / Sec (Recommended upto 60mm/Sec)
Nozzle Size	0.4 mm to 1.0 mm
Position Accuracy	X/Y : 0.01 mm & Z : 0.02 mm
Supported Materials	Heatcore A -ULTRAFUSE 316L Heatcore B – PLA,ABS,ASA,PETG
Dimension	560 mm x560 mm x 750 mm approx.
Weight	45 Kg Approx.
Electrical	110V/230V – 50/60 Hz
Slicer Software	Simplfy 3D & Cura
Input Format	STL, OBJ & 3mf
Output Format	G Codes
Connectivity	Wi Fi , Web enabled

Fabforge Innovations Pvt Ltd
39/1A, RPR Complex, Annur Road, Karumathampatty, Coimbatore – 641 659.
Phone: 0422-4371454. Mobile: 97919 073763. www.fabforge.in. email: fabforgeipl@gmail.com
Corporate ID No: U29309TZ2020PTC034126. GSTIN: 33AAECF1530B1ZH. PAN: AAECF1530B. TAN- CMBF03872B.

fabforge™

Furnace Structure

1. Outside Shell size : ≈ 600 x 600 x 900 mm
2. Useful volume : 150mm (H) x 150mm (W) X 150MM (D)
3. Shell Construction : **Double Wall** High quality fabrication of S. S. Body and S. S. Angle's structure with proper stiffeners and neat **powder coat painting**
4. Skin Temperature : **Double wall structure & special air circulating fan** will be provided to maintain the skin temperatures just above **ambient**
5. Door Construction : Sophisticated system to avoid heat loss made by **Stainless steel** door with proper insulation
6. Insulation : Total thickness - 200mm in all sides
   CUMILAG 32 INSULATION BRICK

HEATING SYSTEM

1. Heating elements : **Element- Molybdenum di silicide rods**
   Source :I SQUIRRED R , USA make
   1700 deg C element

   Shape - U-shape
   Size - 6/12
   Hot zone (Le) - **125mm**
   Cold zone (Lu)- **225mm**
   Total number - 4 **numbers**
   Electrical connections - At the top of the furnace
2. Operation : 415 / 2phase / 20 A
   with power isolation transformer
3. Power : A. Each Element withstand the Power of ≈0.82kW and Total loads for Elements – ≈4 KW
4. Maximum temperature : 1700 deg C (At the element)
5. Maximum temperature ; 1600 ℃ (Mesurable temperature at chamber)
6. Rate of heating : Rapid heating 1to 10 deg/minute
7. Temperature uniformity : Each two Heating elements are placed both the sides to get the temperature uniformity

Prestigious Clients – FDM & SLA

Amrita University, Amrita Nagar, Ettimadai, Coimbatore – 641 112.
Contact Person : Dr. Ramu – 73971 72677
Project Value @ Coimbatore Campus : Rs. 6L
Project Value @ Chennai Campus : Rs. 10L
Project Value @ Guntur Campus : Rs. 6.5 L

MGR University, 69, Anna Salai, Guindy, Chennai – 600 032.
Contact person : Dr. Rama Vaidhyanathan - 98410 02846 / Mr. Rizwan - 74182 74974
Project Value : Rs. 3L

Vellore Institute of Technology, Gorbachev Road, Vellore – 632 014
Contact person : Dr. A.S.S. Balan - 97899 41487
Project Value : Rs. 6L

Park College of Engg, Coimbatore
Contact Person : Dr. Mohan Kumar – 94437 43348
Project Value : Rs. 6.4 L

Karunya Institute of Technology & Sciences, Coimbatore
Contact Person : Dr. Jims – 94878 46614

Prestigious Clients – Food 3D Printer

Indian Institute of Food Processing Technology, PudukkotaiRoad,Tanjavur – 613005.
Contact person : Ms. AnuKrithika - 86103 94813
Project Value : Rs. 12L

Kerala Agricultural University - NAHEP- CAAST Project
Knowledge and Skill Development on Coconut Based Secondary Agriculture
Contact Person : Dr. K. P. Sudheer - 94476 89466
Project Value : Rs. 9L

VIT, Vellore, Tamilnadu
Contact Person : Dr. Renold – 99943 04360 / 94862 89801
Project Value : 7.5 L

Ongoing projects

Malnad College of Engg, Hasan, Karnataka
Contact Person : Dr. Rajendran – 94485 22744 & 78925 94106
Project Value : 1.9 L

PA College of Engg, Pollachi, Tamilnadu
Contact Person : Dr. Varun – 90034 09044
Project Value : 9.0 L

IIITT, Trichy, Tamilnadu
Contact Person : Dr. Velmurugan - 9943 22961

Terms and Condition

Rates: The rate quoted by us are exclusive of all electrical related works like tools & tackles, loading & unloading labor, over heads, profit and other incidental expenses etc,.

Time of Delivery and Completion: The entire works will be completed within 10 to 12 weeks from the date of issue of purchase order.

Terms of Payment: 100 % along with official purchase order.

Extra Works: Extra works / increase in scope of work if any should be paid by customer

Power: Customer has to provide proper 230V AC with proper grounding. You may provide UPS output for un-interrupted printing.

Tax: GST @ 18 % is includes in the commercial. GST will be relaxed to 5 % if the Institution produce GST Relaxation certificate against Notification No: 47/2017.

For **FABFORGE INNOVATIONS PRIVATE LIMITED**

K. Albert Kennedy
Executive Director
98430 98084

Fabforge Innovations Pvt Ltd
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Corporate ID No: U29309TZ2020PTC034126. GSTIN: 33AAECF1530B1ZH. PAN: AAECF1530B. TAN- CMBF03872B.