Investigation on Multi-Plane Fusion Deposition Modeling (FDM) using 6-Axis Industrial robot with vision system

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Submitted By : vikram kumar chintamreddy

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Proposal

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Proposal Details

Project Title :	Investigation on Multi-Plane Fusion Deposition Modeling (FDM) using 6-Axis Industrial robot with vision system		
Scheme :	Core Research Grant		
Broad Area :	Engineering Sciences	**Sub Area :**	Mechanical & Manufacturing Engineering & Robotics
Duration In Month :	36	**Total Cost (in Rs.) :**	*27,71,030*
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Project Summary : Additive manufacturing or rapid prototypingis a group of techniques used to create physical part or product using three-dimensional computer aided design (CAD) data.Fused Deposition Modelling (FDM) is one of the most used additive manufacturing (AM) techniques due to its abilityto manufacture very complex geometries. A conventional fused deposition modelling machine builds a 3D object by printing layer by layer on horizontal surface (base plate) from bottom to top fashion. Each layer is printed by moving extruder in XY plane (Horizontal Plane), once a layer is built, the base plate moves downwards in Z-axis to facilitate the deposition of next layer. The movement along z-axis is equal to the layer thickness. In FDM process head extrudes material in a semi liquid state to build layer by layer on platform. It uses to construct the three dimensional objects directly from 3D CAD data. FDM import the CAD model in STL format and sliced into horizontal layers. The head extrudes the material on fixtureless base and produces solidified material laminating to the preceding layer. The degree of freedom of a conventional FDM machine is limited to 3 and it is not capable to print the object in inclined planes and produces stair-case effect in printing curved surfaces. These problems can overcome by printing the objects using six axis industrial robot, which is capable to move its end effecter in a preferred orientation in a 3D space with high resolution and repeatability. The robot with an extruder as an end effector has capability to print objects on multiple planes and curved surfaces, and also possible to print over entire work volume. The work aims to print the object using industrial robot and FDM technique. This work also aims to develop 3D CAD data of an object using 3D scanner. The 3D scanner are widely used as a reverse engineering tool to develop the 3D data of the object, which is essential to print the object using

additive manufacturing. In this work the scanned 3D CAD data of the object is used to reproduce the object by integrating the robot with FDM process. During 3D printing of the object with robot it is essential to provide vision system to monitor the movements of the robot end-effector to avoid the obstacles.

This projects aims to integrate the 3D scanner data, robot technology, FDM process and artificial intelligence using vision system. The outcome of the project is to reproduce the object by 3D scanning, and FDM integrated with robot, and continuously monitoring the 3D printing process by proving artificial intelligence to robot.

Objective :

• Fabricate the new set up for Fusion Deposition Modelling for Industrial Robot.
• Develop new algorithms to print 3D objects using FDM with industrial robot.
• Develop new algorithms to print the 3D objects in inclined planes.
• Reverse Engineering the 3D objects by integrating 3D scanner, Industrial robot and FDM technique.
• Develop feedback system to the robot during 3D printing using vision system.
• Optimization of process parameters to print 3D objects with good surface finish and higher productivity.

Keywords : 3D printing, Fused deposition modelling, Industrial robot, 3D scanning, Reverse engineering, Vision system

Expected Output and Outcome of the proposal :

The present work is to develop new algorithms to print 3D objects by integrating 3d scanner, robotics with Fusion Deposition Modelling. It has major applications in production of geometrical complex shapes using reverse engineering. Based on the experimental results it is possible to study the feasibility for commercial components made of different materials. For the academic point of view it is possible guide research scholars in this area and to publish papers in international journals.

Other Technical Details

1. Origin of the Proposal: *(Maximum 1 page)*

Additive Manufacturing (AM) technologies are capable to avoid some difficulties such as the under-cutting features, the tool accessibility, and the tool path generation. Fused Deposition Modelling (FDM) is one of the most diffused technologies able to fabricate prototypes, tooling, accessories and functional parts directly from a virtual model. FDM machine can only print objects in horizontal flat plane and they are limited to 3 DOF. The commercially available FDM machines are capable to print on horizontal plane surface. They have limited capabilities to print complex and curved objects, and produce poor surface finish due to stair case-effect on curved surfaces. In FDM machine, the extruder moves in X or Y directions and after completion of one layer printing the base plate move vertically downward in Z- direction equal to layer thickness to print second layer. The extruder of FDM is not capable to move simultaneously in X, Y and Z directions to print the object in inclined planes. Some of these limitations can overcome by adding additional degrees of freedom using industrial robot. Industrial robots with six degrees of freedom are capable to move its end-effector in any preferred orientation and position in 3D space with high resolution and repeatability. Additional degrees of freedom can be provided to the extruder by using it as an end-effector to six axis industrial robots, and robot is capable to move extruder in 3D space with preferred orientation. Industrial robot with 3D printing head (extruder) as a tool is capable to print the objects in inclined planes and also possible to move curved path in vertical directions (i.e. XZ, YZ or XYZ paths). Robots can be useful to build the objects of different size based on their work space. In reverse engineering the CAD model of the object is obtained by 3D scanner and this data is used for building the object. Artificial intelligence using vision system is the best tool to develop feedback loop to monitor the movements of the end effector, this work also includes to develop artificial intelligence to 3D printing process with robot.

2. Review of status of Research and Development in the subject

2.1 International Status: *(Maximum 2 pages)*

In recent, many investigators are working in FDM process to improve the capabilities of machine. This section briefly discusses the improvements in FDM. Tse et al (1997) used milling tool as end-effector of industrial robot for rapid prototyping to machine the prototype of a solid model drawn in commercial CAD systems. Huang Xiaomao et al., (2009) developed robust Slice Data Based Support Generation Algorithm for Fused Deposition Modelling. Jae-Won Choi et al., (2011) developed flexible and mobile fused deposition modelling (FDM) system from an existing FDM system to enable deposition of material on virtually any surface without being confined to a build chamber and demonstrated by depositing ABS on different surfaces. B. Huang et al (2012) proposed adaptive flat layer deposition and curved layer deposition for FDMand developed mathematical models for curved slicing to print physical parts. It indicated that for curved parts, curved layer deposition is expected to ensure fiber continuity and better meso-structure. Jorge Mireleset al., (2013) developed extended applications of fused deposition modelling (FDM)by extrusion and deposition of low melting temperature metal alloys to create threedimensionalmetal structures and single-layer contacts which may prove useful for electronic interconnects.Eric J. McCullough and Vamsi K. Yadavalli (2013) developed a versatile method to modify surfaces of ABS fused deposition modelling rapid prototyped devices with micro-structured features to render them water-impermeable, hydrophilic, and biocompatible. In this work an acetone-based sealing method is described that has a minimal effect on surface roughness and structural fidelity.Godfrey C. Onwubolu and FarzadRayegani (2014) studied the effect of five important process parameters in FDM such as layer thickness, part orientation, raster angle, raster width, and air gap on tensile strength using design of experiment (DOE). Boschetto and Bottini (2014) developed a geometrical model of the filament, dependent upon the deposition angle and layer thickness to predict the obtainable part dimensions in FDM.Lee et al., (2014) developed Hybrid Rapid Prototyping System using low-cost Fused Deposition Modelling and five-axis machining. Eric Barnett et al (2015) introduced a large scale 3D printer using six-degree-of-freedom cable suspended robot for positioning, with polyurethane foam as the object material and shaving foam as the support material. It indicated that cable-positioning systems provide large ranges of motion and cables can be compactly wound on spools, making them less expensive, much lighter, more transportable and more easily reconfigurable compared to the gantry type positioning systems traditionally used in 3D printing. Ismayuzri Ishak et al (2015) demonstrated the concept of using a robot arm platform for rapid prototyping. It explored the concept of integration of 3D printing technology with an industrial robotic arm to create a 3D printer with a higher degree of freedom. Alberto Boschetto and Luana Bottini (2016) developed new methodology using Design for manufacturing of surfaces to improve accuracy in Fused Deposition Modelling. Yu-an Jin (2015) proposed new approach to parallel filling path generation based on adaptive gaps for fused deposition modelling (FDM) and indicted that the fabricating quality significantly improved with some improvements in the machining efficiency.Mark Swanson et al (2016) showed the process to make a robot arm capable of producing 3D printed parts. The design, construction, and testing of extruder end of arm effector was discussed in this work. It also discussed the process of creating a translator for G-code taken from an open source slicing software. Their translator takes G-code and turns it into instructions for the robot.

2.2 National Status: *(Maximum 1 page)*

Thrimurthulu et al., (2004) developed optimum part deposition orientation for fused deposition modelling process for enhancing part surface finish and reducing build time using evolutionary algorithm. Debapriya Chakraborty et al (2008) developed extruder path generation for a new rapid prototyping technique named “Curved Layer Fused Deposition Modeling” (CLFDM), and indicated that it is suitable for manufacturing of thin, curved parts (shells) by reduction of stair-step effect, increase in strength and reduction in the number of layers. Vijayaraghavan et al., (2015) characterized the 3D-printed FDM components using improved evolutionary computational approach using Improved approach of multi-gene genetic programming (Im-MGGP) to formulate the functional relationship between wear strength and input process variables of the FDM process. It indicated that air gap, has the maximum influence on the wear strength of the FDM fabricated component. Sadegh Rahmati and EbrahimVahabli (2015) presented analytical models to express surface roughness distribution in FDM are assessed according to the variations in surface build angle by considering the main factors which crucially affect surface quality. Biranchi N. Panda et al., (2017) proposed evolutionary system identification (SI) approach to explicitly quantify the warp deformation and dimensional error based on the four inputs such as line width compensation, extrusion velocity, filling velocity, and layer thickness of FDM prototypes. It indicated that the layer thickness and extrusion velocity influence the warp deformation and, while filling velocity and line width compensation, influences the dimensional error. Vishal Francis and Prashant K. Jain (2016) investigated fused deposition modelling of polymer-layered silicate nanocomposite filament and indicated that significant improvements in mechanical properties, reduced porosity and better neck formation were observed for the developed nanocomposite. The developed nanocomposite may reduce the gap for availability of materials for FDM in terms of improved mechanical properties. The work will assist to promote low-cost FDM processed parts for direct applications. Ashu Garg et al.,(2015) studied the effect of part deposition orientation on surface finish and dimensional accuracy of FDM parts using vapour treatment process and indicated surface finish of the components is greatly improved by this process with minimal variations in part.

2.3 Importance of the proposed project in the context of current status *(Maximum 1page)*
(*Highlight what is the new area or gap which will be solved in the project in relatingto what is already known. This is a very important section to project the novelty content of the proposal*)

Rapid prototyping (RP) or Additive manufacturing (AM) is one of the most promising technologies widely used today to reduce product development time by way of realising the prototype component that can be directly used in assemblies, product testing or tooling for short or medium run production. Many industries have shifted from the traditional product development methodology to the rapid prototyping techniques.Additive manufacturing (AM) is used for making real three dimensional object, with metal or ceramic or plastic or thereby combination, which may be subjected to various applications. For more utilization and versatility, special attention is required to develop new techniques or methodologies and materials to increase the service life, dimensional accuracy, desired properties with high productivity and minimum cost. The present work aims to develop new methodology to print 3D objects by integrating the 3D scanning technique, FDM process and industrial robots. This work finds new application for robotics in manufacturing or prototyping the parts using 3D scanner and FDM process. This work finds wide applications in printing complex shapes by printing 3D objects in inclined plane using six degrees of freedom of the robot. The industrial robots are also capable to move its end-effector with high resolution and accuracy within the work volume, hence it is possible to print large sized components. This work also aims to develop artificial intelligence to the robot during 3D printing process using vision system. This work aims to integrate the 3D scanner, six axis industrial robot, extruder of FDM process and vision system to reproduce the complex shapes for various industrial applications.

2.4 If the project is location specific, basis for selection of location be highlighted: **NO**
(Maximum 1/2 page)

3. Work Plan:

3.1 Methodology:*(Maximum of 5 pages)*
(It should contain all the details of how each of the objectives will be addressed. This section must be detailed and have clear plans, not vague and generalized statements. It should have several schemes, tables, figures, equations etc. in addition to text, explanation and justification of why the project research plan will work)

The total work is divided into four phases. In the first phase is to develop algorithms to scan the objects using 3D scanner to generate CAD model with high precision. For accurate scanning proper illumination setup needed to be done. The second phase of the work is to develop generalized algorithms for printing over multiple planes and printing over multiple planes is to be evaluated. Third phase is to develop artificial intelligence using vision system to during 3D printing with robot. Final phase of the project is optimization various process parameters of 3D printing using the industrial robot.

a) 3D scannig of the object

This phase involves setting of correct scanning strategy which includes the correct scanning technique, preparing the part to be scanned, and performing the actual scanning to capture information that describes all geometric features of the part such as steps, slots, pockets, and holes. Three-dimensional scanners are employed to scan the part geometry, producing clouds of points, which define the surface geometry. There are two distinct types of scanners, contact and non-contact. After scanning the object a point cloud of data is formed. This point cloud data is processed and the noise is reduced. Appropriate filter algorithms are used for doing this. After this step a clean, merged, point cloud data set in the most convenient format is obtained. Next step is to generate surfaces that accurately represent the 3D information described within the point cloud data sets. Surface fitting algorithms are used for doing this task. Hence the CAD models from the point cloud are formed.

b) Printing of 3D objects using robot

In this section the methodology to be followed for printing 3D objects using the industrial robot is presented. Conventional 3D printers utilize G and M codes for controlling the motion of the extruder and for the material deposition. Robot programming commands are used for the movement of the extruder which is attached to the industrial robot. In conventional fused deposition modelling machine, the extruder movement is constrained only in two directions i.e. x and y. The z movement is provided by the heating bed i.e. the base plate. Once this extruder is attached to the industrial robot it acts like an end effector and does contain six degrees of freedom.

The flow chart indicating the procedure followed in preliminary investigation to print the objects with an industrial robot is shown in figure 1. First the CAD model of the 3D object is converted into the STL format. Then this STL file is sliced and the horizontal slices are extracted with required thickness. For the first slice the boundary of the area is extracted and then points on the boundary are determined by scanning horizontal line, and for second slice scanning is done by horizontal line perpendicular to scan line of the first slice. The procedure is repeated for scanning the remaining slices. The program is developed to generate the tool path in such a way that first tool (extruder) has to move along the boundary and then fill inside the boundary. After completing of single slice the same procedure is adopted for the second slice. Like that for the entire object (Cube in the present case) the tool path is generated. Investigation is required to be carried out to study the effect of various printing process parameters for different components of different shapes and sizes.

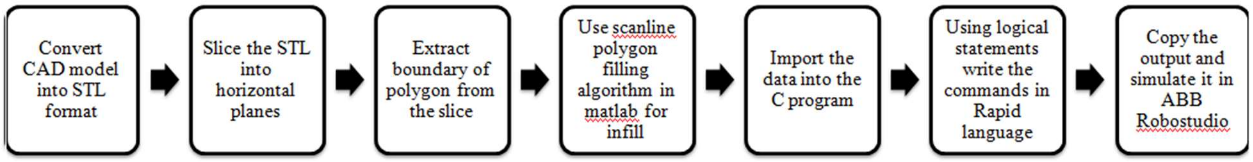


Fig.1 Flow Chart for 3D printing

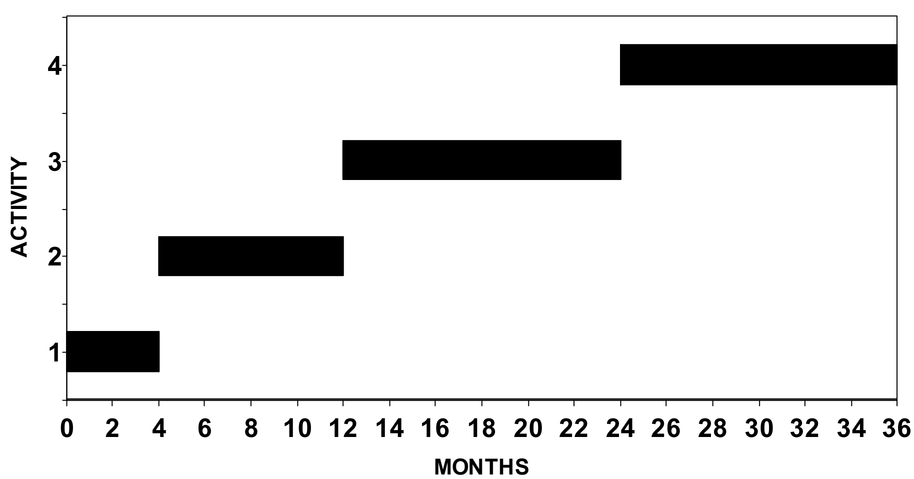
c) Develop an artificial intelligence using vision system during robot 3D printing process

The artificial intelligence using vision system of robot is an effective feedback system to monitor the movements of the robot. The aim of the work is to print the object using robot i.e. the process of printing is going on using the six axis industrial robot, the position and orientation of the end-effector is needed to be monitored for each layer. Each layer thickness is around 0.3-0.5 mm, so the end-effector moves in such a small increments from layer to layer. So for a good print, the end-effector needed to travel along the specified trajectory as planned. Hence, a vision system is needed to monitor, control and develop feedback system during printing process. The vision system must inspect, analyze and give feedback for each layer. Image system also protect the robot from obstacle avoidance during complex path followed during printing i.e. the vision system monitor the robot arm movement from the hitting the 3D objects during the printing process. In this phase, new vision based algorithm are required to control the printing process.

d) Optimization of process parameters

Fused Deposition Modelling (FDM) is a solid-based rapid prototyping method that extrudes material, layer-by-layer, to build a model. Knowledge of the quality characteristics of FDM fabricated parts is vital. Quality extensively depends on process variable parameters. Hence, the Optimization of these process parameters of FDM is able to make the system more specific and repeatable and such progression can guide to use of FDM in rapid manufacturing applications rather than only producing prototypes. In order to understand this issue, this work focus on to study the effect of the main FDM process variable parameters namely, layer thickness, air gap, and raster orientation etc.In this FDM process is integrated with robotic technology, various control parameters of the robot like rotational speed of the joints, speed of the end-effector, and distance between printer head to surface will influence the printing quality of the objects. The CAD model for 3D printing is obtained by 3D scanner and it depends upon proper illumination and orientation of the object. The slicing algorithm to divide the scanned 3D object into slices, which also plays important role on quality of the object. In this work optimization of various process parameters consisting FDM process parameters, robot control parameter, Scanning parameters and slicing parameters will consider to print the object with good quality. This work also aims to modelling the process using soft computing techniques in terms of various process parameters.

3.2 Time Schedule of activities giving milestones through BAR diagram. (Maximum1 page)



S.No	Activity	Duration
1	Recruiting the project staff and calling quotations for the equipment	4 months
2	Purchasing and Installation of equipment, and development of FDM setup for robot.	8 months
3	Experimentations and analysis using 3D scanning, printing using robot, developing vision system.	12 months
4	Modeling, optimization of the process parameters	12 months

3.3 Suggested Plan of action for utilization of research outcome expected from the project. *(Maximum ½ page)*

The present work aims to print 3D objects using robot. It has major applications in reverse engineering process by reproducing the components of same size and shape. In industrial point of view this work can use for development of new products and also for reproducing the parts to replace the defective parts in automobile industry. Based on the experimental results it is possible to study the feasibility for commercial components made of different materials. For the academic point of view it is possible guide research scholars in this area and to publish papers in international journals.

3.4 Environmental impact assessment and risk analysis. *(Maximum ½ page)*

This work aims to integrate the FDM, 3D Scanning and robotic technology to manufacturing the components. This work may not have any environmental impact and risk.

4. Expertise:

4.1 Expertise available with the investigators in executing the project: *(Maximum 1page)*

(*Professional expertise existing with each of the investigators in terms ofpublications, Patents and preliminary results, to execute every component of the proposal should be highlighted)*

Simulation of 3D printing on robotics.

Simulation of 3D printing of cube using industrial robot is performed. For simulation, ABB make IRB 1600 robot having 6 degrees of freedom, 1.45 m range and 6 kg payload with IRC5 industrial robot controller is used. First CAD model of cube is generated then it is converted into STL file format. In this format the surface of the CAD model is represented by triangles. Now this STL file is sliced and horizontal slices are obtained. The generation of CAD model, conversion into STL format and slicing are shown in fig. 1. Now form the sliced model each plane containing boundary of the object is extracted separately depending upon the z values. The simulation of 3D printing of cube using ABB make IRB 1600 industrial robot is shown in Fig.2.

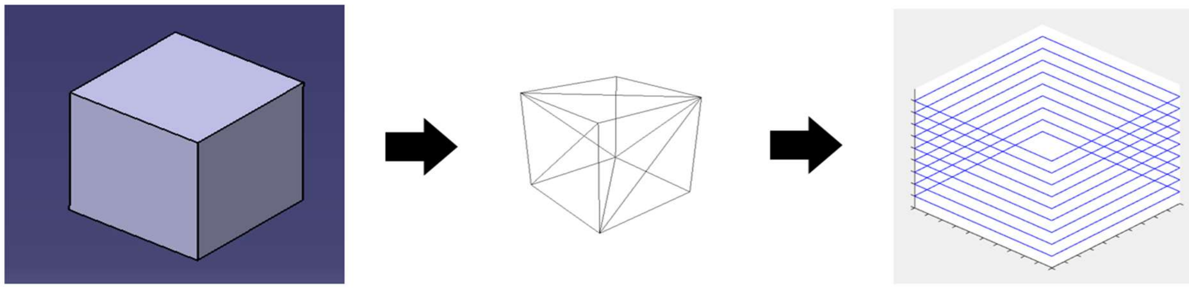


Fig.1. Slicing of the CAD model

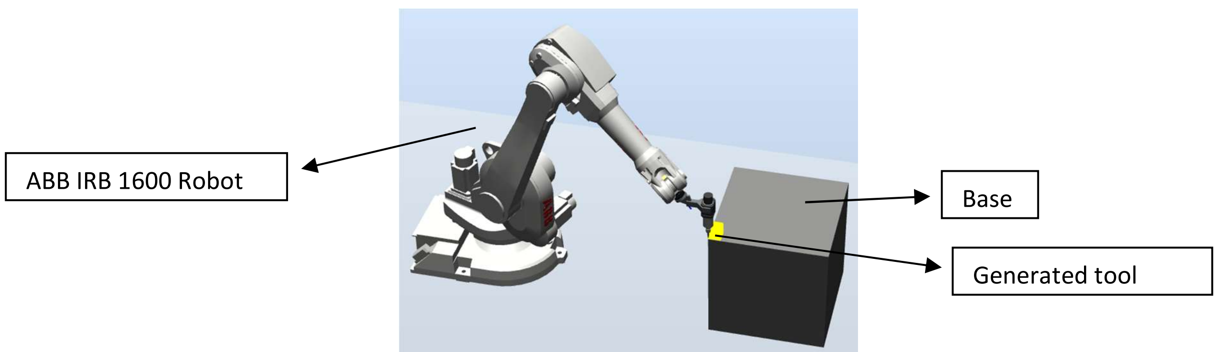
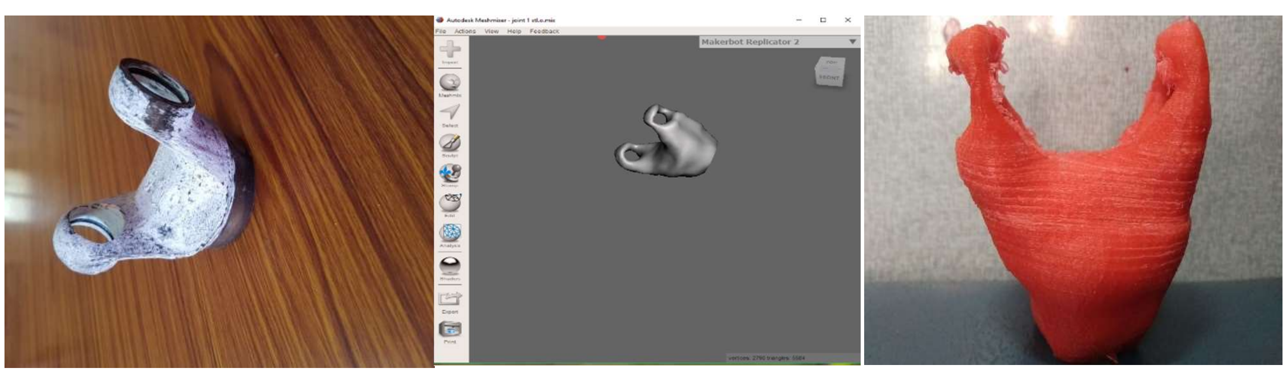


Fig.2. Simulation of cube using ABB make six-axis IRB 1600 industrial robot.

Printing of 3D objects and 3D scanner

Preliminary investigations were carried out by reproducing the object using low resolution Kinect sensor and 3D printer. In this work a simple axle shaft yoke half as shown Fig.3(a) is consider as object for printing. The CAD model of the object is generated by 3D scanning as shown in Fig.3(b). The 3D printed object using commercially available 3D printer is shown in Fig.3(c)



(a) Object **(b) Scanned CAD model** **(c) 3D printed object**

Fig.3. Phases in reverse engineering of Axle shaft yoke half

Developed vision system for tracking and extracting the features of the objects on moving conveyor.

The Industrial robots are widely used for pick and place operations. The location, shape and size of the object are very important for the robot controller to pick the object. New algorithms are developed to trace to trace the centroid of the object over moving conveyor using image subtraction technique combined with object segmentation technique. The image subtraction methodology is developed based on Gaussian Mixture Model (GMM). The approach is used to separate foreground and background to identify the features of the object from the background. It consists of processing video of the object movement over conveyor at particular location, and then subtracting each frame of the video from the reference frame i.e. the frame without any object. Fig.4 shows the various phases involved in separating the objects from the background. By subtracting the background frame from current frame by pixel by pixel based on Gaussian Mixture Model the output frame consisting the objects with color and shape. The background subtraction efficiency is decreased by variations in light illumination while capturing video. The intensity variations in each frame is added to the updated foreground frame. By segmenting the image based on intensity of the pixels, clusters formed similar to shape of the object. Theses intensity clusters are used in finding the features of the object. The centroid of the objects are determined based on the center of the each object in frame, i.e., it indicates the coordinates of the center pixel of each object in a frame. The center pixel of consecutive frames of particular object gives the information about the path of the object travel, it also gives the information about the speed of the conveyor. The center coordinates of the object are used to interface the robot with conveyor to pick object.

(a) Reference frame (b) Current Frame (c) Centroid of the objects

Fig.4. Various stages in determining the centroid of the object

4.2 Summary of roles/responsibilities for all Investigators: No Co-investigator

(If the proposal contains more than one Investigator, it is important to clearly mention the role of each Investigator in implementing the objectives of the proposal. The Board does not encourage Investigators who do not have specific scientific role in the proposal)

S. No.	Name of the Investigators	Roles/Responsibilities

4.3 Key publications published by the Investigators pertaining to the theme of the proposal during the last 5 years

Papers related robotics and 3D printing

1) Pramod Kumar Thotapalli, CH. R. VikramkumarandB.ChandraMohana Reddy, ‶Object tracking on moving conveyor using Image subtraction With Gaussian Mixture model(GMM)″ published and Presented at XXV Silver Jubilee Congress & National Conference Emerging Trends In Mathematical Sciences Application In Engineering Sciences organized by Andhra Pradesh Society for Mathematical Sciences Hosted at NBKRIST 9-11 December 2016. pp-60.
2) Pramod Kumar Thotapalli, CH. R. Vikramkumar and B.ChandraMohana Reddy "Trace the centroid of coloured object on a conveyor using Digital Image Processing" Published and Presented International Conference on International Conference on Manufacturing Technology and Simulation (ICMTS - 2017) organized by Mechanical Engineering Department ,7 th& 8 th July 2017,IITMadras pp-33-37.
3) Pramod Kumar Thotapalli, CH. R. Vikramkumar andB.ChandraMohana Reddy, ‶Feature Extraction of Moving Object over a Belt Conveyor Using Background Subtraction Technique″ attended for 10th International Conference on Precision, Meso, Micro and Nano Engineering (COPEN 2017) organized by Mechanical Engineering Department, 7-9, Dec 2017, IIT Madras pp 87-91 ISBN: 978-93-80689-28-9.

4) A. Sri Harsha and Ch. R. Vikramkumar, "Fused Deposition Modeling Using 6-Axis Industrial Robot", communicated to The 7th International & 28th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2018).
5) P. Bharat Arun and CH R Vikram Kumar, "Controlling the Position of jointed arm robot using image processing for pick and place operation." International journal computational vision and robotics, Vol.2 (1) 2011, 34-48.
6) P. Bharat Arun, P. Vijaya Bhaskara Reddy and CH R Vikram Kumar, "Controlling the Position of jointed arm robot using image processing for pick and place operation." 2nd International AIMTDR conference IIT Madras Dec. 2008, 177-182.

Other publication details

S.No	Title of the Paper	Name of the Journal	Month and Year of Publication
1.	Modeling of Surface roughness in wire electrical discharge machining using artificial neural network.	International Journal of Mechanical Engineering and Robotics Research.	Vol.2 (1) 2013 1-8
2.	Investigation on the Effect of Diethyl Ether additive on the performance of variable compression ratio diesel engine.	International Journal of Engineering Research.	Volume No.3 Issue No: Special 1, PP: 11-15
3.	Performance evaluation of composite (TiCN) coated engine valve using finite element - analysis.	South Asian Journal of Engineering and Technology (SAJET)	Vol.2 No.1 2015 41-461
4	Significance of finite element method based modeling in analyzing temperature generation and distribution during hard turning.	International Journal of Mechanical and Production Engineering Research and Development,	Vol.6 No.1 2016 23-32
5.	Finite Element Model Based On Abaqus / Explicit To Analyze The Temperature Effects Of Turning	International Journal of Applied Engineering Research.	Volume 11, Number 8 (2016) pp 5728-5734
6.	Influences of the Cutting and fluid application parameters on the surface roughness in hard turning with minimum fluid application.	Manufacturing Technology Today.	CMTI,Oct 2004 10-12
7.	Development of fuzzy controller for prediction of surface roughness in hard turning with coated cutting tools.	Journal of Technology Spectrum.	Vol.4 (2) 2010 52-56.

Other conference papers

S.No.	Title or Topic of Invited Lecture or Presentation	Name of the conference/seminar	Month and Year of Presentation	International / National / State / University level	Location where the event is organized
1.	Multi-objective parametric optimization onWEDM of Cr-Mo-V alloy steel using Neuro—Genetic approach	International Conference on Precision, Micro and Nano Engineering , COPEN – 2013	Dec. 2013 657-660	International Conference	NIT Calicut
2	Design of Automatic Deep Well Hand Pumpusing Magnetic Material	ICMMM 2014	Aug. 2014 387-388	International Conference	IIT Madras

3.	Comparative Performance of Vegetable Oil Based Cutting Fluids in Turning of Hardened AISI 1040 Steel	ICMMM 2014	Aug. 2014 235-236	International Conference	IIT Madras
4.	Prediction of Temperature on Coated Tungsten Carbide Inserts using 3D Finite Element Modeling	ICMMM 2014	Aug. 2014 289-290	International Conference	I IT Madras
5.	Performance Evaluation of Composite (TiCN) Coated Engine Valve Using Finite Element Analysis	ICRTME 2015	Nov. 2015	International Conference	Narasaraopet Engg. college
6.	Metallurgical investigation on failure of engine valves used in internal combustion engine	Indo Brazil Bilateral International Conference on "Advanced Materials & Processing	23-24 March 2017	International Conference	Kalasilingam University
7.	Prediction of temperature in turning using 3d finite element analysis	Indo Brazil Bilateral International Conference on "Advanced Materials & Processing	23-24 March 2017	International Conference	Kalasilingam University
8.	Investigation on the Effect of Diethyl Ether additive on the performance of variable compression ratio diesel engine	National conference on emerging trends in mechanical engineering for sustainable development	Mar. 2014	National Conference	RGMCET, Nandyala
9.	Simulation of Composite (Tic/Al2O3) Coated Engine Valve Using Finite Element Analysis	17th ISME conference on Advance in Mechanical engineering	Oct. 2015	National Conference	IIT Delhi
10.	Performance evaluation of composite (DLC) coated engine valve using finite element analysis	RAMM 2015	Dec. 2015	National Conference	SSN College of Engineering Chennai

4.4 Bibliography

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3. Jae-Won Choi, Francisco Medin, Chiyen Kim, David Espalin, David Rodriguez, Brent Stucker, Ryan Wicker, “Development of a mobile fused deposition modeling system with enhanced manufacturing flexibility”, Journal of Materials Processing Technology 211 (2011) 424–432.
4. B. Huang and S. Singamneni (2012) “Alternate slicing and deposition strategies for fused deposition modelling of light curved parts”Journal of Achievements in Materials and Manufacturing Engineerig Volume 55 Issue 2 Pages 511-517.
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6. Eric J. McCullough and Vamsi K. Yadavalli, “Surface modification of fused deposition modeling ABS to enable rapid prototyping of biomedical microdevices”, Journal of Materials Processing Technology 213 (2013) 947–954.
7. Godfrey C. Onwubolu and FarzadRayegani, “Characterization and Optimization of Mechanical Properties of ABS Parts Manufactured by the Fused Deposition Modelling Process”, International Journal of Manufacturing Engineering Volume 2014, Article ID 598531, 13 pages.
8. A. Boschetto and L. Bottini, “Accuracy prediction in fused deposition modeling”, International Journal of Advanced Manufacturing and Technology (2014) 73:913–928.
9. Wei-chen Lee, Ching-chihwei, Chung and Shan-chenchung, “Development of a Hybrid Rapid Prototyping System Using Low-Cost Fused Deposition Modeling and Five-Axis Machining”, Journal of Materials Processing Technology (2014).
10. Eric Barnett Clement Gosselin (2015) “Large-Scale 3D Printing With A Cable-Suspended Robot” Accepted manuscript Additive Manufacturing, Elsevier.
11. IsmayuzriIshak and Pierre Larochelle (2015) "Robot Arm Platform for Rapid Prototyping: Concept” Proceedings in Florida Conference on Recent Advances in Robotics.
12. Alberto Boschetto and LuanaBottini, “Design for manufacturing of surfaces to improve accuracy in Fused Deposition Modeling”, Robotics and Computer-Integrated Manufacturing 37 (2016) 103–114.
13. Yu-an Jin, Yong He, Guang-huaiXue and Jian-zhong Fu, “A parallel-based path generation method for fused deposition modeling”, International Journal of Advanced Manufacturing and Technology (2015) 77:927–937.
14. Mark Swanson, Will Spurgeon, Taylor Vass and Monika Danielewicz (2016) “3D Printing Robotic Arm” Project report, Worcester Polytechnic Institute.
15. K. Thrimurthulu, Pulak M. Pandey and N. Venkata Reddy, “Optimum part deposition orientation in fused deposition modeling”, International Journal of Machine Tools & Manufacture 44 (2004) 585–594.
16. Debapriya Chakraborty, B. Aneesh Reddy and A. Roy Choudhury, “Extruder path generation for Curved Layer Fused Deposition Modeling”, Computer-Aided Design 40 (2008) 235–243.
17. V. Vijayaraghavan, A. Garg, Jasmine Siu Lee Lam, B. Panda and S. S. Mahapatra, “Process characterisation of 3D-printed FDM components usingimproved evolutionary

computational approach", International Journal of Advanced Manufacturing and Technology (2015) 78:781–793.

18. Sadegh Rahmati andEbrahimVahabli, "Evaluation of analytical modeling for improvement of surfaceroughness of FDM test part using measurement results", International Journal of Advanced Manufacturing and Technology (2015) 79:823–829.
19. Biranchi N. Panda, K. Shankhwar, Akhil Garg and Zhang Jian, "Performance evaluation of warping characteristic of fuseddeposition modelling process", International Journal of Advanced Manufacturing and Technology (2017) 88:1799–1811.
20. Vishal Francis and Prashant K. Jain, "Experimental investigations on fuseddeposition modelling of polymer-layered silicatenanocomposite", Virtual and Physical Prototyping, ISSN: 1745-2759 (Print) 1745-2767 (Online), 2016http://dx.doi.org/10.1080/17452759.2016.1172431.
21. Ashu Garg, Anirban Bhattacharya and Ajay Batisha, "On Surface Finish and Dimensional Accuracy of FDMParts after Cold Vapor Treatment", Materials and Manufacturing Processes 2015, http://dx.doi.org/10.1080/10426914.2015.1070425.

5. List of Projects submitted/implemented by the Investigators

(All the Investigators should list out details of the Projects submitted, implementing and completed by them. The list should start with the Projects implemented by the Principal Investigator, followed by Co-PI1, Co-PI 2 etc.)

5.1 Details of Projects submitted to various funding agencies: Nil

S. No	Title	Cost in Lakh	Month of submission	Role as PI/Co-PI	Agency	Status

5.2 Details of Projects under implementation

S. No	Title	Cost in Lakh	Duration	Role as PI/Co-PI	Agency
1.	Controlling the position of jointed arm robot using image subtraction technique with minimum distance approach for pick and place operation	12.35	2015-18	PI	AICTE
2.	MODROBS - Modrenization of production engineering laboratory	10	2016-18	Coordinator	AICTE

5.3 Details of Projects completed during the last 5 years

S. No	Title	Cost in Lakh	Duration	Role as PI/Co-PI	Agency

6. List of facilities being extended by parent institution(s) for the project implementation.

6.1 Infrastructural Facilities

Sr. No.	Infrastructural Facility	Yes/No/ Not required Full or sharing basis
1.	Workshop Facility	YES
2.	Water & Electricity	YES
3.	Laboratory Space/ Furniture	YES
4.	Power Generator	YES
5.	AC Room or AC	NO
6.	Telecommunication including e-mail & fax	YES
7.	Transportation	YES
8.	Administrative/ Secretarial support	YES
9.	Information facilities like Internet/Library	YES
10.	Computational facilities	YES
11.	Animal/Glass House	Not necessary
12.	Any other special facility being provided	---

6.2 Equipment available with the Institute/ Group/ Department/Other Institutes for the project:

Equipment available with	Generic Name of Equipment	Model, Make & year of purchase	Remarks including accessories available and current usage of Equipment
PI & his group	Six axis industrial robot	Model-IRB1600, ABB Make and 2016 purchased.	Pneumatic gripper and 3D printing extruder setup is available, used as end effectors.
	3D printer	S300-DH Model, Real time controls make and 2017 purchased.	Possible print with dual extruder to size 300X300X300 mm size components
	Xbox one kinect sensor	Microsoft Xbox Kinect camera, 2018 purchased	Suitable to scan 3D objects with low resolution. Reverse engineering is being done using kinect sensor (scanner).
PI's Department			
Other Institute(s) in the region			

7. **Name and address of experts/ institution interested in the subject / outcome of the project.**

1. **Dr. Pulak Mohan Pandey,**
   Professor,
   Block III, Room No. 361 ,
   Department of Mechanical Engineering,
   Indian Institute of Technology Delhi.
   Hauz Khas, New Delhi-110016, INDIA.
   Email : pmpandey@mech.iitd.ac.in,
   pulakmohan@gmail.com .
   Phone : 011 26596083 (office)
   Fax : 26582053

2. Dr. Karunakaran
   Professor,
   Department of Mechanical Engineering,
   Indian Institute of Technology, Bombay
   Mumbai- 400079
   Phone: +91-22-2576-7530
   Email: karuna@iitb.ac.in

3. Dr. Subir Kumar Saha
   Naren Gupta Chair Professor
   Department of Mechanical Engineering
   Indian Institute of Technology Delhi
   Hauz Khas New Delhi 110 016, India
   Email: saha@mech.iitd.ac.in, sahaiitd@gmail.com
   Tel: (91)-11-2659-1135 (O)
   Fax: (91)-11-2658-2053 (Dept.)

4. Dr. Prashant Kumar Jain,
   Associate Professor (Mechanical)
   Indian Institute of Information Technology, Design and Manufacturing,
   205, NR-II, IIITDM Jabalpur Campus,
   Dumna Airport Road, Jabalpur (M.P.) - 482005
   Phone No.: 09425800310, 09425805421
   Email : pkjain@iiitdmj.ac.in , pkjain2006@gmail.com

Budget Details

Full Summary (in Rs.)

Institute	Manpower Budget	Consumables	Travel	Equipment	Contingencies	Overhead Costs	Total
N.B.K.R. Institute of Science & Technology,	*9,00,000*	*75,000*	*45,000*	*17,21,030*	*30,000*	*0*	*27,71,030*
Total	***9,00,000***	***75,000***	***45,000***	***17,21,030***	***30,000***	***0***	***27,71,030***

Manpower Budget Breakup

Institute Name : N.B.K.R. Institute of Science & Technology,

Summary :

Budget Head	Year-1 Amt (in Rs.)	Year-2 Amt (in Rs.)	Year-3 Amt (in Rs.)	Total (in Rs.)
Manpower Budget	*2,88,000*	*3,00,000*	*3,12,000*	*9,00,000*
Consumables	*25,000*	*25,000*	*25,000*	*75,000*
Travel	*15,000*	*15,000*	*15,000*	*45,000*
Equipment	*17,21,030*	*0*	*0*	*17,21,030*
Contingencies	*10,000*	*10,000*	*10,000*	*30,000*
Overhead Costs	*0*	*0*	*0*	*0*
Grand Total (in Rs.)	***20,59,030***	***3,50,000***	***3,62,000***	***27,71,030***

Manpower Budget Detail :

Designation	Year-1 Amt (in Rs.)	Year-2 Amt (in Rs.)	Year-3 Amt (in Rs.)	Total Amt (in Rs.)
Junior Research Fellow	*2,88,000*	*3,00,000*	*3,12,000*	***9,00,000***

Justification for Manpower :

1 . The project work consists of fabrication, experimental investigation and programming. This project consists developing programming to generate CAD models using 3D scanner, printing objects using 3D printer and operating Robot for 3D printing. It is not possible for principle investigator to carry out these works apart from regular works. To carry out these works and to complete the project within the stipulated time period it is essential to take one post graduate engineering student as JRF.

Consumable Cost Detail :

Year-1 Amt (in Rs.)	Year-2 Amt (in Rs.)	Year-3 Amt (in Rs.)	Total Amt (in Rs.)
25,000	25,000	25,000	***75,000***

Justification for Consumables :

1 . This project does not require any costly consumables. In this experiments have to be conducted to print the objects using 3D printer and robotics. For these works raw material and necessary accessories have to be purchased for experimentation. Consumables include 3D printing material like spools of PLA, asbestos etc., Nozzles, chemicals for cleaning etc. are required to procure.

Travel Cost Detail :

Travel	Year-1 Amt (in Rs.)	Year-2 Amt (in Rs.)	Year-3 Amt (in Rs.)	Total Amt (in Rs.)
Inland travel	*15,000*	*15,000*	*15,000*	***45,000***

Justification for Travel :

1 . The college is situated in a rural place, it is required to travel nearest places to purchase raw materials and necessary accessories. The amount of travel includes expenses expenses to present progress report, expenses to present the papers in the conferences etc. For the characterization of the samples it is required to take the samples to different places and the traveling expenses also included in the budget.

Equipment Cost Detail :

Generic Name	make	Model	Quantity	Estimated Cost in INR	Estimated Cost in Foreign Currency	Foreign Exchange Rate	Spare time for other users (in %)
3D scanner	Shining 3D/Think 3D	Einscan pro+	1	***6,20,090***	0 (US Dollar)	0	50
Robot Vision System	Cognex	IS7600C-363-50	1	***11,00,940***	0	0	50

Justification for Equipments :

1 . In the present work, the CAD model of the object is to be generated based on reverse engineering principles, hence a good quality 3D scanner is required to carry out the project. The EinScan-Pro+ is having consistent and excellent scanning quality. It provides multiple scanning modes and delivers simple and fast scanning with its convenient handheld design.
2 . Vision based feedback control can improve control performance and extend application areas of robot manipulators. In the present work, the position of the end-effector is supposed to be monitored while printing. So continuous feedback is needed. Hence a high resolution vision camera is needed for a solid print using the industrial robot.

Contingency Cost Detail :

Year-1 Amt (in Rs.)	Year-2 Amt (in Rs.)	Year-3 Amt (in Rs.)	Total Amt (in Rs.)
10,000	*10,000*	*10,000*	***30,000***

Justification for Contingency :

1 . The contingency cost includes purchase of books, contingency, stationary for documentation and report preparation etc. These items are necessary to carry out the documentation of the research. The contingency also includes the cost associated with metallurgical characterization of the printed samples

Overhead Detail :

Year-1 Amt (in Rs.)	Year-2 Amt (in Rs.)	Year-3 Amt (in Rs.)	Total Amt (in Rs.)
0	*0*	*0*	***0***

Justification for Overhead :

1 . No overhead cost to the Institute

RTGS Details :

Comments :

Name of Account Holder :	Dr V Vijaya Kumar Reddy	**Email ID :**	ist@nbkrist.org
Designation :	Director	**Account Number :**	116010011007180
Bank Name :	Andhra Bank	**Branch Name and Address :**	Vidyanagar Educational complexVidyanagar, Kota Mandal, SPSR Nellore(dist)Andhra Pradesh - 524 413
IFSC Code :	ANDB0001160		

Any other relevant matter : This aim of the work is to develop reverse engineering concepts using robotics and 3D printing. Presently principle investigator started preliminary investigation on 3D printing using robotics.

Suitability of the proposed work in the major national initiatives of the Government :

SNo.	Program Name

1	Make in India
2	Digital India

Theme of Proposed Work :

SNo.	Theme Name
1	Cyber Physical Systems including AI, IOT and Cyber Security
2	Manufacturing

Dr. CHINTAM REDDY. VIKRAM KUMAR.
M.Tech., Ph.D. (IITM)

Professor & Head,
Dept. of Mechanical Engineering,
N.B.K.R.I.S.T., Vidyanagar, Nellore (dist),
Andhra Pradesh - 524 413, India
Email: cvikramkumar@gmail.com
Ph: 09490321975 (M), 0862422281 2(H)

EDUCATIONAL QUALIFICATIONS:

Sl. No.	Degree Obtained &Branch / Specialization	Name of the University/Institute	Year of Passing	% of Marks/ CGPA	Class/ Division
1	B Tech (Mechanical Engg)	Sri Venketeswara University, Tirupati	1997	72%	First class with Distinction
2	M Tech (Production Engg)	Sri Venketeswara University, Tirupati	2001	80.1%	First class with Distinction
3	Ph.D. (Manufacturing Engg)	Indian Institute of Technology Madras	2007	Awarded	_

DETAILS OF EXPERIENCE

Total Experience: Around 17 years 3 months

i) Teaching Experience :

Sl.No.	Name of the organization where employed	Designation	Date of Joining	Date of leaving
1.	N.B.K.R.I.S.T Vidyanagar	Professor	Oct 2013	Till date
2	Audisankara College of Engineering for Women, Gudur	Principal	Oct 2012	Oct 2013
3	N.B.K.R.I.S.T Vidyanagar	Professor	Mar 2011	Oct 2012
4	N .B.K.R.I .S.T Vidyanagar	Associate professor	Nov 2010	Mar 2011
5	Sri Padmavthi Engineering	Principal	April 2010	Nov 2010
6	N.B.K.R.I.S.T Vidyanagar	Associate professor	July 2007	April 2010
7	N.B.K.R.I.S.T Vidyanagar	Assistant Professor (Sr lec)	Dec 2006	Jun 2007
8	S.V. University Tirupati	Academic Consultant	August 2000	Dec 2001

ii) Research Experience:				
Sl.No.	Name of the organization	Designation	Date of Joining	Date of leaving
1.	Indian Institute of Technology Madras	Research scholar	Jan 2002	Dec 2006

TOTAL RESEARCH PUBLICATIONS / PRESENTATIONS

Sl. No.	Nature		Published
1.	Refereed Journals	National	2
		International	13
2.	Presentations (Proceedings)	National	12
		International	24
		Accepted	1
		Total	52

RESEARCH AREAS

- Metal cutting and hard coatings on cutting tools
- Modeling of manufacturing process use soft computing techniques
- Simulation of metal cutting tools
- Robotics
- 3D printing

NO. OF Ph. D THESIS GUIDED : 1(Main Super visor)

Title of the thesis: Modeling and Optimization of Wire Electrical Discharge Machining of Cr-Mo-V special alloy using Neuro-Genetic approach.

NO. OF PH D Scholar under guidance: 2 Full Time + 3 Part Time
(3 as a Main supervisor and 2 as a single supervisor)

RESEARCH PROJECTS

Sl. No.	Title of the Project	Amount in Rs.	Funding Agency	Period	Remarks (Completed/ Ongoing)
1.	Design and fabrication of computer control robot using image processing for pick and place operations	Rs. 30,000/-	Institute sponsored	One year	Completed

RESEARCH PROJECTS UNDER PROGRESS

S.No	Title of the project	Duration	Funding Agency	Project Cost (lakhs)	REMARKS
1.	Controlling the positon of jointed arm robot using Image subtraction technique	2015-18	AICTE	12.3	Under Progress
2.	Development of Bio- degradable cutting fluids for machining Ni based super alloys	-	AR&DB	9.5	Received mail indicating that the proposal is accepted in principle

PROJECTS GUIDED UNDER UG/PG LEVEL

- Design and fabrication of a computer controlled jointed arm robot controlled through image processing.
- Finite element analysis to predict temperature on piston in IC engine.
- Performance of biodegradable cutting fluids in machining.
- Finite element analysis to predict temperature on Engine valve.
- Fabrication of belt conveyor.
- Fabrication of vertical wind mill
- Fabrication wave energy converter
- Design of magnetic operated deep water pump
- Fabrication computer controlled Jointed arm robot

SPONSORED PROJECTS COORDINATED

S.No.	Position	Name of the Project	Sponsoring Authority	Duration
1.	Chief coordinator	Industry Institute Partnership cell	AICTE	Dec 2008 to Jan 2010
2.	Co-coordinator	MODROBS (8 Lakhs)	AICTE	2011-12
3.	Co-coordinator	MODROBS (10 Lakhs)	AICTE	2017-18

COURSE CONDUCTED

- One week AICTE sponsored Staff Development programme is conducted as coordinator on "ADVANCES IN MANUFACTURING TECHNOLOGY" from July 13th -18th, 2009, in Department of Mechanical Engineering, N.B.K.R.I.S.T., Vidyanagar.

- Two week Staff Development programme is conducted as coordinator on "ADVANCES IN MANUFACTURING PROCESS" from 02nd – 13th June 2014, in Department of Mechanical Engineering, N.B.K.R.I.S.T., Vidyanagar.

- One week Faculty Improvement Programme on CATIA V5 in Association with APSSDC and EDS technologies from 10th – 15th April 2017, in Department of Mechanical Engineering, N.B.K.R.I.S.T., Vidyanagar.

LABORATORIES ESTABLISHED

1. Instrumentation laboratory
2. E-yantra laboratory in association with IITB
3. Robotics laboratory

COURSES ATTENDED

S.No	Name of the course	Duration	Organized by	Venue
1	Advances in Manufacturing	Two weeks	AICTE/IIT Madras	IIT Madras
2	Modern Teaching Methods	3 days	NITTTR, Chennai	N .B.K.R.I.S.T Vidyanagar
3.	Outcome Based Engineering Education	1 day	Dr. M V R R Sastri	N .B.K.R.I.S.T Vidyanagar
4.	ABB Basic Robotic training Program	3 days	ABB India	Bangalore

EXPERT LECTURES DELIVERED

- N B K R Institute of Science And Technology, Vidyanagar on 15th July 2009.
- Siddharth Institute of Technology, Puttur on 23rd March 2011.
- PBR VITS, Kavali on 12th March 2012.
- Yogananda Institute of Technology and Science, Tirupati on 7th March 2013.
- N. B K R Institue of Science And Technology, Vidyanagar on 04th June 2014
- Gudlavalleru Engineering College, Gudlavalleru on 27th June 2014.

PAPER SETTER FOR VARIOUS UNIVERISTIES/INSTITUTIONS

- Padmavathy Mahila Universiy Tirupati.
- Sri Venkateswara University, Tirupati.
- Jawaharlal Nehru Technological University Anantapur.
- K L University, Vijayawada
- VR Siddhartha Engineering college Vijayawada.
- Swarnadhra Bharathi Engineering college, Amalapuram

EXTERNAL EXAMINER FOR VARIOUS UNIVERSITIES/INSTITUTES

- Padmavathy Mahila University, Tirupati.
- Sri Venateswara University, Tirupati
- Narasaraopeta Engineering college, Narasarao pet
- A1 Global Engineering college, Markapur
- Kalasingam Univesity, Villiputthur

Courses/Labs HANDLED

B.Tech	M.Tech	Labs Handled
• Tool Design • Machine Tools • Advanced Manufacturing Process • Metrology • Computer Based Engineering Drawing • Engineering Graphics • Robotics • Automation • CAD/CAM • Applied Thermodynamics-I & II	• Computer Based Metrology • Advanced CAD • Cutting tool design • Advanced Material Technology	• Production Engineering -II • Metal Cutting • Work Shop Practice • Robotics • Production Lab • Thermal Engineering lab • Metrology

RESPONSIBILITIES AT THE PRESENT POSITION

- Head, Department of Mechanical Engineering.
- Institute level coordinator for National Assessment and Accreditation Council (NAAC) of UGC during Reaccreditation 2nd cycle process. Institute obtained ‘A’ grade.
- Nodal officer for National Institutional Ranking Framework (NIRF).
- Coordinator for Internal Quality Assurance Cell (IQAC).
- Established Robotics club and coordinated many workshops to students.
- Coordinator for R& D cell.
- Coordinator for E-yantra lab supported by I IT Bombay and MH RD, India.

- Departmental Coordinator for NBA (AICTE)
- In-charge Robotic lab

Permanent address : Dr. Ch R. Vikram Kumar
S/o Ramachandra Reddy,
2/186, N R Pet,
Gudur, SPSR Nellore (dist),
Andhra Pradesh – 524 102,
India.

Declaration:

I hereby declare that the information furnished above is true to the best of my knowledge.

(Dr. CHR. VIKRAM KUMAR)

N.B.K.R. INSTITUTE OF SCIENCE & TECHNOLOGY
(AUTONOMOUS)
COLLEGE WITH POTENTIAL FOR EXCELLENCE (CPE)
Affiliated to JNTUA, Anantapuramu
Accredited by NAAC with 'A' Grade
B.Tech. (ECE, EEE, CSE, CE, ME) Courses Accredited by NBA under TIER-I

Dr. V. Vijaya Kumar Reddy
Director

26.06.2018

Endorsement from the Head of the Institution

This is to certify that:

1. Certified that the Institute welcomes participation of Dr. CH R. Vikram Kumar as the Principal Investigator for the project titled **Investigation on Multi-Plane Fusion Deposition Modeling (FDM) using 6-Axis Industrial robot** and that in the unforeseen event of discontinuance by the Principal Investigator, the Principal Co-Investigator will assume the responsibility of the fruitful completion of the project with due information to SERB.

2. The date of project starts from the date on which the University/Institute/ Organisation/College receives the grant from SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi.

3. The investigator will be governed by the rules and regulations of University/ Institute/Organisation/College and will be under administrative control of the University/ Institute/Organisation/College for the duration of the project.

4. The grant-in-aid by the SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi will be used to meet the expenditure on the project and for the period for which the project has been sanctioned as mentioned in the sanction order.

5. No administrative or other liability will be attached to SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi at the end of the project.

6. The University/Institute/Organisation/College will provide basic infrastructure and other required facilities to the investigator for undertaking the research project.

7. The University/ Institute/Organisation/College will take into its books all assets created in the above project and its disposal would be at the discretion of SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi.

8. The University/ Institute/Organisation/College assumes to undertake the financial and other management responsibilities of the project.

Seal of
University/ Institute/Organisation/College

Signature
Registrar of University/Head of the Institute/Head of organisation / Principal of College

Office of the N.B.K.R. Institute of Science & Technology, VIDYANAGAR - 524413, SPSR Nellore

DIRECTOR
N.B.K.R. Institute of Science & Technology
Vidyanagar, SPSR Nellore Dt.

Certificate from the Investigator

Project Title:

It is certified that

1. The same project proposal has not been submitted elsewhere for financial support.
2. We/I undertake that spare time on equipment procured in the project will be made available to other users.
3. We/I agree to submit a certificate from Institutional Biosafety Committee, if the project involves the utilization of genetically engineered organisms. We/I also declare that while conducting experiments, the Biosafety Guidelines of Department of Biotechnology, Department of Health Research, GOI would be followed in toto.
4. We/I agree to submit ethical clearance certificate from the concerned ethical committee, if the project involves field trails/experiments/exchange of specimens, human & animal materials etc.
5. The research work proposed in the scheme/project does not in any way duplicate the work already done or being carried out elsewhere on the subject.
6. We/I agree to abide by the terms and conditions of SERB grant.

Name and signature of Principal Investigator:
Date: 26-6-18
Place: Vidyanagar

Name and signature of Co-PI (s) (if any):
Date:
Place: