Optimal design and analysis of integrated spindle-tool system with a sensor based system for high speed machining

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PROPOSAL DETAILS

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Technical Details :

Scheme :	Core Research Grant		
Research Area :	Mechanical & Manufacturing Engineering & Robotics (Engineering Sciences)		
Duration :	36 Months	**Contact No :**	+918596957456
Date of Birth :	13-Apr-1985		
Nationality :	INDIAN	**Total Cost (INR) :**	19,00,000

Is PI from National Laboratory/Research Institution ? No

Project Summary :

High speed machining using vertical CNC milling centers continues to find widespread applications in a variety of sectors, specifically in aerospace, automobile, mould and die-cavity preparation and other processes. During past, very less works have been focused on fabrication of low-duty machine tools for internal requirements. Due to economic considerations, sometimes a specific machine tool has to be employed for different machining operations. For example, in order to carryout vertical milling operations, a drilling machine may be economically employed with appropriate modifications in design by changing the tools and operating parameters. However, as the original machine tool is designed for one series of operating conditions, in its original form it cannot be used for other high-end machining applications. While machining especially in longitudinal planes, unstable oscillations called chatter phenomenon leading to a significant reduction in metal removal rates. The spindle is one of the important components in machine tools, which dictates the dynamic stability during cutting operation. Its design influences the frequency response at the tool-tip significantly and alters the vibration levels and cutting forces during machining. To enhance the use of the drill spindles effectively for end-milling operation, its geometrical topology is to be modified by adding the additional bearings with the collar system, which improves its dynamic rigidity during milling operation. Further, a portable X-Y table is planned to fabricate as per the existing dimensions of the drilling machine to carry-out the cutting tests for assessing the stability. Analytical stability lobe diagram is to be constructed for modified optimal spindle and the stability boundaries of these lobes are to be verified by vibration tests and sound spectrum measurements. Further the manual feed of the work table is automated with stepper motors in both the directions which will produce the automatic feed. This type of small scale models will be better alternative for the costly CNC milling machine. These types of in-house machine tool units will be effectively installed in the educational institutions to carry out the basic machining process like drilling, slotting etc. at a lower range of speeds and depths of cuts.

Objectives :

Dynamic modeling of modified drill spindle topology for end-milling operations by providing the additional bearing-collar supports.

• Cutting experiments with end-milling tools on a bench drilling machine, it was found that the system perceives a limited range of stable operating states and most of the time the work surface was uneven. This motivated to modify the spindle so as to minimize the coupled vibrations due to multi-flute milling cutter.

• Initially, the tool-tip frequency response function (FRF) is obtained from finite element model of the spindle-tool unit. A novel method like receptance coupling sub-strurcture analysis is developed in this work to identify the frequency response at the tool tip end. Further, the correctness of the model will be verified by the three dimensional approach using ANSYS WORKBENCH and experimental testing such as sine sweep modal testing.

• The resultant analytical stability lobe diagrams are generated at different conditions of material damping and immersion rates. The improved stability regions are illustrated with experimental tests using vibration and sound spectrum measurements.

• The merits of revised spindle over the conventional drill spindle are reported in terms of stability of cutting and more working range.

Keywords :

FEM, OPTIMIZATION, CUTTING FORCES, STABILITY LOBES, X-Y TABLE

Expected Output and Outcome of the proposal :

The spindle-holder and tool system of a modified drill spindle center will be analysed by finite element modelling and receptance coupling method to obtain the tool-tip frequency response functions. These analytical methods will provide an effective way modelling the complex structural units of machine tools. The generalized computer programs will be further used to carry out parametric studies on dynamic stiffness of spindle and optimum spindle system variables were identified to achieve the maximum dynamic stiffness. Based on the simulated results, the data was generalized with the help of a neural network model that works as a function estimator for the GA based optimization module. The optimal data obtained from this optimization technique increases the dynamic stiffness of the structure and proposes to design a new modified spindle-tool unit which can be able to bear the dynamic vibrations during the cutting process. The modelling methods developed in this work facilitate to us apply to any type spindle-tool assemblies. In view of this, a practical spindle unit of an in-house manual drilling machine is considered for the analysis. Finite element models are applied for the spindle-tool unit of a drill spindle and optimal topology of designs were proposed to improve the dynamic stiffness.

Any other relevant information:

In India, a few researches have been conducted, with dynamic stability studies and chatter modeling in high speed machining. The conversion of a radial drilling machine into a vertical milling machine with modifications at the design stage is an innovative idea in fabrication. Single machine tool will be utilized for the multipurpose operations.

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

Make in India

Theme of Proposed Work:

Energy

Collaboration Details for last 5 Years :

Planned Collaboration for the proposed work with any foreign scientist/ institution ? **No**

SNo.	CO-PI Details
1	 **A Raveendra** akununuraveendra@mrec.ac.in Professor(Mechanical) **Malla Reddy Engineering College** Maisammaguda, Dhulapally (Post via. Kompally), Secunderabad, Rangareddy Dt, TELANGANA, HYDERABAD D.O.B : 17 Dec, 1970

Other Technical Details

1. Origin of the Proposal:

For the past one decade, very few researches have been carried out for the utilization of in house machine such as the drilling, milling for several applications. For simple machining operations like slotting, the use of CNC end milling will costs more machining cost. In certain European countries, these type of design modifications are implemented at the design stage to utilize one machine for multiple operations. In the current research area high speed machining using vertical CNC milling centers continues to find widespread applications in a variety of sectors, specifically in aerospace, automobile, mould and die-cavity preparation and other processes. During past one decade, several works like Axinte, D.A et al. (2010), Mao, J. (2015) have focused on fabrication of low-duty machine tools for internal requirements. Determination of transfer function by using inverse modeling of the self-excited vibrations is one of the recent concepts are given by solis et al. (2004). Here, the modal factors were enhanced to reduce the errors among the systematic and the trial stability boundaries. Some preliminary work in this direction by the investigators (Jin, X., et al, 2016;Totis, G. et al, 2014) has inspired the team to investigate the development of a spindle-tool unit for milling and drilling, modeling of torsional-axial vibrations of tool with flute effects and development of a dynamic model of a machine tool for combined drilling and milling operations. However, stability studies of a retrofitted drill spindles used for milling operations have not been attempted in any work.

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

2.1 International Status:

Performance of the machining process can be enhanced in a straight way using process optimization; although, the machine tool chatter is a foremost aspect that affects the process effectiveness. Research on chatter stability analysis with modifications in spindle design and its chatter control has started in the international arena since early 1970s. Chatter causes a powerful uncertainty in cutting operation resulting in excessive material removal, poor surface area and almost certainly damaging the tool and workpiece. In automated manufacturing systems, an accurate estimation of cutting force and chatter vibrations are especially required for recognizing the high-proficient, high-eminence and inexpensive milling process. Chatter oscillations continue to be a significant restricting aspect to enhance the metal removal rates of the machining process. In an effort to choose the factors that avoid chatter and to attain the better surface finish, accurate dynamic models of tool-holder-spindle assembly are required. Such a dynamics reflected at tool tip can be acquired by modal testing, but entails a huge number of tool-holder arrangements in a manufacturing facility. The measurements are time taking and at times, problematic as in the case of micro-end mills. Several studies reported analytical and experimental works relating to regenerative chatter phenomenon in milling. Both theoretical and experimental are reported in the literature. Some of the work in the last decade is summarized below:

Wang and Chang(2007) employed finite element method for analysis of a spindle bearing unit using Rayleigh's formulation, with exclusive considerations of high speed effects in the system. A new technique was designed, which opinions the consequences of multiple-mode features of an application, at high excitation frequencies and wider ranges of spindle speed.

Tanga and Song(2009) studies are employed to obtain the stability limits to increase the enhanced metal removal rate without chatter.

Gagnol et al.,(2007) formulated a highly effective design of high-speed spindle-bearing model and it is analyzed with the basic applications of rotor dynamics and its design is modified with the help of experimentation. It is identified that lobe diagrams were altered as of the non-rotational frequency response function (FRF) predictions due to changes in dynamic stiffness.

Bravo et al.,(2005) analyzed a means for obtaining both the uncertainty zones and stability zones in the lobe diagrams, relevant for both the machine tool structure and work piece possess the same dynamic behavior.

Lin and Tu(2007) designed a flowchart to signify all the general spindle design problems. Sensitivity analysis is carried out for the major eight design factors with the help of finite element analysis to examine their control on the frequencies of the system.

Ozturk et al.,(2012) improved the bearing service life by adjusting the preload. Predicted the speed dependent spindle dynamics at the tool tip.

Hung et al.,(2016) illustrated the effect of interaction on spindle and machine frame on the machining stability using finite element modeling.

2.2 National Status:

In India, a few researches have been conducted, with dynamic stability studies and chatter modeling in high speed machining. The conversion of a radial drilling machine into a vertical milling machine with modifications at the design stage is an innovative idea in fabrication. Single machine tool will be utilized for the multipurpose operations.

In this line several industrial organizations and R & D organization such as Central manufacturing technology institute (CMTI) focusing its efforts mainly on harnessing know-how in the manufacturing technology sector to practical purposes and assisting technological growth in the country.

Several other organizations such as advanced machine tool testing facility (AMTTF) has the role of being a Catalyst and a Key Player in manufacturing technology growth in the country. AMTTF is a dedicated facility equipped with the latest equipment and facilities to test machine tools, accessories, parts and subsystems to establish their performance and reliability against international standards. The facility will help machine tool and related companies to test, trouble shoot and upgrade their products to higher levels of performance.

Similarly Central Institute of Tool Design (CITD) located in Hyderabad, established in 1968 by the Govt. of India with the assistance of UNDP and ILO, is a poineering Institution in the field of Tool Engineering in the Country. The Institute was initially established as a United Nations Development Programme (UNDP) Project and was executed by International LabourOrganisation (ILO). Various R&D projects have been undertaken by the IIT Bombay Machine tool Laboratory under the supervision of Prof. Ramesh singh.. A few projects are

(i)Precision machining of components (2004-2006), A development project to develop machining and inspection process for precision components, Sponsored by Mechvac Fabricators (India) Pvt. Ltd., Mumbai,

(ii) Generation of 3D Microstructures on Metallic Surfaces using Excimer Laser Micromachining, (2008-2009) A Research and Development Project, Sponsored by ISRO, Govt. of India,

IMTMA Technology Centre conducts the training programmes by the Indian Machine Tool Manufacturers' Association is a sincere effort towards the knowledge up gradation and skill development in the country. Since Learning & Development is very crucial for industries to enhance competitiveness in manufacturing, we empower the industry professionals with the latest technological developments through various training sessions, workshops and seminars.

2.3 Importance of the proposed project in the context of current status:

High speed machining using vertical CNC milling centers continues to find widespread applications in a variety of sectors, specifically in aerospace, automobile, mould and die-cavity preparation and other processes. During past, very less works have been focused on fabrication of low-duty machine tools for internal requirements. Due to economic considerations, sometimes a specific machine tool has to be employed for different machining operations. For example, in order to carryout vertical milling operations, a drilling machine may be economically employed with appropriate modifications in design by changing the tools and operating parameters. However, as the original machine tool is designed for one series of operating conditions, in its original form it cannot be used for other high-end machining applications. While machining especially in longitudinal planes, unstable oscillations called chatter phenomenon leading to a significant reduction in metal removal rates. The spindle is one of the important components in machine tools, which dictates the dynamic stability during cutting operation. Its design influences the frequency response at the tool-tip significantly and alters the vibration levels and cutting forces during machining. To enhance the use of the drill spindles effectively for end-milling operation, its geometrical topology is to be modified by adding the additional bearings with the collar system, which improves its dynamic rigidity during milling operation. Further, a portable X-Y table is planned to fabricate as per the existing dimensions of the drilling machine to carry-

out the cutting tests for assessing the stability. Analytical stability lobe diagram is to be constructed for modified optimal spindle and the stability boundaries of these lobes are to be verified by vibration tests and sound spectrum measurements. Further the manual feed of the work table is automated with stepper motors in both the directions which will produce the automatic feed. This type of small scale models will be better alternative for the costly CNC milling machine. These types of in-house machine tool units will be effectively installed in the educational institutions to carry out the basic machining process like drilling, slotting etc. at a lower range of speeds and depths of cuts.

- This project presents an optimum design approach of a multiple spindle-tool system to improvise the dynamic stability of end-milling as well as the drilling stability. Initially, the tool-tip frequency response function is obtained by analyzing the various spindle-tool assemblies with various numerical techniques such as the finite element modeling and advanced mode coupling techniques such as the receptance coupling substructure approach. These numerical techniques and the modular computer programs developed in this work facilitate in adding more number of geometric parameters of the spindle-tool system to have an accurate picture of cutting stability with respect to the spindle dynamics.

- In view of this, a practical spindle unit of an in-house manual drilling machine is considered for the analysis. Finite element models are applied for the spindle-tool unit of a drill spindle and optimal topology of designs were proposed to improve the dynamic stiffness.

- The fundamental frequency responses arrived from the spindle-tool unit was utilized to plot the two and three dimensional stability lobes. Both these plots were further validated by conducting the cutting tests which shows the correctness of boundaries.
- The time-domain simulation studies were carried for three dimensional helical force model at different depths of cut. These simulations were further extended to study the various effects like variable tool pitches, tool-run outs, process damping, high speed effects and nonlinear feed rates. This virtual scenario developed in this work can be implemented for milling process optimization at the design stage when selecting various parameters of a particular cutting tool and their associated process dynamics.

- In order to control the instability and improve the stable depth of cut, two control schemes such as semi-active and active strategies were implemented using the finite element model of the spindle-tool system.

2.4 If the project is location specific, basis for selection of location be highlighted:

Malla Reddy Engineering College (MREC) has set a benchmark in providing its students the very best in terms of infrastructure and faculty. This college meticulously implements quality policy. With absolute discipline, well ventilated classrooms, multimodal teaching methodology and, campus placement training. MREC a unique professional college in the state of Telangana is approved by AICTE and accredited with NAAC 'A' Grade and NBA.

Here the Mechanical Engineering department is having well equipped labs with latest machinery from the reputed suppliers. In addition to regular curriculum labs, department having 4 Special Labs which are more convenient to do the research work by the faculty and students.

3. Work Plan:

3.1 Methodology:

Evaluating the combined effect of a spindle-housing and tool holder on the dynamics of cutting tool by considering the flexibility of spindle unit supported on bearings. The spindle-tool be analyzed by using finite element modeling using Timoshenko beam theory. The dynamic characteristics and tool-tip frequency responses are obtained without considering the cutting forces. The results are compared with receptance coupling approach and using 3D modeling in ANSYS. Further experimental modal analysis on the machining spindle of same dimensions has revealed the same dynamic modes. Using the validated FE model of the system, the effects of nonlinear bearing contact forces, spindle-tool holder interface stiffness, bearing span and axial preload, tool overhang and diameter on the frequency response and cutting process stability are studied. Optimal spindle-tool system is designed for achieving maximum dynamic stiffness.

The analytically stability lobe diagrams are obtained from the real and imaginary terms of these frequency responses at the tool tip. Dynamic stability issues in helical end-milling using the two and three dimensional cutting force models are considered for the analysis. The stability boundaries are experimentally verified using the cutting tests on both drilling spindle and modified drilling tool spindle systems while machining Al-alloy work pieces. Vibration and sound pressure levels are also employed to assure the stability of cutting operations, while surface images are used to identify the chatter marks at various combinations of cutting parameters. Dynamic milling model is employed with the flexible spindle-tool system by considering several effects including variable tool pitch, tool run-out, nonlinear feed forces and process damping. Design and stability studies on the modified drill spindle with a custom-designed work table for milling operations allowed in understanding several interesting facts about spindle-tool systems. Some control strategies

including semi-active and active methods are implemented using finite element model of the spindle-tool system to minimize the chatter vibration levels/maximize the stable depth of cut during cutting operations.

Modeling of the spindle-tool Assembly

Finite element modeling

The finite element modeling is one of the most effective approaches for reasonably provide the relationship between the displacements and forces at a finite number of discrete points (called nodes) of a continuous structure.

By considering the shape functions [N] and [D] according to the following equations. $\begin{Bmatrix} v \\ w \end{Bmatrix} = [N][q_e]$ (3.23)

$$\begin{Bmatrix} \theta_y \\ \theta_z \end{Bmatrix} = [D][q_e]$$

$$\text{Where } [N] = \begin{bmatrix} N_{t1} & 0 & 0 & N_{t2} & N_{t3} & 0 & 0 & N_{t4} \\ 0 & N_{t1} & -N_{t2} & 0 & 0 & N_{t3} & -N_{t4} & 0 \end{bmatrix}$$

$$[D] = \begin{bmatrix} 0 & -N_{\theta 1} & N_{\theta 2} & 0 & 0 & -N_{\theta 3} & N_{\theta 4} & 0 \\ N_{\theta 1} & 0 & 0 & N_{\theta 2} & N_{\theta 3} & 0 & 0 & N_{\theta 4} \end{bmatrix}$$

Where, [N] and [D] are translational and rotational shape function matrices and are given in the appendix-A. By introducing the above equations into the kinetic and potential energy expressions and carrying out the integrations over the element length and applying the Hamilton's principle, the following matrix equations of motion for the beam are generated

$$[M_b] = \int_0^L \rho A[N\ ]^T[N\ ]ds + \int_0^L \rho I\ [D]^T[D\ ]ds$$

$$[G_b] = \int_0^L \rho I_p [D]^T \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} [D] ds$$

$$[K_b] = \int_0^L EI[D']^T[D']ds + \kappa GA \int_0^L \left\{ [N]^T[N] + [D]^T[D] + 2[N]^T \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} [D] \right\} ds$$ The following equations of the beam in matrix forms can be obtained by using the finite element method for the whole spindle-tool system is written as:

$[M_b]\{\ddot{q}\}-\Omega[G_b]\{\dot{q}\}+\left([K_b]+[K_b]_P-\Omega^2[M_b]_C\right)\{q\}=\{F_b\}$ Where $[M_b]$ is the mass matrix, $[M_b]_c$ is the mass matrix used for computing the centrifugal forces, $[G_b]$ is the gyroscopic matrix which is skew-symmetric, $[K_b]$ is the stiffness matrix, $[K_b]_P$ is the stiffness matrix due to the axial force, and $\{F_b\}$ is the force vector, including the distributed and concentrated forces. The sub-script b represents the beam. The details of the matrices are also shown in Appendix-A. The vibration performance of the spindle-tool device can be effectively recognizedusing confined spindle assembly model shown in Figure 3.5.

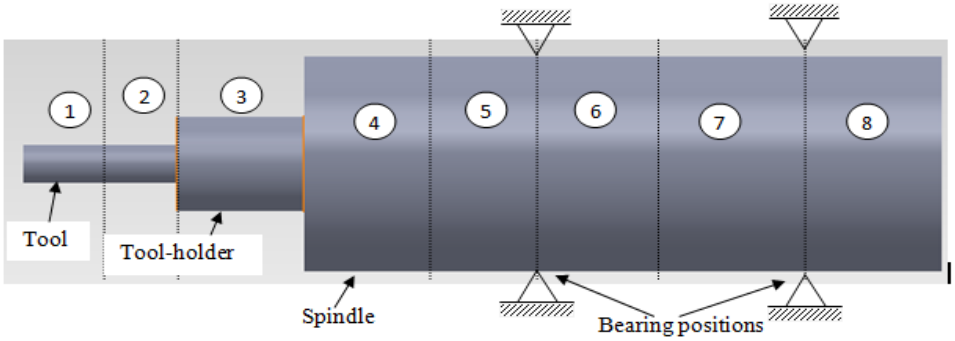

Figure.1 Equivalent model of spindle-tool device

All the segments of the spindle-holder-tool can be discretized with Timoshenko beam elements incorporating shear deformation and rotary inertia effects. In the presentanalysis,eight elements are considered and each node has two translations (x, y) and two rotational (θ_x, θ_y) degrees of freedom. The spindle is supported between two bearings at the front and rear positions.

Receptance coupling Methodology

Finite element models have the potential to provide more precise design model predictions for the spindle -tool receptances. The spindle-housing receptances are acquired by finite element modelling with Timoshenko beam theory.

The free-free component receptances of I (tool) and II (tool-holder) are connected to obtain the sub assemblage I-II, it might be firmly connected towards the spindle-device (component-III) to obtain the final assembled tool end point receptances, T'_{11}. The possible connection is employed by means of equation given below

$$T'_{11}=T_{11}-T_{13a}\left(T_{3a3a}+Y_{3b3b}\right)^{-1}T_{3a1}=\begin{bmatrix}U_{11} & V_{11}\\ W_{11} & Z_{11}\end{bmatrix}$$

where the $T_{ij}$are the individual subassembly matrices. The remaining unknown in the equation is the spindle-device receptance matrix:Y_{3b3b}. The receptances of the spindle-machine (component-III) are difficult to obtain due to operating speed and interference coupling. This receptance matrix can also be obtained

using dynamic modelling of spindle machine. In present case, the four bending component receptances are arrived for the spindle using finite element analysis.

Validation of the spindle-tool Assembly

- In order to further validate the natural frequency results, a three-dimensional finite element analysis of the entire spindle tool unit is carried in ANSYS workbench.
- An experimental modal analysis would be conducted further for the spindle -tool holder system of modified drill spindle system.
- Several parametric studies were conducted for understanding the most influencing spindle-tool parameters on dynamic rigidity of the system.
- Based on the obtained results, a function approximation model was developed with the help of a neural network that works as an estimator for the GA optimization module to optimize the spindle geometry.

Cutting Dynamics

The chip thickness is a function of the cutter vibrations, flute-to-flute run out, and the surface undulations left by the previous tooth.Since the tool and workpiece are not rigid, they vibrate as the flutes of the tool move through the workpiece. The vibration results in the tooth leaving a wavy surface behind the workpiece. The variations in the instantaneous chip thickness result from the phasing between the surface left by the previous tooth and the current tooth. The magnitude and phase of the vibration are governed by the tool and workpiece dynamics. Because of phasing, the forces can develop unstable cutting phenomenon called chatter. Chatter is characterized by violent oscillations, changes in the time/frequency domain responses etc. Chatter conditions may occur due to be due to regeneration behavior or by mode-coupling phenomena. The stability lobe diagram is famous tool based on frequency-domain response for demarking the stable and unstable states during cutting process. The time domain simulation can also be used to determine stability of a process with the selected cutting conditions.

Figure 4.1 shows a milling cutter model with two degrees of freedom having $N_t$number of teeth with a zero helix angle. The tool is assumed to be compliant relative to the rigid work piece. Both tool geometry and machining specifications are important to assess the cutting process stability. The tool geometry includes the number of teeth, helix angle, tooth-to-tooth angle, cutter diameter and the flute-to-flute run-out. The machining specifications needed are the starting and exit angles (a function of radial immersion), spindle speed, axial depth of cut and feed per tooth.

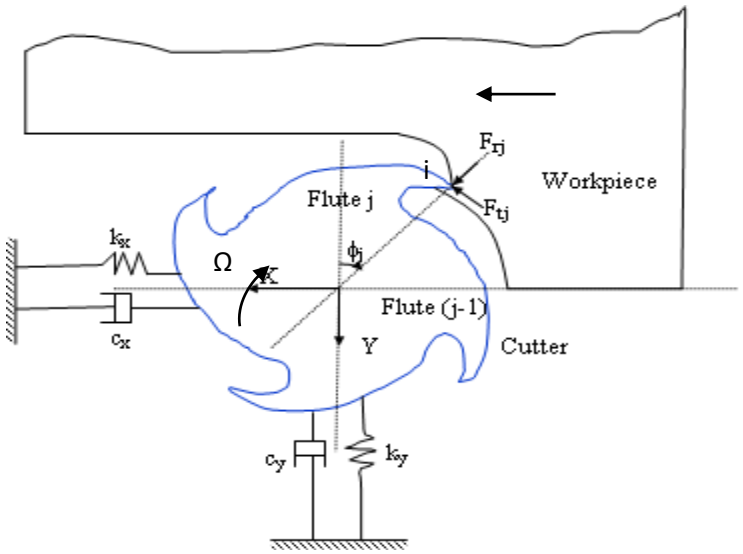

Figure 2. Two-degree of freedom milling model

The cutting forces excite the structure in feed and normal directions, causing dynamic displacements *x* and *y*, respectively. If the spindle rotates at an angular speed of Ω (rad/s), the immersion angle vary with time as $\phi_j(t)=\Omega t$. The resulting chip thickness consists of a static component $f_t \sin\phi_j$, where f_t is feed per revolution, which is due to rigid body motion of the cutter and a dynamic component $(n_{j-1}- n_j)$ caused by the vibrations (displacements) of the tool at the present (n_j) and previous (n_{j-1}) tooth periods. Since the chip thickness is measured in radial direction (n), the instantaneous variable total chip thickness is expressed as [168]:

$$h(\phi_j) = \left(f_t \sin(\phi_j) + (n_{j-1} - n_j)\right) g(\phi_j)$$

where the switching function , $g(\phi_j)$, is equal to one when the j^{th} tooth is engaged in the cut (i.e., between the cut start and exit angles) and zero otherwise and is expressed as:

$$g(\phi_j) = \begin{pmatrix} 1, when \phi_s \le \phi_j \le \phi_e \\ 0, when \phi_j < \phi_s, \phi_j > \phi_e \end{pmatrix}$$

where ϕ_s and ϕ_e are start and exit immersion angles of the cutter to and from the cut, respectively. As static part of the chip thickness ($f_t \sin\phi_j$) has no effect on the dynamic chip load regeneration mechanism, reduces to

$$h(\phi_j) = (\Delta x.\sin(\phi_j) + \Delta y.\cos(\phi_j)) g(\phi_j)$$

The components of linear cutting force in tangential and radial directions ($F_{t,j}$ and $F_{r,j}$) acting on the tooth *j* is proportional to the axial depth of cut (b) and chip thickness $h(\phi_j)$

$$F_{t,j}(\phi) = K_t b h(\phi_j)$$

$$F_{r,j}(\phi) = K_r F_{t,j}(\phi) = K_r K_t b h(\phi_j)$$

The closed-form expressions for cutting forces are computed by including the summation over all the teeth (flutes) to obtain the total forces as:

$$F_x(\phi) = \sum_{j=1}^{N_t} F_{x,j} \; ; F_y(\phi) = \sum_{j=1}^{N_t} F_{y,j}$$

The *X* and *Y* direction force expressions are arranged in matrix form to obtain:

$$\begin{Bmatrix} F_x \\ F_y \end{Bmatrix} = \frac{1}{2} bK_t \begin{bmatrix} a_{xx} & a_{xy} \\ a_{yx} & a_{yy} \end{bmatrix} \begin{Bmatrix} \Delta x \\ \Delta y \end{Bmatrix} = \frac{1}{2} bK_t [A(t)](\Delta(t))$$

where the elements of matrix [A] are the time varying directional dynamic force.

These expressions are periodic with the tooth pitch: $\phi_p = \frac{2\pi}{N_t}$ (rad) and tooth period $\tau = \frac{60}{\Omega N_t}$ (s). In general, the Fourier series expansion of the periodic term is used for the solution of the periodic systems. In stability analysis, the single chatter frequency is usually dominated and the higher harmonics in solution may not be required. Thus, the average term in Fourier series expansion of [*A(t)*] is included to reduce the following form:

$$\{F(t)\} = \tfrac{1}{2} bK_t [A_0]\{\Delta(t)\}$$

where $[A_0]$ consists of four directional orientation factors defined as [168] :

$$\alpha_{xx} = \frac{1}{2}\left[(\cos(2\phi) - 2K_r\phi + K_r \sin(2\phi))\right]_{\phi_s}^{\phi_e}$$

$$\alpha_{xy} = \frac{1}{2}\left[(-\sin(2\phi) - 2\phi + K_r \cos(2\phi))\right]_{\phi_s}^{\phi_e}$$

$$\alpha_{yx} = \frac{1}{2}\left[(-\sin(2\phi) + 2\phi + K_r \cos(2\phi))\right]_{\phi_s}^{\phi_e}$$

$$\alpha_{yy} = \frac{1}{2}\left[(-\cos(2\phi) - 2K_r\phi - K_r \sin(2\phi))\right]_{\phi_s}^{\phi_e}$$

By substituting the response and delay terms, the following expression is obtained.

$$\{F\}e^{i\omega_c t} = \frac{1}{2} bK_t[A_0](1 - e^{-i\omega_c t})[G(i\omega_c)]\{F\}]e^{i\omega_c t}$$

where $\{F\}$ represents the amplitude of dynamic milling force vector {F(t)}and the transfer function matrix is given as:

$$[G(i\omega_c)] = \begin{bmatrix} G_{xx} & G_{xy} \\ G_{yx} & G_{yy} \end{bmatrix}$$

Here, the terms are computed as summation of the cutter and work piece transfer function components. The characteristic equation of the closed loop dynamic milling system is finally expressed as:

$$\det\left([I] - \frac{1}{2} bK_t(1 - e^{-i\omega_c \tau})[A_0][G(i\omega_c)]\right) = 0$$

where the product $[A_0][G(i\omega_c)]$ gives the oriented frequency response function $[G_0]$.

A new variable, Λ is now introduced as

$$\Lambda = \Lambda_{\mathrm{Re}} + i\Lambda_{\mathrm{Im}} = -\frac{N_t}{4\pi} bK_t(1 - e^{-i\omega_c \tau})$$

So that the characteristic equation can be rewritten as

$$\det([I] + \Lambda[FRF_{or}]) = 0$$

The eigenvalue of the above equation can easily be solved for a given chatter frequency ω_c, static cutting factors (K_t , K_r) , radial immersion angles (ϕ_s and ϕ_e) and frequency response function at the tool-tip.

By using,

$$\kappa = \frac{\Lambda_{\text{Im}}}{\Lambda_{\text{Re}}} = \frac{\sin \omega_c \tau}{1 - \cos \omega_c \tau}$$

the expression for the stability limit is obtained as:

$$b_{\text{lim}} = -\frac{2\pi}{N_t K_t} \Lambda_{\text{Re}} (1 + \kappa^2)$$ The

corresponding frequency dependent spindle speeds are determined by first by writing the phase shift in the surface undulations between subsequent tooth passages, $\varepsilon = \pi - 2\psi$ where $\psi = \tan^{-1}(\kappa)$.The tooth passing periods are next expressed as $\tau = \frac{1}{\omega_c}(\varepsilon + j2\pi)$, where j=0, 1, 2…. refers to the integer number of waves between the teeth and incrementing j leads to the individual lobes. Finally the spindle speeds in rpm are obtained from

$$\Omega = \frac{60}{N_t \tau}$$

There are three main graphs employed for stability analysis: (i) the limiting depth-of-cut graph (b_{lim} versus Ω) (ii) the chatter frequency graph ($\omega_c$versus Ω) and (iii) phase shift graph (ε versus Ω). The first plot (called analytical stability lobe diagram) gives the boundary between stable and unstable zones and is often used in most cases.

3.2 Time Schedule of activities giving milestones through BAR diagram.

Activities	**Months**					
	1-6	**7-12**	**13-18**	**19-24**	**25-30**	**31-36**
Literature Survey						
Recruitment of Research Associate						
Analysis of spindle-tool						

Design of experimental setup					
Development of a Simulation algorithm					
Fabrication of portable X-Y table					
Experimental verification of stability					
Control strategies					
Documentation					

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

Budget Estimates: Summary

	Item	BUDGET			(in Rupees)
		1st Year	2nd Year	3rd Year	Total
A.	Recurring				
	1.Salaries/wages	1,46,000	1,46,000	1,46,000	438,000
	2.Consumables	10,000	30,000	30,000	70,000
	3.Travel	30,000	30,000	30,000	90,000
	4. Other costs	--	227,000	115,000	342,000
B.	Equipment		960,000	--	960,000
	Grand Total (A+B)	186,000	1393,000	321,000	1900000

Budget for Salaries/Wages

Designation & number of persons	Monthly Emoluments	BUDGET			(in Rupees)
		1st Year	2nd Year	3rd Year	Total
SRF	11,500	1,38,000	1,38,000	1,38,000	4,14,000
Attendant	4,000	4000	4000	4000	12,000
Total		1,46,000	1,46,000	1,46,000	4,38,000

Justification for the manpower requirement:

One person is required with M. Tech or equivalent degree to conduct the advanced analysis and to carry out the experiments. The position requested is Research Associate with a pay of Rs. 11,500/- per month. Since there is a provision to pay House Rent and Medical allowance, about 40% additional amount is put in the budget.

Budget for Consumable Materials

	BUDGET			(in Rupees)
Item	1st Year	2nd Year	3rd Year	Total
	10,000	30,000	30,000	70,000
Total	10,000	30,000	30,000	70,000

Justification for costly consumable:

Since the experimental work will start from 2nd year, cables, electronic circuitry, etc. may be required besides regular requirement of papers, printer cartridges, floppies, CDs, etc., the budget in the last two years are kept little high.

Budget for Travel

	BUDGET			(in Rupees)
	1st Year	2nd Year	3rd Year	Total
Travel (Only inland travel)	30,000	30,000	30,000	90,000

Justification for intensive travel, if any:

A few trips are envisaged to discuss the problem with the peopleworking in this area, visit places ha finalizing thepurchases with the suppliers, and attending conferences/symposiumfor the disseminat and third years, it ismore because there may be more visits to attendseminars/conferences.

Justification for specific costs under other costs

Sl. No.	Other costs/Contingency costs	BUDGET			(in Rupees)
		1st Year	2nd Year	3rd Year	
1.		--	2,27,000	1,15,000	3,42,000

Contingencies are kept for fabrication charges, buying books (if necessary), etc.

Budget for Equipment

S.No.	Generic name of the Equipment along with make & model	Estimated Costs
1.	Radial drilling machine	3,60,000
2.	Fabrication of milling bed with radial and axial feed	1,50,000
3.	4 channel digital Oscilloscope	1,00,000
4.	Signal generator	60,000
5.	Vibration shaker	70,000
6.	Power amplifier	60,000
7.	Accelerometer with charge amplifier	40,000
8.	Microphone sensors with accessories	40,000
9.	Digital milling force dynamometer	80,000

Justification for the proposed equipment:

Radial drilling machine is required to carry out the necessary cutting operations. A milling bed is required for provide the necessary x-y movement. Bearing collar systems is required to improve the rigidity. Accelerometer and microphone sensors are required to estimate the detection of chatter regions. Dynamometer is required to estimate the cutting forces.

3.4 Environmental impact assessment and risk analysis:**NIL**

4. Expertise:

4.1 Expertise available with the investigators in executing the project:

Dr. Ramesh Singh key interest areas is finite element modeling of different manufacturing processes, such as machining, flow forming, ring rolling and electromagnetic forming. Another active field in modeling is multistate modeling of damage evolution in composites. His important research contributions include the micro scale manufacturing which poses unique challenges with respect to both machine tool design and development and the process dynamics. Scaling down the macro processes, such as milling and drilling is extremely difficult due to the orders of magnitude lower stiffness of the tool. This low stiffness could result in catastrophic failure of the micro-tool, especially, during cutting of high strength materials, such as hard steels and Ti/Ni alloys. To address these issues, two approaches can be used: firstly, high speed micro milling (spindle speeds > 100,000 rpm) can be used to reduce the chip load and cutting forces to prevent the tool failure, secondly, localized thermal softening can be induced via laser.

Dr. Ram NareshRai has long been associated with the research in the area of machine tool dynamics, metal matrix composites rolling and Forging etc. He has significant contribution in carrying out several research projects on metal matrix composites. His research work is focused on design and development of composites for dynamic applications. His important research contributions include machinability of different Aluminum alloys of composite materials. His current interests are in vibration control and he has guided a number of research works in which useful algorithms are designed and developed to optimize the process parameters.

4.2 Summary of roles/responsibilities for all Investigators:

S.No	Name of the Investigator	Roles/ Responsibilities
1.	Dr. Shaik Jakeer Hussain	1. Developing a general theory for loading the rolling elements under high-speed operation. 2. Evaluating the combined effect of a spindle-housing and tool holder on the dynamics of cutting tool by considering the flexibility of spindle unit supported on bearings. The spindle-tool is analyzed by using finite element modeling using Timoshenko beam theory. 3. In this work, unlike use of the

		experimental data of the spindle unit, a FE model of spindle alone is employed to obtain spindle-tip receptances. While the tool and holder receptances are computed analytically in an independent way. These spindle-device receptances are then systematically combined to the beam designs of tool and tool-holder to visualize the tool end point receptances for grouping of tool-holders and tools. The tool and the tool-holder are described using Bishop and Johnson theory with free-free boundary conditions, while the receptances of the spindle-machine are difficult to model based on first principles, primarily due to the difficulty in estimating damping at interfaces and the actual supporting conditions 4. Using the validated FE model of the system, the effects of nonlinear bearing contact forces, spindle-tool holder interface stiffness, bearing span and axial preload, tool overhang and diameter on the frequency response and cutting process stability are studied. Optimal spindle-tool system is designed for achieving maximum dynamic stiffness.
2.	Dr. Akunuru Raveendra	1. Developing the analytically stability lobe diagrams from the real and imaginary terms of these frequency responses at the tool tip. 2. Dynamic stability issues in helical end-milling using the two and three dimensional cutting force models will be improved for the analysis. 3. Experimental tests are conducted to verify the stability boundaries using the cutting tests on

		conventional radialdrilling machine with modified drilling tool spindle systems while machining Al-alloy work pieces. 4. Vibration and sound pressure levels will be employed to assure the stability of cutting operations, while surface images are used to identify the chatter marks at various combinations of cutting parameters. 5. Dynamic milling model is employed with the flexible spindle-tool system by considering several effects including variable tool pitch, tool run-out, nonlinear feed forces and process damping. Design and stability studies on the modified drill spindle with a custom-designed work table for milling operations allowed in understanding several interesting facts about spindle-tool systems. 6. Some control strategies including semi-active and active methods are implemented using finite element model of the spindle-tool system to minimize the chatter vibration levels/maximize the stable depth of cut during cutting operations.

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

1. **Jakeer Hussain Shaik**, Srinivas J. (2017) Optimal selection of operating parameters in end milling of Al-6061 work materials using multi-objective approach, Mechanics of Advanced Materials and Modern Processes. DOI 10.1186/s40759-017-0020-6.
2. **Jakeer Hussain Shaik**, Srinivas J. (2017) Analytical prediction of chatter stability of end milling process using three dimensional cutting force model, Journal of the Brazilian Society of Mechanical Sciences and Engineering**,** DOI 10.1007/s40430-016-0567-x.
3. **Jakeer Hussain S**, Srinivas J (2015) A modelling approach for the design and study of stability issues in end milling with variable tool parameters. Manufacturing technology today, ISSN: 0972-7396.

4. **Jakeer Hussain Shaik**, Srinivas J. (2015) Dynamic modelling and machining stability in a new mill-spindle design for drilling machine, ELK Asia Pacific Journals – Special Issue, ISBN: 978-81-930411-4-7.

5. **Jakeer Hussain S**, Srinivas J (2014) Influence of Secondary Factors of Spindle Geometry on the Dynamic Stability in End-milling Operation, Journal of Mechanical Design and Vibration vol. 2: 35-46.

6. **Jakeer Hussain Shaik**, Srinivas J. (2014) Dynamic stability of a motorized high speed machine tool spindle supported on bearings, Applied Mechanics and Materials, vol. 612 : 29-34.

7. PMG BasheerAsdaque, RK Behera, **Jakeer Hussain Shaik** (2014) Vibration analysis of multi-disk multi-profiled shaft rotor systems, Applied Mechanics and Materials, vol. 612 : 17-22.

8. **Jakeer Hussain Shaik**, Srinivas J. (2013) Identification of dynamic rigidity for high speed spindles supported on ball bearings, International Journal of Research in Engineering and Technology(IJRET), ISSN: 2319 -1163: 146-150.

9. **Jakeer Hussain Shaik**, Srinivas J. (2017) Optimal design of high speed precise machine tool spindles for improving the dynamic stability in end-milling process, The Arabian Journal for Science and Engineering (Under review)

10. **Jakeer Hussain Shaik**, Ramakotaiah K. (2017) Investigation of chatter prediction in end milling using morphological studies on Aluminium alloy (Al6061), International journal of materials and Product technology (Under review)

11. **Jakeer Hussain Shaik**, Srinivas J. (2016) Effects of spindle geometry and cutting force model on the stability in helical end milling operation, Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture (Under review)

12. **Jakeer Hussain Shaik**, Srinivas J. (2016) Semi-analytical prediction approach of frequency response in high speed machine tool spindle units, Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical sciences (Under review)

13. Study of bifurcation behavior in oblique turning operation, K.Rama Kotaiah,J. Srinivas, Int.Journal of Machine Tools and Manufacture,Vol.49 (12-13) , 2012,1042-1047

14. Prediction of optimal stability states in inward-turning operation using neuro genetic algorithms, K.Rama Kotaiah, J.Srinivas and M. Sekar,Int.Journal of Adv.Mfg.Tech.,Vol.45(7&8),2013,679-689.

15. Dynamic analysis of a turning tool with a discrete model of the workpiece, K.Rama Kotaiah,J. Srinivas,Journal of Engineering Manufacture, Proc. Imech E – Part B, Vol.224, No: B2, 2014,207-216

16. Stability analysis of turning process with tailstock-supported workpiece, K.Rama Kotaiah, M. Sekar, J. Srinivas and S. H. Yang, Int.Journal of Adv. Mfg.Tech., Vol.45(9), 2016, 231-342

17. Force-feed effects on stability in turning ,K.Rama Kotaiah,J. Srinivas and K.J.Babu, Strojnicky casopis, Journal of Mechanical Engineering,Vol.60 (3), 2015,58-67.
18. The Impact of cutting conditions on cutting forces and vibrations for EN8 and EN24 steels, K.Rama Kotaiah, J. Srinivas and K.J.Babu, International journal of systems and Technologies,Vol.1(2), 2017, 27-38.

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5. List of Projects submitted/implemented by the Investigators:NIL

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

6.1 Infrastructural Facilities:

S.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	Yes
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 Required
12.	Any other special facility being provided	Not applicable

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

7.

Equipment available with	**Generic Name of Equipment**	**Model, Make & year of purchase**	**Remarks including accessories available and current usage of equipment**
PI & his group	1HP Motors and machine tool accessories	2015	20%
PI's Department	Horizontal milling machine	0A Model, 2014	30%
	Surface Grinder	500×200 size, 2015	30%
	Lathe machines	4-1/2 inches, 2015	40%
Other Inst In the region	Not Required	Not Required	Not applicable

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

Bio-data of the Co-Investigator

Name: Dr. Jakeer Hussain Shaik

Address:

D no: 15-6-202, TammaRanga Reddy Nagar, 4th lane,
Old Guntur, Guntur District, Andhra Pradesh, PIN: 522 001
Office no: 08645326371, 08645326372
Mob No: 8596957456,
Email: jakeershaik786@yahoo.co.in

Educational Qualifications:

S.No.	Degree	University/Board	Year of passing	Subject	Percentage/ CGPA
1.	B.E.	(Andhra University)	2007	Mechanical Engineering	70.28
2.	Gate	IIT KANPUR & IIT KHRAGPUR	2007 & 2006	Mechanical	89.5 & 86
3.	M.Tech	JNTU Kakinada	2010	Machine Design	9.2/10 CGPA
4.	Ph. D	National Institute of Technology, Rourkela	2016	Machine Design and Analysis	Credits CGPA 9.29/10

ACADEMIC PROJECT DETAILS

- **Ph.D:** Studies on design of spindle-tool system and their effects on overall milling process stability
- **M.Tech:** Analysis of adhesively bonded double lap joints in FRP Laminated composites

EXPERIENCE: Total Nine years eight months teaching experience (till April, 2017)

- Five years teaching experience in K. L UNIVERSITY (Employ id: 1517)
- Four years Research and teaching experience during Ph.D. (NIT ROURKELA)
- One year teaching experience in KKR&KSR institute of technology (Continued…)

List of Publications

1. Jakeer Hussain Shaik, Srinivas J. (2017) Optimal selection of operating parameters in end milling of Al-6061 work materials using multi-objective approach, Mechanics of Advanced Materials and Modern Processes. DOI 10.1186/s40759-017-0020-6.

2. Jakeer Hussain Shaik, Srinivas J. (2016) Analytical prediction of chatter stability of end milling process using three dimensional cutting force model, Journal of the Brazilian Society of Mechanical Sciences and Engineering**,** DOI 10.1007/s40430-016-0567-x.

3. Jakeer Hussain Shaik, CH Sai Krishna, Siva Bhaskara Rao (2016) Stress distribution of adhesively bonded double lap joints in FRP laminated composites using FEM. International Journal of Applied Research 2016; 2(7): 86-90

4. Jakeer Hussain S, Srinivas J (2015) A modelling approach for the design and study of stability issues in end milling with variable tool parameters. Manufacturing technology today, ISSN: 0972-7396.

5. Jakeer Hussain Shaik, Srinivas J. (2015) Dynamic modelling and machining stability in a new mill-spindle design for drilling machine, ELK Asia Pacific Journals – Special Issue, ISBN: 978-81-930411-4-7.

6. Jakeer Hussain S, Srinivas J (2014) Influence of Secondary Factors of Spindle Geometry on the Dynamic Stability in End-milling Operation, Journal of Mechanical Design and Vibration vol. 2: 35-46.

7. Jakeer Hussain Shaik, Srinivas J. (2014) Dynamic stability of a motorized high speed machine tool spindle supported on bearings, Applied Mechanics and Materials, vol. 612 : 29-34.

8. PMG BasheerAsdaque, RK Behera, **Jakeer Hussain Shaik** (2014) Vibration analysis of multi-disk multi-profiled shaft rotor systems, Applied Mechanics and Materials, vol. 612 : 17-22.

9. Jakeer Hussain Shaik, Srinivas J. (2013) Identification of dynamic rigidity for high speed spindles supported on ball bearings, International Journal of Research in Engineering and Technology(IJRET), ISSN: 2319 -1163: 146-150.

10. Jakeer Hussain Shaik , SreenivasuluBezawada , GangadharuduTalla and Pavan Kishore ML (2013) Effect Of Variation Of Width On Static Analysis Of Adhesively Bonded Double Lap Joints In FRP Laminated Composites, International Journal of Engineering Research & Technology, ISSN: 2278-0181.

11. Jakeer hussainshaik, M.L Pavankishore, Gangadharudutalla (2013) Effect of adherend thickness on static analysis of adhesively bonded double lap joints in FRP laminated composites, International journal of pure and applied research in engineering and technology, Volume 2 (6): 1-16.

12. Jakeer hussainshaik, M.L Pavankishore, Gangadharudutalla (2013) effect of adhesive thickness on static analysis of adhesively bonded double lap joints in FRP laminated composites,

International journal of pure and applied research in engineering and technology, Volume 2 (6): 17-32.

13. Jakeer Hussain Shaik, Srinivas J. (2017) Optimal design of high speed precise machine tool spindles for improving the dynamic stability in end-milling process, The Arabian Journal for Science and Engineering (Under review)

14. Jakeer Hussain Shaik, Ramakotaiah K. (2017) Investigation of chatter prediction in end milling using morphological studies on Aluminium alloy (Al6061), International journal of materials and Product technology (Under review)

15. Jakeer Hussain Shaik, Srinivas J. (2016) Effects of spindle geometry and cutting force model on the stability in helical end milling operation, Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture (Under review)

16. Jakeer Hussain Shaik, Srinivas J. (2016) Semi-analytical prediction approach of frequency response in high speed machine tool spindle units, Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical sciences (Under review)

List of Conferences

1. Jakeer Hussain Shaik, Srinivas J. (2016) Analysis and Optimal modeling of end-mill spindles for improvising dynamic stiffness using Neuro-genetic approach, 4th National symposium on rotor dynamics, NIT ROURKELA.

2. Jakeer Hussain Shaik, Ramakotiah K. (2015) Static analysis of adhesively bonded double lap joints in FRP laminated composites using FEM. National seminar on polymer nano-composites for engineering applications, NIT Rourkela (NSPNEA-2015).

3. Jakeer Hussain Shaik, Srinivas J. (2015) Morphological studies to predict the chatter vibrations in end milling of Aluminum (Al6061). NCPCM-2015, NIT ROURKELA.

4. Jakeer Hussain Shaik, Srinivas J. (2015) Design and analysis vibration analysis of milling tool spindle from experimental data: An inverse approach. 12th International conference on vibration problems (ICOVP-15), IIT GUWAHATI.

5. Jakeer Hussain Shaik, Srinivas J. (2014) Dynamic stability of a motorized high speed machine tool spindle supported on bearings, International Conference on Design, Manufacturing and Mechatronics (ISET-2014), KJ Institute of technology, PUNE.

6. Jakeer Hussain Shaik, Srinivas J. (2014) Investigation of the cutting edge radius size effect on dynamic forces in micro end milling, IDMC-2014, NIT Rourkela.

7. Jakeer Hussain Shaik, Ramakotaiah K. (2014) Static analysis of adhesively bonded double lap joints inFRP laminated composites using FEM. National seminar on Polymer Nanocomposites for Engineering Applications, 14th Mar 2015, NIT ROURKELA.

8. **Jakeer Hussain Shaik**, Srinivas J. (2013) Analysis and Dynamic Stability of Integrated Micro End Mill Spindles, International Conference on Computer Aided Engineering (CAE-2013), Department of Mechanical Engineering, IIT Madras.

Institution wise Budget Breakup :

Budget Head	Malla Reddy Engineering College	Total
Manpower	4,14,000	**4,14,000**
Consumables	70,000	**70,000**
Travel	90,000	**90,000**
Equipment	9,60,000	**9,60,000**
Contingencies	3,42,000	**3,42,000**
Other cost	24,000	**24,000**
Total	**19,00,000**	**19,00,000**

Institute Name : *Malla Reddy Engineering College*

Year Wise Budget Summary (Amount in INR) :

Budget Head	Year-1	Year-2	Year-3	Total
Manpower	1,38,000	1,38,000	1,38,000	**4,14,000**
Consumables	10,000	30,000	30,000	**70,000**
Travel	30,000	30,000	30,000	**90,000**
Equipments	9,60,000	0	0	**9,60,000**
Contingencies	0	2,27,000	1,15,000	**3,42,000**
Other cost	8,000	8,000	8,000	**24,000**
Grand Total	**11,46,000**	**4,33,000**	**3,21,000**	**19,00,000**

Manpower Budget Detail(Amount in INR) :

Designation	Year-1	Year-2	Year-3	Total
Junior Research Fellow *One person is required with M. Tech or equivalent degree to conduct the advanced analysis and to carry out the experiments. The position requested is Research Associate with a pay of Rs. 11,500/- per month.*	1,38,000	1,38,000	1,38,000	**4,14,000**

Consumable Budget Detail (Amount in INR) :

Justification	Year-1	Year-2	Year-3	Total
Since the experimental work will start from 2nd year, cables, electronic circuitry, etc. may be required besides regular requirement of papers, printer cartridges, floppies, CDs, etc., the budget in the last two years are kept little high.	10,000	30,000	30,000	**70,000**

Travel Budget Detail (Amount in INR) :

Justification (Inland Travel)	Year-1	Year-2	Year-3	Total
A few trips are envisaged to discuss the problem with the peopleworking in this area, visit places having similar finalizing thepurchases with the suppliers, and attending conferences/symposiumfor the dissemination of the res and third years, it ismore because there may be more visits to attendseminars/conferences.	30,000	30,000	30,000	**90,000**

Equipment Budget Detail (Amount in INR) :

Generic Name ,Model No. , (Make)/ Justification	Quantity	Spare time	Estimated Cost
Z3040 x 13 TAB RADIAL (MTAB) *Radial drilling machine is required to carry out the necessary cutting operations. A milling bed is required for provide the necessary x-y movement. Bearing collar systems is required to improve the rigidity. Accelerometer and microphone sensors are required to estimate the detection of chatter regions. Dynamometer is required to estimate the cutting forces.*	1	40 %	**9,60,000**

Contingency Budget Detail (Amount in INR) :

Justification	Year-1	Year-2	Year-3	Total
Contingencies are kept for fabrication charges, buying books (if necessary), etc.	0	2,27,000	1,15,000	**3,42,000**

Other Budget Detail (Amount in INR) :

Description/Justification	Year-1	Year-2	Year-3	Total
OTHER COSTS wages to attenders and supporting staff During the implementation of the project wages has to pay to the non technical staff	8,000	8,000	8,000	**24,000**

Curriculum-Vitae

Jakeer Hussain Shaik, **M. Tech, Ph. D**
Visiting Assistant Research Fellow,
Dept. of Mechanical Engineering,
National Cheng Kung University,
TAIWAN.
E-mail/Skype ID: jakeershaik786@gmail.com
Mobile / WhatsApp No**:+ 91-8596957456**

QUALIFICATION

Course	Institute/University	Specialization/ Stream	Grade/ Percentage	Year of passing
Visiting Assistant Research Fellow	National Cheng Kung University, Taiwan.	Machining Dynamics	----	-----
Ph. D	National Institute of Technology, Rourkela (N.I.T Rourkela)	Machine Design and Analysis	Credits CGPA 9.36/10	2017(January)
M.Tech	JNTU Kakinada	Machine Design	9.2/10 CGPA	2010
Gate	IIT KANPUR&IIT KHRAGPUR	Mechanical	89.5 & 86	2007&2006
B.E.	S.R.K.R. College of Engineering, Bhimavaram, (Andhra University)	Mechanical Engineering	70.28	2007

ACADEMIC PROJECT DETAILS

- Currently working under Higher Education Sprout Project by the Ministry of Education (MOE) in Taiwan to the Headquarters of University Advancement at National Cheng Kung University (NCKU). The financial and equipment support provided to this study by Winstar Cutting Technology and Ministry of Science and Technology of Taiwan (Grant no: MOST 108-2622-E -006-022-CC3)
- A proposal was sent to SERB under the scheme Extramural research Funding titled "Dynamic modeling and stability studies on a retrofitted drill-spindle using a sensor-based system"
- **Ph.D.:** Studies on design of spindle-tool system and their effects on overall milling process stability
- **M.Tech:** Analysis of adhesively bonded double lap joints in FRP Laminated composites

EXPERIENCE

- **Visiting Assistant Research Fellow experience in National Cheng Kung University, TAIWAN (Continued…)**
- **Four years** of teaching experience in **KKR &KSR institute of technology and sciences**
- **Nine months** of teaching experience in **Chalapathi Institute of Technology, Guntur**.
- **Four years** of Full-time research and teaching assistantce during Ph.D. **(NIT ROURKELA)**
- **Five years** of teaching experience in **K. L UNIVERSITY (Employ id:1517)**

REVIEWER/ADVISORY BOARD MEMBER

- Journal of the Brazilian Society of Mechanical Sciences and Engineering
- Journal of mechanical design and vibration
- International journal of pure and applied research in engineering and technology
- Journal of Materials Procedia

MEMBERSHIPS IN PROFESSIONAL BODIES/SOCIETIES/ORGANISATIONS

- International Association of Engineers
- International Society for research and development
- Institute of Research Engineers and Doctors
- Institute for Engineering Research and Publication

AWARENESS ABOUT TEACHING METHODOLOGIES

- Coordinator for course outcomes and program outcomes for Outcome-Based Education.
- Department Coordinator for the Research & consultancy and Development cell.
- Preparation of Course Handouts, Lesson Plans, Lab Manuals, Result Analysis, Board of Studies (Bos) meeting procedures, file maintenances at department and central level

Programs conducted in the department

- Acts as the Convenor for the A Two-day National Conference on "Current Trends in Advanced Manufacturing and Energy Systems (CTAMES-2019)"
- Acts as the Convenor for a Two-day national level workshop on "Frontiers of Additive Manufacturing" and "Recent trends in Advances in Mechanical Engineering"
- Department level Coordinator for organizing the Guest Lectures, Final year projects, professional societies for the student and faculty memberships.

SUBJECTS TAUGHT

- Finite Element modeling
- Non- Destructive Testing

- Manufacturing Technology (I & II)
- Design of machine elements (I & II)
- Engineering Vibrations
- Robotics
- Theory of metal cutting
- Kinematics of machines
- Thermal Engineering

LABS HANDLED

- Computational Fluid Dynamics Lab.
- Manufacturing Technology Lab
- Machine tools Laboratory
- Modelling and Simulation Lab

List of Publications and Conferences

PUBLICATIONS

Journals:-

1. **Jakeer Hussain Shaik**, Srinivas J. (**2020**) Optimal design of spindle-tool system for improving the dynamic stability in end-milling process, Sadhana - Academy Proceedings in Engineering Sciences, 45:55. https://doi.org/10.1007/s12046-020-1286-7 **(SCI).**
2. **Jakeer Hussain Shaik**, Srinivas J. (**2020**) Dynamic modelling and stability studies on an in-house design mill-spindle, Transaction of Iranian society of Mechanical Science and Technology, https:// DOI: 10.1007/s40997-020-00355-8**(SCI).**
3. Srinivas Rao T, **Jakeer Hussain Shaik** P. Dhanraj **(2019)** Experimental assessment of various fuel additives on the performance and emission characteristics of the spark ignition engine, International Journal of Ambient Energy- Taylor & Francis, https://doi.org/10.1080/01430750.2019.1694987 **(SCI).**
4. **Jakeer Hussain Shaik**, Srinivas J. (2016) Analytical prediction of chatter stability of end milling process using three-dimensional cutting force model, Journal of the Brazilian Society of Mechanical Sciences and Engineering**,** DOI 10.1007/s40430-016-0567-x **(SCI).**
5. **Jakeer Hussain Shaik**, Rama kotaiah K, Srinivas J (2017) Frequency response studies using receptance coupling approach in high speed spindles, Journal of The Institution of Engineers (India): Series C, https://doi.org/10.1007/s40032-017-0438-y. **(SCOPUS)**
6. Mansoor Ahmed, S.M Jameel Basha, B. Durga Prasad, **Jakeer Hussain Shaik (2019)** Performance Research On Water Cooler With Silicon Nitride/Polyolester Nanolubricant, International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249 – 8958, Vol.8(6).**(SCOPUS)**

7. **Jakeer Hussain Shaik**, Srinivas J. (2014) Dynamic stability of a motorized high speed machine tool spindle supported on bearings, Applied Mechanics and Materials, vol. 612: 29-34. **(SCOPUS)**
8. PMG Basheer Asdaque, RK Behera, **Jakeer Hussain Shaik** (2014) Vibration analysis of multi-disk multi-profiled shaft rotor systems, Applied Mechanics and Materials, vol. 612: 17-22. **(SCOPUS)**
9. **Jakeer Hussain Shaik**, Srinivas J. (2017) Optimal selection of operating parameters in end milling of Al-6061 work materials using multi-objective approach, Mechanics of Advanced Materials and Modern Processes. DOI 10.1186/s40759-017-0020-6. **(SPRINGER)**
10. **Jakeer Hussain Shaik,** Jiunn-Jyh Wang, Optimal Insert Edge Geometry for Minimum Specific Cutting Energy in Face Milling, Journal of the Chinese Society of Mechanical Engineers **(Under review)**
11. **Jakeer Hussain Shaik** et al. (**2020**) Identification of practical spindle-tool interface parameters using an Optimization based statistical approach, Sadhana - Academy Proceedings in Engineering Sciences, **(Major revisions completed- Decision in Pending).**
12. **Jakeer Hussain Shaik**, Mansoor Ahmed (**2019**). Optimized based performance enhancement of vapour compression refrigeration system with Nano lubricant, Journal of Institute of Engineers, Springer, (**Under Editor Decision, Major reviews completed)**
13. **Jakeer Hussain Shaik**, Srinivas J. (**2020**) Investigation of chatter prediction in end milling using morphological studies on Aluminum alloy (Al6061), S/N Applied Sciences, **(Under review)**
14. **Jakeer Hussain Shaik**, Srinivas J. (**2019**) Optimal design of high-speed precise machine tool spindles for improving the dynamic stability in end-milling process, The Arabian Journal for Science and Engineering **(Under review)**
15. N. Ramesh, **Jakeer Hussain Shaik** , Ramakotaiah K **(2019)** Design and analysis of composite drive shaft by using finite element method, Journal of Fluid Mechanics and Mechanical Design, Vol.1, pp. 18-33**.**
16. **Jakeer Hussain Shaik (2019)** Design and Fabrication Of Rocker Bogie Rover, Journal of Emerging Technologies and Innovative Research, Vol. 6(5), pp:185-190.
17. **Jakeer Hussain Shaik (2019)** Design and Fabrication Enemy Detection Robot, Journal of Emerging Technologies and Innovative Research, Vol. 6(5), pp:133-139.
18. **Jakeer Hussain Shaik**, Rama kotaiah K **(2018)** Design of Milling Tool Spindle, , Bangladesh J. Sci. Ind. Res. Vol.**53(3)**, pp:191-198.
19. **Jakeer Hussain Shaik**, Rama kotaiah K Mansoor Ahmed S **(2018)** Dynamic modeling and cutting stability of high speed end milling with regenerative effect, Journal of Advancement in Machines, Vol.3, Issue 2. pp 1-7.

20. **Jakeer Hussain Shaik**, Rama kotaiah K Mansoor Ahmed S (2018) Optimal modeling of spindle-tool system with design variables using Taguchi based approach, Journal of Recent Trends in Mechanics, Vol.3, Issue 2. pp 1-7.
21. Rama kotaiah K, **Jakeer Hussain Shaik** (2017) Investigation of dynamic response on the system stability for an integrated spindle unit, Journal of Advancement in Machines Volume 2 Issue 3.
22. **Jakeer Hussain Shaik**, Rama kotaiah K (2017) Influence of spindle design parameters on the dynamic stability in end-milling operation, Journal of Recent Activities in Production, Volume 2 Issue 2.
23. **Jakeer Hussain S**, Srinivas J (2015) A modelling approach for the design and study of stability issues in end milling with variable tool parameters. Manufacturing technology today, ISSN: 0972-7396.
24. **Jakeer Hussain Shaik**, Srinivas J. (2013) Identification of dynamic rigidity for high speed spindles supported on ball bearings, International Journal of Research in Engineering and Technology(IJRET), ISSN: 2319 -1163: 146-150.
25. **Jakeer Hussain S**, Srinivas J (2014) Influence of Secondary Factors of Spindle Geometry on the Dynamic Stability in End-milling Operation, Journal of Mechanical Design and Vibration vol. 2: 35-46.
26. **Jakeer Hussain Shaik** , Sreenivasulu Bezawada , Gangadharudu Talla and Pavan Kishore ML (2013) Effect Of Variation Of Width On Static Analysis Of Adhesively Bonded Double Lap Joints In FRP Laminated Composites, International Journal of Engineering Research & Technology, ISSN: 2278-0181.
27. **Jakeer hussain shaik**, M.L Pavan kishore, Gangadharudu talla (2013) Effect of adherend thickness on static analysis of adhesively bonded double lap joints in frp laminated composites, International journal of pure and applied research in engineering and technology, Volume 2 (6): 1-16.
28. **Jakeer hussain shaik**, M.L Pavan kishore, Gangadharudu talla (2013) effect of adhesive thickness on static analysis of adhesively bonded double lap joints in frp laminated composites, International journal of pure and applied research in engineering and technology, Volume 2 (6): 17-32.
29. **Jakeer Hussain Shaik**, Srinivas J. (2015) Dynamic modelling and machining stability in a new mill-spindle design for drilling machine, ELK Asia Pacific Journals – Special Issue, ISBN: 978-81-930411-4-7.
30. **Jakeer Hussain Shaik**, CH Sai Krishna, Siva Bhaskara Rao (2016) Stress distribution of adhesively bonded double lap joints in FRP laminated composites using FEM. International Journal of Applied Research 2016; 2(7): 86-90

Conferences:-

1. **Jakeer Hussain Shaik,** Shaik Khadar Basha. (2019) Design and Fabrication of Enemy detection robot, National conference on Current trends in Advanced manufacturing and Energy systems, KITS Guntur.
2. **Jakeer Hussain Shaik,** Rohit Eswar. (2019) Design and Fabrication of Rocker Bogie Rover Mechanism, National conference on Current trends in Advanced manufacturing and Energy systems, KITS Guntur.
3. **Jakeer Hussain Shaik,** Rama Kotaiah K, Mansoor Ahmed MD. (2017) Investigation of Spindle bearing system and its dynamic stability in an end mill, National conference on Recent advances in Mechanical Engineering, PVPSIT.
4. **Jakeer Hussain Shaik,** Rama Kotaiah K, Mansoor Ahmed MD. (2017) Investigation of Spindle bearing system and its dynamic stability in an end mill, National conference on Recent advances in Mechanical Engineering, PVPSIT.
5. **Jakeer Hussain Shaik**, Rama Kotaiah K, Johny Shaik. (2017) Optimal design of high speed end mill spindles with Taguchi based approach, National conference on Recent advances in Mechanical Engineering, PVPSIT.
6. **Jakeer Hussain Shaik**, Srinivas J. (2012) Dynamic behaviour of high speed spindles, International National Conference on Recent Advances in Material Processing Technology, National Engineering College, Kovilpatti.
7. **Jakeer Hussain Shaik**, Srinivas J. (2013) Analysis and Dynamic Stability of Integrated Micro End Mill Spindles , International Conference on Computer Aided Engineering (CAE-2013) ,Department of Mechanical Engineering, IIT Madras.
8. **Jakeer Hussain Shaik**, Srinivas J. (2014) Dynamic stability of a motorized high speed machine tool spindle supported on bearings, International Conference on Design, Manufacturing and Mechatronics (ISET-2014), KJ Institute of technology, PUNE.
9. **Jakeer Hussain Shaik**, Srinivas J. (2014) Investigation of the cutting edge radius size effect on dynamic forces in micro end milling, IDMC-2014, NIT Rourkela.
10. **Jakeer Hussain Shaik**, Ramakotaiah K. (2014)Static analysis of adhesively bonded double lap joints inFRP laminated composites using FEM. National seminar on Polymer Nanocomposites for Engineering Applications, 14th Mar 2015, NIT ROURKELA.
11. **Jakeer Hussain Shaik**, Srinivas J. (2015) Morphological studies to predict the chatter vibrations in end milling of Aluminum (Al6061). NCPCM-2015, NIT ROURKELA.
12. **Jakeer Hussain Shaik**, Ramakotiah K. (2015) Static analysis of adhesively bonded double lap joints in FRP laminated composites using FEM. National seminar on polymer nano-composites for engineering applications. (NSPNEA-2015).

13. **Jakeer Hussain Shaik**, Srinivas J. (2015) Design and analysis vibration analysis of milling tool spindle from experimental data: An inverse approach. 12th International conference on vibration problems (ICOVP-15), IIT GUWAHATI.
14. **Jakeer Hussain Shaik**, Srinivas J. (2016) Analysis and Optimal modeling of end-mill spindles for improvising dynamic stiffness using neuro-genetic approach, National symposium on rotor dynamics-2016, NIT ROURKELA.
15. **Jakeer Hussain Shaik,** Rama Kotaiah K, Mansoor Ahmed MD. (2017) Investigation of Spindle bearing system and its dynamic stability in an end mill, National conference on Recent advances in Mechanical Engineering, PVPSIT.
16. **Jakeer Hussain Shaik**, Rama Kotaiah K, Johny Shaik. (2017) Optimal design of high speed end mill spindles with Taguchi based approach, National conference on Recent advances in Mechanical Engineering, PVPSIT.

Workshops & FDPS

1. One week faculty development program on Autodesk AutoCAD in Mechanical Engineering by ICT ACADEMY, from 10th -14th June, 2019.
2. One week faculty development program on Applications of CFD and MATLAB in Mechanical Engineering by ARTEM ACADEMY, from 14th -20th November 2018.
3. A Three-day faculty development program on Recent Innovations in Mechanical Engineering, KITS GUNTUR, MAY, 2017.
4. A self-financed short term course on Applications of artificial techniques in engineering systems (AAITES-2013) at Motilal Nehru National Institute of Technology, Allahabad.
5. Principles and Computational techniques in Multi-body Dynamics (PCTMD-2013) at the National Institute of Technology Rourkela.
6. A three-day short term course on Experimental approaches for analysis and condition monitoring of machinery at the National Institute of Technology Rourkela.
7. Developments in Dynamic and numerical modeling of production, at the National Institute of Technology Rourkela.
8. Scientometric Tools and Techniques for Research Analysis, at K.L.University
9. Recent Advances in Manufacturing and Supply Chain Management at K.L.University
10. Author Workshop conducted by Elsevier at the National Institute of Technology Rourkela.

COMPUTER SKILLS

- MATLAB (Matrix Laboratory)
- ANSYS WORKBENCH
- SOLIDWORKS
- Auto CAD
- MINITAB

STRENGTHS

- Hardworking
- My determination to learn
- Commitment at work
- Self Learning

PERSONAL PROFILE

Name	**:**	**Jakeer Hussain Shaik**
Father's Name	**:**	Abdul Gafoor Shaik
Mother's Name	**:**	Irshad Begum Shaik
Languages Known	**:**	English, Telugu & Hindi
Date of Birth	**:**	13-04-1985
Marital Status	**:**	Married
Permanent Address	**:**	Door No. 59-6-863, Vishnu Priya villa, Tamma ranga reddy Nagar, 4th lane, Old Guntur, Guntur Dist, Andhra Pradesh, India, 522001

DECLARATION

I hereby declare that the above-mentioned particulars are true to the best of my knowledge and belief.

Yours sincerely,

Place: Guntur

(Jakeer Hussain Shaik)

BIO-DATA

1. Name and full correspondence address : Dr. A.RAVEENDRA
   Professor,Dept of Mechanical Engg
   Mallareddy EngineeringCollege
   Maisammaguda,Secunderabad,Telangana
   500100.
2. Email(s) and contact number(s) : akunururaveendra@mrec.ac.in
   9502294258
3. Institution : MallaReddy Engineering College (**A**)
4. Date of Birth : 17-12-1970
5. Gender (M/F/T) : M
6. Category Gen/SC/ST/OBC : OBC
7. Whether differently abled (Yes/No) : No
8. Academic Qualification :

	Degree	Year	Subject	University/Institution	% of marks
1	B.Tech	1994	Mechanical Engg	REC-Warangal, AP.	58
2	M.Tech	2003	Production Engg	VTU-Belgaum	72
3	Ph.D	2017	Welding	JNTUH-Hyderabad	

9. Ph.D thesis title, Guide's Name, Institute/Organization/University, Year of Award.

   Title: Experimental Investigations on welding Characteristics of Aluminium alloy(5052) and Alloy steel(EN24) using gas tungsten arc welding(GTAW).

   Year of Award : 2017

   Guide : Dr.B.V.R Ravi kumar

   University : JNTUH-Hyderabad

10 .Work experience :

S. No.	Positions held	Name of the Organization/ Institute	From	To	Pay Scale
1.	Planning Engineer	H.H.V CO.Pvt Ltd, Bangalore	1995	2000	Rs 6000+ perks
2.	Assist.prof	Dr.SGIET- Markapur	2003	2005	Rs 8000-275-13500
3.	Assoc.prof	Malla Reddy Engg College	2005	Feb 13th 2020	37400-67000
4.	Principal	Malla Reddy Engg College	Feb14th 2020	Till date	

11.Publications (List of papers published in Journals.

S.No	Author(s)	Title	Name of Journal	Volume	Page	Year
1.	A.Raveendra, Dr.B.V.R.Ravi Kumar	Welding characteristics of Aluminium alloy (6082) and stainless steel(304) weldments, using pulsed and non-pulsed current GTAW	Technical journals(IJMEAR) ISSN:2249-6548	Vol 02, issue 03	50-59	Aug 2011
2.	B.Tularirama Rao K.Srinivas P.Rami Reddy A.Raveendra B.V.R.Ravi kumar	Effect of processing parameters on surface finish of the components processed by CNC turning machine	Technical journals(IJMEAR) ISSN:2249-6564	Vol 04,issue 01	224-228	Jan-Mar 2013
3.	A.Raveendra B.V.R.Ravi Kumar	Effect of pulsed current on welding characteristic of aluminium alloy(5052) using gas tungsten arc welding	IJSR, ISSN:2319-7064	VOL 2 Issue 5	82-86	May 2013
4.	A.Raveendra B.V.R.Ravi Kumar	Effect of pulsed current on welding characteristic of EN19alloy steel using gas tungsten arc welding	IJIRSET ISSN:2319-8753	Vol 2 Issue 5	1359-1367	May 2013
5.	A.Raveendra B.V.R.Ravi Kumar	Experimental study on pulsed and non-pulsed current TIG welding of stainless steel(SS304)	IJIRSET ISSN:2319-8753	Vol:2, Issue 6	2337-2344	June 2013
6.	A.Raveendra B.V.R.Ravi Kumar	Experimental study on pulsed and non-pulsed current tig welding of aluminium sheet(6082)	IJSER ISSN:2277-2685	Vol-3 Issue 6	4102-4108	June 2013
7.	B.Tularirama Rao Dr.K.Srinivas P.Rami Reddy A.Raveendra Dr.B.V.R.Ravi kumar	Experimental study on the effect of cutting parameters on surface finish obtained in CNC turning operation	IJIRSET ISSN:2319-8753	Vol 2 Issue 9	4547-4555	Sept 2013
8.	A.Raveendra B.V.R.Ravi Kumar	Effect of pulsed current on welding characteristic of EN24	IJAST ISSN:2229-5216	Vol 8 No 1	28-37	Jan 2014

		alloy steel using gas tungsten arc welding				
9.	A.Raveendra Dr.B.V.R.Ravi Kumar Dr.A.Siva Kumar V.Prudhvi Kumar Reddy	Influence of welding parameters on weld characteristics of 5052 aluminium alloy sheet using tig welding	IJAIEM ISSN:2319-4847	Vol 3 Issue 3	186-190	Mar 2014
10.	B.Tularirama Rao Dr.K.Srinivas P.Rami Reddy A.Raveendra Dr.B.V.R.Ravi kumar	Measuring cutting forces while cutting of different metals with different speeds	IJAIEM ISSN:2319-4847	Vol 3 Issue 9	163-169	September 2014
11.	B.Tularirama Rao Dr.K.Srinivas P.Rami Reddy A.Raveendra Dr.B.V.R.Ravi kumar	Finding cutting forces while turning operations on lathe machine at different depth of cut of different metals	IJIRSET ISSN:2319-8753	Vol 3 Issue 10	16866-16872	Oct 2014
12.	A.Raveendra B.V.R.Ravi Kumar	Micro-Hardness and mechanical properties of EN24 Alloy steel weldments using pulsed and non-pulsed current gas tungsten arc welding	IJIRSET ISSN:2319-8753	Vol 03 Issue 10	16588-16592	Oct 2014
13.	A.Raveendra .B.V.R.Ravi Kumar Dr.Siva Kumar Mr.N.Santhosh	Effect of welding parameters on 5052 aluminium alloy weldments using TIG welding	IJIRSET ISSN:2319-8753	Vol 3 Issue 3	10302-10308	Mar 2014
14.	A.Raveendra .B.V.R.Ravi Kumar Dr.Siva Kumar Mr.V.Pruthvi Kumar Reddy	Influence of welding parameters on weld characteristics of 5052 aluminium alloy sheet using TIG welding	IJAIEM ISSN:2319-4847	Vol 3 Issue 3	186-190	Mar 2014
15.	K.Vinay A.Raveendra	Effect of exhaust gas recirculation on the performance and emission characteristic of diesel engine using biodiesel	IJERT ISSN:2278-0181	Vol 4 Issue 5	1276-1281	May 2015
16.	A.Raveendra M.Satish Sagar Dr.B.V.R.Ravi Kumar	Effect of pulsed current on TIG weldments of aluminium alloy (5052) and alloy steel(EN24)	IJIRSET ISSN:2319-8753	Vol 4 Issue 5	3095-3101	May 2015
17.	J.Padmaja A.Ravindra	Design and Analysis of a Heat Sink for a High Power LED System	IJERT ISSN:2278-0181	Vol 4 Issue 7	975-982	July 2015
18.	Ch.Naveen Kumar M.V.Vara Lakshmi	Measurement of cutting forces while turning different	IJIRSET ISSN:2319-8753	Vol 4 Issue 7	6070-6076	July 2015

	A.Raveendra	materials by using lathe tool dynamometer with different cutting tool nomenclature				
19.	V.Sravanthi A.Raveendra	Experimental investigation on influence of welding parameters on welding characteristics of aluminium alloy using TIG welding	IJETTS ISSN:2348-0246	Vol 5 Issue 3	407-418	Sept 2015
20.	Korri Pradeep Kumar A.Raveendra	Thermal load effect on value by using conventional and blended fuels	IJOER ISSN:2321-7758	Vol 3 Issue 6	211-215	Nov-Dec 2015
21.	V.Lokesh Varma A.Raveendra	Structural design and FEM analysis of butterfly valve	AIJREAS ISSN:2455-6300	Vol 1 Issue 6	56-62	June 2016
22.	B.Akshay Kumar A.Raveendra	Effect of pulsed and non-pulsed current on welding characteristics of AA6061 Aluminium alloy welded joints using Tig welding	IJOER ISSN:2395-6992	Vol 2 Issue 7	93-102	July 2016
23.	K.Abhilash Korvi A.Raveendra	Improving productivity and quality by changing feeding system in an injection moulding process	GJAET ISSN:2277-6370	Vol 6 Issue 1	1-5	2017
24.	M. Ravi Teja A.Raveendra	Simulation in composition of cement manufacturing and comparison of mechanical properties	IJSETR ISSN:2319-8885	Vol 6 Issue 3	1-7	Feb 2017
25.	Ch.Prahallad A.Raveendra	Modeling and optimization of cushioning system in hydraulic cylinder to achieve performance characteristics	IJIR ISSN:2454-1362	Vol 3 Issue 1	2122-2128	2017
26.	B.Sampath A.Raveendra	CFD analysis of steam ejector with different nozzle diameter	IJR ISSEN:2348-6848	Vol 4 Issue 14	2448-2452	Nov 2017
27.	Bhiksha Gugulothu A.Raveendra M.Uma Mahesh	Effect of process parameters on Mrr and surface roughness in turning process of EN8	IFERP ISSN:2456-1290	Vol 2 Issue 9	28-34	Sep 2017
28.	A.Rohith,Dr.A.Raveendra,Dr.D.K.Nageswara rao,M.Ramesh Babu	Stress Distribution around Polygonal Holes in Graphite/Epoxy Laminates Under in Plane Loading	IJR ISSN:2348-6848	VOL 05 Issue 01	1488-1507	Jan 2018
29.	A.Raveendra, B.V.R.Ravi Kumar, S.Sudhakara Reddy	Micro-Hardness and Mechanical properties of 5052 aluminium alloy weldments using pulsed and non-pulsed current gas tungsten arc welding	International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) ISSN:2249-8001 (**scopus**) Indexed Journal	Vol.8,Issue 6,	691-698	Dec2018
30.	A.Raveendra,K.Sri Noothan Reddy	Infinitely Variable Valve Lifting	International Journal of Innovative Technology and Exploring	Vol.8 Issue-2S	280-285	Dec 2018

			Engineering(IJITEE) ISSN:2278-3075 (**Scopus**) Indexed			
31.	A.Raveendra,Mohammed Abdul Mubashir	Design and Analysis of Leaf Spring for Heavy Weight Vehicles using Composite Materials	International Journal of Innovative Technology and Exploring Engineering(IJITEE) ISSN:2278-3075 (**Scopus**) Indexed	Vol.8 Issue-2S	286-291	Dec 2018
32.	B.Tulsiramarao,P.Ramreddy,K.Srinivas,A.Raveendra	Effect of tool Overhang on turning operation using finite element model	International Journal of Innovative Technology and Exploring Engineering(IJITEE) ISSN:2278-3075 (**Scopus**) Indexed	Vol.8 Issue-4S2	486-488	Dec 2018
33.	B.Tulisiramarao,P.Ramreddy,K.Srinivas,A.Raveendra	A Multivariable model of orthogonal turning operation on cutting dynamics modeled by optimum cutting Parameters using genetic algorithm	International Journal of Recent Technology and Engineering(IJRTE) ISSN:2277-3878 (**Scopus**) Indexed	Vol-7,Issue-5S2	530-535	Jan 2019
34.	A.Raveendra	Experimental Research of wire cut EDM for SR&MRR using Taguchi Method	International Journal of Engineering and Advanced Technology(IJEAT) ISSN:2249-8958 (**Scopus**) Indexed	Vol-9,Issue-2	3096-3701	Dec 2019
35.	A.Raveendra	Characterization of Roselle &Kevlar hybrid Composites	International Journal of Engineering and Advanced Technology(IJEAT) ISSN:2249-8958 (**Scopus**) Indexed	Vol-9,Issue-2	3699-3701	Dec 2019
36.	Dr.A.Raveendra	Optimization of process parameters in Turning operation by using taguchi method Special issue-NCAETS 2019	Suraj punj Journal for Multidisciplinary Research(SPJMR) UGC,approved https://app.box.com/s/b6t4n95da16g0uve3bk5shap6397odpv	Vol 9,Issue 4 ISSN:2394-2886	473-479	Dec 2019

37.	Dr.A.Raveendra	A Study on the effect of process parameter variation in TIG welding	Suraj punj Journal for Multidisciplinary Research(SPJMR) UGC,approved https://app.box.com/s/077yde65q7vyia7wdgu1i8nd191nbb4m	Vol 9,Issue 4 ISSN:2394-2886	469-472	Dec 2019
38	K.Chaitanya, Dr.A.Raveendra	Design and analysis of composite drive shaft	International Journal of Research ISSN NO:2236-6124 (UGC)	Vol 8, Issue IV	4031-4041	Dec/2019
39	S.Praveen Kumar Dr.A.Raveendra	Practical Investigation of Tool Wear Mechanism of PCBN Material by using FSP	International Journal of Advanced Science and Technology(IJAST)	ISSN:2005-4238 Vol.28, No.18,	338-348	2019
40	Dr.A.Raveendra, D.Nithis kumar	Exploration of indispensible properties of textile-grade glass fibers/white caustic treated banana fiber hybrid composite	ELSEVIER Material Today :Proceedings (**SCOPUS**)	Article in press		2020
41	Mr.K.Tarun kumar Dr.A.Raveendra	Study and Effectiveness and Reconfiguration of a Jar Tilting Mechanism of an RFC Machine	Journal of Engineering, computing and Architecture(jeca) UGC,approved	Vol:10, Issue 4,ISSN:1934-7197	159-173	2020

12. Detail of patent:

S.No	Patent Title	Name of Applicant(s)	Patent No.	Award Date	Agency/Country	Status
1	Apparatus to automatically draw two –dimensional drawing	Malla Reddy Engineering College.Department of Mechanical Engineering	Application no. 201841017390A ApplicationDate: 25/05/2018		India	published
2	An Extendable and height adjustable ceiling fan with eject abla blades.	Malla Reddy Engineering College.Department of Mechanical Engineering	Application no.202041003637A Dated27/01/2020		India	published

13. Books/Reports/Chapters/General articles etc.

S.No	Title	Author's Name	Publisher	Year of Publication
1.	An Overview of Additive manufacturing Technology	Dr. A. Raveendra Dr. N. Rishi Kanth Dr. G. Suryaprakash Rao Dr. L. Rasidhar	AkiNik Publications New Delhi	In progress
2.				

14. Any other Information (*maximum 500 words*)

a. Conferences Attended

Sl No	**Name of the Conference**	**Title of the paper**	**Organized by**	**Period**
1.	National seminar on applications of optimization in mechanical engineering	Taguchi technique as a tool to optimize the operating parameters of CNC drilling to minimize burr size	Gudlavalleru Engineering college Andhra Pradesh.	18-20 Jan 2008
2.	International conference on renewable energy and Environment for sustainable development	Transesterification process of Bio-Diesel	IIT-Delhi	11^{th}-13^{th} Dec 2008 Pp623-631
3.	NEC128-PA05MM-66NAC09	Development of mathematical models in gas metal arc welding	Dayanand sagar college of Engineering Bangalore	2009
4.	International conference on computational methods in Engg & Science-2009	Experimental investigations of Jatropa oil(preheated and blends) in a direct injection C.I Engine.	CBIT-Hyderabad	8^{th}-10^{th} Jan 2009
5.	National conference on excellence in new technologies in new mechanical Engineering(ENTIME)	Comparison of welding characteristics between TIG& MIG weldments	Malla Reddy Engineering College Secunderabad	12^{th} &13^{th} Dec 2009
6.	National conference on Aerospace Engineering (NCAE-2009)	Mechanical properties of gas metal arc weldments	Malla Reddy college of Engineering and Technology	Dec 04-05 2009
7.	ICSE 2010	Optimizing pulsed current TIG welding parameters to refine the fusion zone	Dayanand sagar Engineering college Bangalore	April 21-23 2010

8	International conference in Material processing& Characterization(ICMPC-2012)	Experimental Investigation on welding characteristics of aluminium alloy(6082) weldments using pulsed and non-pulsed current GTAW	Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad	8th-10th Mar2012
9	RITS- ICAEM-2012	Experimental Investigations on welding characteristics of stainless steel (304) weldments using pulsed and non-pulsed current GTAW.	Royal institute of Technology and management	28th and 29th Feb 2012
10	RCMS-2K13	Supersonic flow through conical nozzle with various angles of divergence	Malla Reddy Engineering College	Sept 20th &21st 2013
11	RCMS-2K13	Experimental investigations on welding characteristics of similar metal weldments and dissimilar metal weldments using arc welding	MallaReddy Engineering College	Sept 20th &21st 2013
12	RITS- ICAEM-2013	Characteristics of force feed on stability in various turning process	Royal college of management and sciences Hyderabad	Feb 28 &29 2013
13	RITS- ICAEM-2013	Comparative study on welding characteristics of EN8 &EN31 alloy steel weldments using Gas Tungsten Arc Welding	Royal college of management and sciences Hyderabad	Feb 27&28 2013
14	Emerging Trends in Science, Technology& Management (NCETSTM 2K14)	Numerical analysis of free convection with effect of surface radiation between parallel vertical heated plates with experiment data	Malla Reddy Engineering college Secunderabad	08-09 Aug 2014
15	International conference on Advanced Materials and Manufacturing Technologies(AMMT)	Micro-Hardness and Mechanical properties of 5052 aluminium alloy weldments using pulsed and non-pulsed gas tungsten arc weldments	JNTUH-Hyderabad	Dec18-20 2014
16	Inter National conference on Emerging Technologies in Mechanical Sciences(ICEMS-2014)	Microscopic study of EN24 alloy steel weldments using pulsed and non-pulsed current gas tungsten arc welding	Malla Reddy college of Engineering and Technology Secunderabad	Dec-26-27 2014
17	ICICASEMC-2016	Structural Design and FEM Analysis of Butterfly valve	Anveshana Educational and Research Foundation	18th June 2016

18	ICRCET 17	Effect of process Parameters on MRR and Surface Roughness in Turning process of EN8	Annamacharya Institute of Technology & Sciences,Ttrupathi.AP.	12th-13th Sept 2017

FDP/ Workshops Attended		
Sl.no	**Name of the work shop**	**Organization & Year**
1	**Refresher course** on Operational Research	Departments of Civil &Mechanical Engineering during 21st -22nd June 2007.
2	3 day **national seminar** on Applications of Optimization Techniques in Mechanical Engineering ,	Gudlavalleru Engineering college During 18-20 Jan 2008.
3	Two day **refresher course** in Internal Combustion Engines	Dept of Mechanical Engineering Malla Reddy Engineering on 18th &19th of June 2008.
4	**FDP** on Design Aspects of Mechanical &Aerospace Engineering	Departments of Mechanical &Aeronautical Engineering MRCET &CMEC from 2nd to 10th July 2009.
5	Two day **workshop** on Recent Developments in Mechanical Engineering	Dept of Mechanical Engineering. Malla Reddy Engineering college on12th &13th of March 2011
6	A Two day **national level work shop** under TEQIP-II on Recent Advances in CFD for industrial Applications.	Dept of Mechanical Engineering. Malla Reddy Engineering college on24th &25th of March 2012
7	One day **workshop** on Advanced trends in I.C engines and combustion	28th Feb 2013 organized by Dept of Mechanical Engineering. JNTUH college of Engineering
8	One day **workshop** on advances in welding and Surface Engineering(AWSE)	Indian Institute of Welding ,Hyderabad branch on 17th Oct17th October 2014.
9	5-day workshop(**FDP**) on principles of additive/ Generative Manufacturing	IIT-Hyderabad. Dec 1-4, 2014
10	Two-day **workshop** on Engineering Drawing	During 12th &13th Sept 2014, MallaReddy Engineering College
11	Two-day **FDP**on Finite Element Analysis	Mallareddy Engineering College during 20th and21st Feb 2015 by dept of Mechanical Enineering.
12	A **two day workshop** on Innovations in Waste Water and Energy Technologies	BITS Pilani, Hyderabad Campus during 13th &14th July 2015.
13	**One day workshop** on Outcome Based Education and Accreditation	JNT University,Hyderabad,Kukatpally on Sept 2015
14	One week **FDP** on Applications of CFD in Thermal-fluids Engineering	CMR Engineering College Kandlakola.Medchal,Hyderabad. During 29 Feb-06 Mar 2016
15	Six day **FDP** on Hyper-Works &Computational Fluid Dynamics	St.Martin's Engineering college,Dulapally,Secunderabad. 5th -10th Dec 2016

16	**FDP** on Engineering Mechanics made easy	Narasimha Reddy Engineering College during 28th June to 2nd July 2017.
17	**AICTE** sponcered two weeks **FDP** on Design for Manufacturing,Assembly,Environment for Product Innovation &Optimization	Dr.MAHALIMGAM college of Engineering and Technology-Pollachi.25th Nov 2019 to 7th Dec 2019.
18	**AICTE** sponcered one week Short Term Training Programme(STTP) on Innovations and Research Challenges in LoT Applications for Smart Manufacturing and Smart Design	Sri Ramakrishna Engineering – Vattamalaipalayam,N.G.G.O.Colony post.Coimbatore,Tamalnadu. From 09.12.2019 to 14.12.2019.
19	Five day **FDP(**online**)** on Emerging Technologies in Robotics	MallReddy Engineering College(Autonomous),Maisammaguda,Secunderabad.
20	Six day **FDP** (online) on Emerging areas in Manufacturing	Vimal jyothi Engineering College,Trivandrum,Kerala..
21	One week **FDP(**online**)** on Advanced NDT Techniques &Applications in Industry	Indian society for Non-Destructive Testing,Hyderabad Chapter in association with department of Mechanical Engineering,QISCET.Ongole from 25th to 29th May,2020.
22	One week **FDP** (online) on contemporary developments in manufacturing and industrial technologies	Dept of mechanical Engineering, Pragati Engineering College ,during 9th to 13th June, 2020
23	One week **FDP**(online) on multi objective optimization for mechanical applications	Dept of Mechanical Engineering QIS College of Engineering and Technology, Ongole,AP.During 8th to 12th June 2020.
24	One week **FDP**(online) on Disruptive Technologies in Mechanical Engineering	Dept of Mechanical Engineering Sreenidhi Institute of Science and Technology-Hyderabad during 8th to 13th June 2020.
25	Three day **FDP**(online) on "The Role of Artificial Intelligence and Machine Learning in Robotics and Automation"	During 1st-3rd June 2020 organized by Science and Technology Innovation Center, Anurag University, Hyderabad.
26	One Week **FDP** (Online) on **"**Advanced NDT Techniques & Applications in Industry	From 25th to 29th May,2020 organized **by** Indian Society for Non Destructive Testing, Hyderabad Chapter in association with Department of Mechanical Engineering, QISCET, Ongole.
27	8 weeks FDP(online) on Advanced Manufacturing Processes by IIT-Madras	From Sep-Nov 2020. Organized by IIT-M
28	AICTE approved Two weeks FDP (online) programme on Renewable Energy Intervention in industry, commercial and domestic application	From 14th Dec to26th Dec 2020 organized by Rajeev Gandhi memorial college of Engineering and Technology-Nndyal AP.

Endorsement from the Head of the Institution of PI

This is to certify that:

1. Institute welcomes participation of Name : Dr. Shaik Jakeer Hussain Designation : Associate Professor as the Principal Investigator and Dr. Akunuru Raveendra as the Co- Investigator/s for the project titled Optimal design and analysis of integrated spindle-tool system with a sensor based system for high speed machining and that in the unforeseen event of discontinuance by the Principal Investigator, the Co-Investigator will assume the responsibility of the fruitful completion of the project with the approval of SERB.
2. The PI, Dr. Shaik Jakeer Hussain is a permanent or regular employee of this Institute/University/Organization and has 10 years of regular service left before superannuation
3. The project starts from the date on which the University/Institute/ Organization/College receives the grant from SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi.
4. The investigator will be governed by the rules and regulations of University/ Institute/Organization/College and will be under administrative control of the University/ Institute/Organization/College for the duration of the project.
5. 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.
6. No administrative or other liability will be attached to SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi at the end of the project.
7. The University/Institute/Organization/College will provide basic infrastructure and other required facilities to the investigator for undertaking the research project.
8. The University/ Institute/Organization/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.
9. The University/ Institute/Organization/College assumes to undertake the financial and other management responsibilities of the project.

Seal

Malla Reddy Engg. College (A) 500 100 Hyderabad

Date:7-3-2021

Signature
PRINCIPAL
Malla Reddy Engineering College
(Autonomous)
Maisammaguda, Dhulapally,
(Post Via Kompally), Sec'bad-500 100.

Endorsement from the Head of the Institution of Co-PI

This is to certify that:

1. Institute welcomes participation of Name : Dr. Shaik Jakeer Hussain Designation Associate Professor as the Principal Investigator and Dr. Akunuru Raveendra as the Co- Investigator for the project titled Optimal design and analysis of integrated spindle-tool system with a sensor based system for high speed machining and that in the unforeseen event of discontinuance by the Principal Investigator, the Co-Investigator will assume the responsibility of the fruitful completion of the project with the approval of SERB.

2. The Co-PI, Dr. Akunuru Raveendra is a permanent or regular employee of this Institute/University/Organization and has 17years of regular service left before superannuation

3. The Co-PI will be governed by the rules and regulations of University/ Institute/Organization/College and will be under administrative control of the University/ Institute/Organization/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/Organization/College will provide basic infrastructure and other required facilities to the investigator for undertaking the research project.

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

Seal

Malla Reddy Engg. College 500 100 Hyderabad

Date:7-3-2021

Signature

PRINCIPAL
Malla Reddy Engineering College
(Autonomous)
Maisammaguda, Dhulapally,
(Post Via Kompally), Sec'bad-500 100.

Certificate from the Investigator

Project Title:

Optimal design and analysis of integrated spindle-tool system with a sensor based system for high speed machining

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: Dr. SHAIK JAKEER HUSSAIN

Date: HYDERABAD
Place:07-03-2021

Name and signature of Co-PI (s) (if any): Dr. A.RAVEENDRA
Date: HYDERABAD
Place: 07-03-2021

Undertaking by the Principal Investigator

To

The Secretary
SERB, New Delhi

Sir

I Dr. SHAIK JAKEER HUSSAIN herby certify that the research proposal titled Optimal design and analysis of integrated spindle-tool system with a sensor based system for high speed machining

Submitted for possible funding by SERB, New Delhi is my original idea and has not been copied/taken verbatim from anyone or from any other sources. I further certify that this proposal has been checked for plagiarism through a plagiarism detection tool i.e. Turnitin approved by the Institute and the contents are original and not copied/taken from any one or many other sources. I am aware of the UGCs Regulations on prevention of Plagiarism i.e. University Grant Commission (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulation, 2018. I also declare that there are no plagiarism charges established or pending against me in the last five years. If the funding agency notices any plagiarism or any other discrepancies in the above proposal of mine, I would abide by whatsoever action taken against me by SERB, as deemed necessary.

Dr. SHAIK JAKEER HUSSAIN
Assoc.Professor