Review And Suggested Generalized Approach To Analyze The Impact Of Vibration On Two Wheeler Rider.

Harshada G. Deshmukh[1], S. G. Dambhare[2], M. R. Phate[3]
[1,2,3] Mechanical Engineering department, Pune University, Padmabhooshan Vasantadada Patil Institute of Technology Pune, India

Abstract— **Now a day's millions of people prefer two wheeler rather than four wheeler as economic point of view as well as to reach the destination in time due to traffic. The Impact of whole body vibration on health of two wheeler rider is the main aim of study. For that generalized approach is suggested in the given paper. For that 4 degree of freedom vibratory model for whole system will be taken. Two wheeler rider system is considered as spring-mass damper system .The modeling and segmentation of the Two Wheeler Rider Body and two-wheeler will be done. An anthropomorphic data is used for modeling of human body. The evaluation of mass and stiffness values of individual segment will also be carried out. Analysis of the model will be done and result we get in terms of frequency response of human body and two wheeler for ideal operating condition..Also from analysis we will come to know to that which part of human body is affected more due to vibration.**

Index Terms— **Four degree of freedom model, Human body, Two wheeler rider, Whole body vibration**

I. INTRODUCTION AND REALATED WORK

In Today's world millions of people are using two wheeler in economic point of view. These two wheeler riders are exposed to whole body vibration i.e. mechanical vibration. As Per Experimental studies on (WBV) whole body vibration and as per literature certainly confirms that the health of rider is affected much therefore it becomes necessary to find out the effects of vibration on different body parts and according to make changes in design of two wheeler and selection parts. If rider is exposed to certain frequency of vibration it may have effects on specific body part of rider. When studied vibration and its effects on health of two wheeler rider for HERO HONDA SPLENDOR. It came forward that 13.33% of the Indian people are having musculoskeletal pain because of bad road condition and design of vehicle. After analysis is done using HERO HONDA SPLENDOR it was found that frequency in ideal operating condition is 8Hz for human body and two wheeler rider and 49.66 km/hr should be the ideal speed [1]. Vertical as well as lateral transmissibility for FTH and FTK for six male as a subjects in a standing position and two hand support one with handle another with handrail were studied. Resonance for both hand support position is observed for head and knee in vertical direction at 4.5Hz to 5.5Hz.whereas for lateral direction it was seen at 2Hz to 3Hz for head in both position. For knee in both positions more transmission of vibration is found out as compare to head that for holding handle is than holding handrail means holding handrail had greater vibration transmissibility [2]. After so much of data collection and survey it was came to know that this lower back bone problem (LBBP) due to transmission of whole body vibration is because of lack of lumbar support in two wheeler seat. To optimize this LBBP ,we have to provide lumbar in adequate amount in the seat of two wheeler which will directly affect the vertical joint rotation and spine of lumbar[3].one o the study investigated about effects of spring stiffness and shock absorber damping on suspension deformation, dynamic wheel load and vertical acceleration of driver's body. This investigation also served the purpose that it recommends selection of oscillation parameters which are required for suspension system of a intercity bus. Using statistical dynamic equation, an analysis was carried out in the frequency domain through a simulation. It was concluded after the result of analysis that for driver's oscillatory comfort bus should have suspension system with spring of small stiffness and shock absorber with low damping coefficient. For active safety purpose stiffness of spring should be small but damping coefficient should be high .While for a wheel motion to be minimum spring should have great stiffness and whereas shock absorber should have high damping coefficient. [4].Four D.O.F. lumped parameter model under random excitation collected from six Indian railway trains was studied. It was observed that at resonance frequency vibration level has significant effect as well as if we increase frequency this effect became less [5].

Various effects of vibrations which may cause noise in the passenger car cabin were investigated. It was found that the noise annoyance level which was evaluate by vehicle acoustical comfort index (VACI) and whereas vibration level was evaluated by vibration dose value (VDV).Hearing impairment, hypertension, annoyance and lack of focus in driving which may lead to an accident are causes of noise in the passenger car cabin system this noise can be reduced by decreasing amount of level of vibration. For that LP models were studied and this came forward that by some kind of modification in the system of the car we are able to reduced exposed vibration level with increase of VACI vehicle acoustical comfort index values as well as level of noise in the passenger car is decreased but could able to get the pleasant sound in the car cabin interior [6]. One of the had aim of identifying variables which governs the

ISSN: 2278 – 7798

non-linear responses of seated human body during vertical whole body vibration.The review of six most revelent studies were taken for non linear biodynamics responses to whole body vibration.The study also compared the explanations of the mechanisms controlling non-linear behaviour.Posture,muscle tone, dynamics of buttocks tissue and geometric non-linearity were classified as dominant variables.The study showed that four variables influences more the characteristic of non-linearity and those were posture,muscle tone,dynamics of buttocks tissue and geometry of body. Finally it was concluded that posture has minor contribution to the nonlineariy. Fundamental contribution to non-linearity may be due to muscle tone and geometric non-linearity. Whereas influence on non-linearity is due to pressure on buttocks tissue [7]. An algorithm using MATLAB Simulink software which can convert the input signal into road profile which was measured had developed.Four Degree of freedom half car modelled is taken properties like laser sensor and accelerometer were introduced in whole simulink mode to make it more realistic. The results of simulation of an algorithm with a half car model were studied in distance, time and frequency domain. The outcome of between input and output road profile was found good agreement after simulation of 4 D.O.F. half car road profile measuring system. Only pitching and bouncing motions were considered for simulation of road profile measurement system whereas rolling was not taken into consideration[8].Responses of human body under random whole body vibration in standing position were studied. Also what are its effects on health and comfort of human body. They have taken 6 healthy male persons in standing position and their floor to head and floor to knee transmission of WBV whole body vibration was studied. For this magnitude of vibration was taken within 0.5m/s2 to 1m/s2 and range of frequency was 1-20Hz.Under this study two situations were taken those were with handle and with handrail.For both situation transmission of whole body vibration to FTH and FTK was studied for six standing males.From result it was came to noticed that for floor to knee transmissibility was greater for handrail support than handle and FTK had little effect. Also for floor to head FTH transmission of whole body vibration for both positions i.e. handle and handrail first peak was within 4 to 7 Hz frequency range [9]. The experiments were conducted for the measurement of magnitude of vibration affecting two wheeler riders while riding under different road condition. For that they carried out experiment in that they have taken four types of motorcycles and 7 road condition according to their roughness index. While performing experiment accelerometers were connected at handle bar for hand arm vibration HAV to measure and one was connected at seat to measure WBV whole body vibration. It was observed that acceleration values of HAV and WBV should be kept within1m/s^2 and 0.315 m/s^2 respectively. According to standard level of vibration total acceleration should be within0.8m/s^2.Study also stated that below 90Hz should be the vibrational frequency. They also found out that even if for short duration of riding HAV and WBV would be hazardous when checked for different road condition for dissimilar motorcycles [10]. For the study transmissibility and dynamic stiffness of wheelchair cushions using two laboratory test methods were selected and those were: 1] WRC wheel chair road course 2] Material testing system (MTS). It was necessary to do because WC wheelchair users are subjected to unhealthy vibrations during its use which may cause vertebral disc generation and back pain. Also from some literature it was suggested that cushions used for WC wheel chair amplifies vibrations. So above two tests were carried out by author and found that transmissibility measured during MTS Material testing system and WRC did not correlate and there is need of some future work. Also Foam and gel-based cushions have greater transmissibility than air-based cushions [11].

II. PROPOSED METHODOLOGY

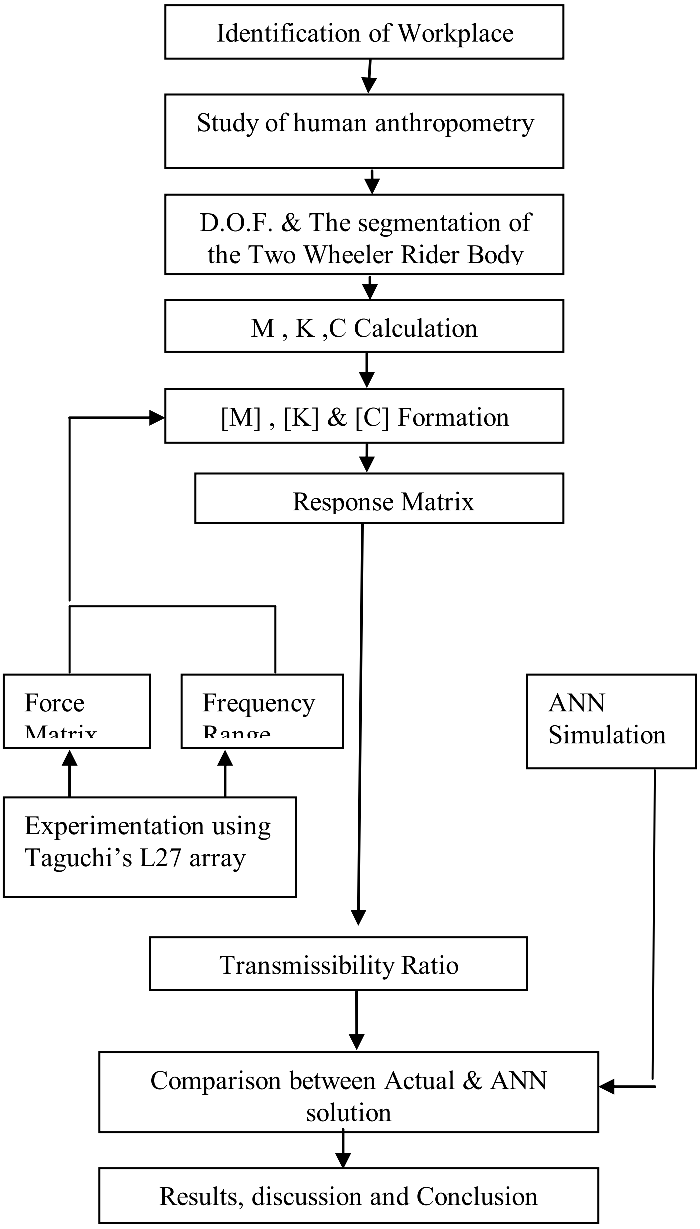

Fig 1: Proposed Methodology

III. SUGGESTED APPROACH

A. SYSTEM DESIGN

The Modeling of vibratory system of human body and its study under sitting posture. The system i.e. two wheeler rider system

ISSN: 2278 – 7798

should be considered as spring mass damper system. Through anthropometric model a generalized procedure for modeling of human body will be developed.

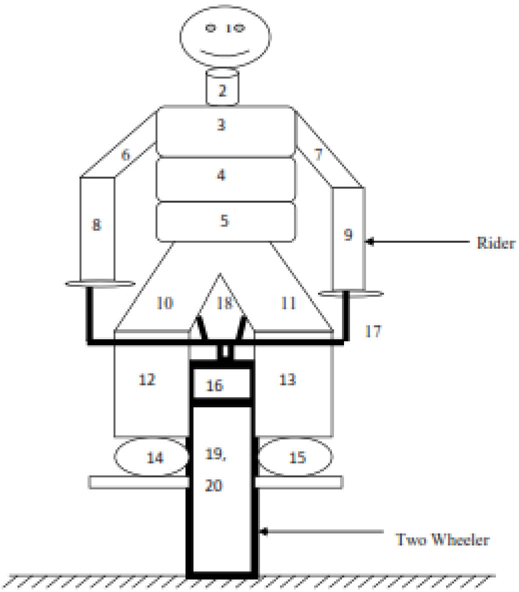

Fig 2: Sitting Posture for the Two Wheeler rider.

B. PROPOSED MODEL

For preparing proposed model two wheeler rider system we have to select first parameters for both rider as well as two-wheeler. One can select different parameters as per requirement & convenience.
Following are the parameters selected for study.

1) Rider Parameters:

A1. Head (H)

A2. Neck (N)

A3. Upper Torso (UT)

A4. Central Torso (CT)

A5. Lower Torso (LT)

A6. Right Upper Arms (RUA)

A7. Left Upper Arms (LUA)

A8. Right Lower Arms (RLA)

A9. Left Lower Arms (LLA)

A10. Right Upper Legs (RUL)

A11. Left Upper Legs (LUL)

A12. Right Lower Legs (RLL)

A13. Left Lower Legs (LLL)

A14. Right Feet (RF)

A15. Left Feet (LF)

2) Two Wheeler Parameters:

B1. Seat (ST)

B1. Handle Bar (HB)

B3. Chassis (CHS)

B4. Front Wheel (FW)

B5. Rear Wheel (RW)

IV. MATHEMATICAL FORMULATIONS

For derivation of dynamic model of human body and two wheeler for the intention of analysis following Assumptions are made as follows: [1]

- Only vertical motion of the vehicle is considered.
- Pitching and rolling motion are not taken into account.
- The Shape of road profile was considered to be of Sinusoidal and amplitude is 5cm.
- The spring characteristics were assumed to be linear They are taken from one of the references.

***Generalize Multi-degree Vibration Model for the Two Wheeler Rider System*:**

In matrix form the generalized equations can be written as

[M] { X'' } + [C] { X' } + [K] { X } = [F] s i n w t .

Where [M],[C] and [K] are mass, damping and stiffness matrices respectively. The elements of damping and stiffness matrices were obtained from equation of motion for the various displacements. [F] is the force matrix.

1. For Segment 1- (Head):

$$M_1 \ddot{X}_1 - C_1(\dot{X}_2 - \dot{X}_1) - K_1(X_2 - X_1) = 0 \quad (1)$$

2. For Segment 2 -Neck (N):

$$M_2 \ddot{X}_2 + C_1(\dot{X}_2 - \dot{X}_1) - C_2(\dot{X}_3 - \dot{X}_2) + K_1(X_2 - X_1) - K_2(X_3 - X_2) = 0 \quad (2)$$

3. For Segment 3- Upper Torso (UT):

$$M_3 \ddot{X}_3 + C_2(\dot{X}_3 - \dot{X}_2) - C_4(\dot{X}_4 - \dot{X}_3) - C_5(\dot{X}_5 - \dot{X}_3) - C_3(\dot{X}_8 - \dot{X}_3) - K_3(X_8 - X_3) - K_4(X_4 - X_3) - K_5(X_5 - X_3) + K_2(X_3 - X_2) = 0 \quad (3)$$

4. For Segment 4 -Central Torso (CT):

$$M_4 \ddot{X}_4 - C_6(\dot{X}_6 - \dot{X}_4) + C_4(\dot{X}_4 - \dot{X}_3) - K_6(X_6 - X_4) + K_4(X_4 - X_3) = 0 \quad (4)$$

5. For Segment 5 -Lower Torso (LT):

$$M_5 \ddot{X}_5 - C_7(\dot{X}_7 - \dot{X}_5) + C_5(\dot{X}_5 - \dot{X}_3) - K_7(X_7 - X_5) + K_5(X_5 - X_3) = 0$$
(5)

ISSN: 2278 – 7798

6. For Segment 6 -Right Upper Arms (RUA):

$$M_6 \ddot{X}_6 + C_6(\dot{X}_6 - \dot{X}_4) + K_6(X_6 - X_4) = 0 \quad (6)$$

7. For Segment 7 - Left Upper Arms (LUA):

$$M_7 \ddot{X}_7 + C_7(\dot{X}_7 - \dot{X}_5) + K_7(X_7 - X_5) = 0 \quad (7)$$

8. For Segment 8-Right Lower Arms (RLA):

$$M_8 \ddot{X}_8 + C_3(\dot{X}_8 - \dot{X}_3) - C_8(\dot{X}_9 - \dot{X}_8) - K_8(X_9 - X_8) + K_3(X_8 - X_3) = 0 \quad (8)$$

9. For Segment 9- Left Lower Arms (LLA):

$$M_9 \ddot{X}_9 + C_8(\dot{X}_9 - \dot{X}_8) - C_9(\dot{X}_{10} - \dot{X}_9) - C_{10}(\dot{X}_{11} - \dot{X}_9) - C_{17}(\dot{X}_{16} - \dot{X}_9) - K_{17}(X_{16} - X_9) - K_9(X_{10} - X_9) - K_{10}(X_{11} - X_9) + K_8(X_9 - X_8) = 0 \quad (9)$$

10. For Segment 10- Right Upper Legs (RUL) :

$$M_{10} \ddot{X}_{10} + C_9(\dot{X}_{10} - \dot{X}_9) - C_{11}(\dot{X}_{12} - \dot{X}_{10}) - K_{11}(X_{12} - X_{10}) + K_9(X_{10} - X_9) = 0 \quad (10)$$

11. For Segment 12- Right Lower Legs (RLL):

$$M_{11} \ddot{X}_{11} + C_{10}(\dot{X}_{11} - \dot{X}_9) - C_{12}(\dot{X}_{13} - \dot{X}_{11}) - K_{12}(X_{13} - X_{11}) + K_{10}(X_{11} - X_9) = 0 \quad (11)$$

12. For Segment 12- Left Upper Legs (LUL):

$$M_{12} \ddot{X}_{12} + C_{12}(\dot{X}_{12} - \dot{X}_{10}) - C_{13}(\dot{X}_{14} - \dot{X}_{12}) - K_{13}(X_{14} - X_{12}) + K_{12}(X_{12} - X_{10}) = 0 \quad (12)$$

13. For Segment 13- Left Lower Legs (LLL):

$$M_{13} \ddot{X}_{13} + C_{12}(\dot{X}_{13} - \dot{X}_{11}) - C_{14}(\dot{X}_{15} - \dot{X}_{13}) - K_{13}(X_{15} - X_{13}) + K_{12}(X_{13} - X_{11}) = 0 \quad (13)$$

14. For Segment 14- Right Feet (RF):

$$M_{14} \ddot{X}_{14} + C_{13}(\dot{X}_{14} - \dot{X}_{12}) - C_{15} \dot{X}_{14} - K_{15} X_{14} + K_{13}(X_{14} - X_{12}) = 0 \quad (14)$$

15. ForSegment15-LeftFeet(LF):

$$M_{15} \ddot{X}_{15} + C_{14}(\dot{X}_{15} - \dot{X}_{13}) - C_{16} \dot{X}_{15} - K_{16} X_{15} + K_{14}(X_{15} - X_{13}) = 0 \quad (15)$$

16. ForSegment16Seat:

$$M_{16} \ddot{X}_{16} + C_{17}(\dot{X}_{16} - \dot{X}_9) - C_{18}(\dot{X}_{17} - \dot{X}_{16}) - K_{18}(X_{17} - X_{16}) + K_{17}(X_{16} - X_9) = 0 \quad (16)$$

17. For Segment 17- Chassis :

$$M_{17} \ddot{X}_{17} + C_{18}(\dot{X}_{17} - \dot{X}_{16}) - C_{20}(\dot{X}_{20} - \dot{X}_{17}) - K_{20}(X_{20} - X_{17}) + K_{18}(X_{17} - X_{16}) = 0 \quad (17)$$

18. For Segment 18- Handle :

$$M_{18} \ddot{X}_{18} - C_{19} \dot{X}_{18} - K_{19} X_{18} = 0 \quad (18)$$

19. For Segment 19- Rear Wheel :

$$M_{19} \ddot{X}_{19} + C_{19}(\dot{X}_{19} - \dot{X}_{18}) - C_{21} \dot{X}_{19} - K_{21} X_{19} + K_{19}(X_{19} - X_{18}) = 0 \quad (19)$$

20. For Segment 19- Front Wheel :

$$M_{20} \ddot{X}_{20} + C_{20}(\dot{X}_{20} - \dot{X}_{17}) - C_{22} \dot{X}_{20} - K_{22} X_{20} + K_{20}(X_{20} - X_{17}) = 0 \quad (20)$$

V. PLAN OF EXPERIMENTATION

Process parameters may be different as per your requirement or as per need of study.

Table I: plan for the experimentation

Process Parameters	Designation	Level		
		-1	0	+1
Speed (km/ Hr)	**A**	Below 50	51 -60	Above 60
Riding Time	**B**	1min	1.5min	2min
Road Profile	**C**	High Roughness	Low Roughness	Smooth
Air in Tube	**D**	25-30	30-35	35-40

ISSN: 2278 – 7798

Table II: Standard Experimental Plan (L27 Array)

Exp. No	Speed	Riding Time	Road Profile	Air in tube	Exciting Frequency HZ
1	0	-1	0	-1	
2	1	1	0	0	
3	0	0	-1	-1	
4	0	-1	-1	0	
5	1	0	0	1	
6	1	0	-1	0	
7	0	0	-1	-1	
8	0	1	0	1	
9	-1	0	1	0	
10	-1	0	0	1	
11	0	-1	0	1	
12	0	1	-1	0	
13	1	0	1	0	
14	0	1	1	0	
15	0	1	0	1	
16	1	-1	0	0	
17	1	0	0	-1	
18	-1	-1	0	0	
19	0	-1	1	0	
20	0	0	0	0	
21	0	0	1	-1	
22	0	0	1	1	
23	-1	0	-1	0	
24	0	0	0	0	
25	-1	0	0	-1	
26	0	0	0	0	
27	-1	1	0	0	

VI. DETERMINATION OF RESPONSE

For multi degree of freedom system to obtain response of forced vibration we can use matrix inversion method .We get the immediate response of system to forced vibration for damped or undamped multi degree of freedom system. Because basis has been form by matrix inversion method for solution, which can be easily calculated by computer, using software and by creating independent program. In matrix inversion method we can write differential equation in the form of matrix after solving equation we get the solution in terms of the displacement matrix. There in displacement matrix equation we get one unknown matrix suppose it is called as [A].This [A] can be calculated by developing C program for different frequency range.

VII. RESULTS AND DISCUSSION

As this paper is on generalized approach on formulation of a multi-degree vibratory model for two wheeler rider system, result we get in terms of frequency response of human body and two wheeler for ideal operating condition..Also from analysis we will come to know to that which part of human body is

ISSN: 2278 – 7798

affected more due to vibration.

REFERENCES

[1] Jaimon Dennis Quadros, Suhas, Vaishak N. L, Shilpa.B. , "Study of vibration and its effects on health of a twowheeler rider," International Journal of Research in Engineering and Technology, Volume: 02 Issue: 08,pp.51-55 Aug-2013.

[2] Vikas Kumar, V. H. Saran and Veeresalingam Guruguntl "Study of Vibration Dose Value and Discomfort due to Whole Body Vibration Exposure for a Two Wheeler Drive," 1International and 16 National Conference on Machines and Mechanism. , pp. 947-952, Dec 18-20 2013 , IIT Roorkee, India.

[3] Ashwin S. Chandor , Dr. T. R. Deshmukh, " Study of Problem of lower Bback pain of two wheeler riders- A critical review" International Journal of pure and applied Research in Engineering and Technology, Volume 1(8),pp. 94-100 Apr-2013.

[4] Dragan Sekulic, Vlastimir Dedovic "The Effect of Stiffness and Damping of the Suspension System Elements on the Optimisation of the Vibrational Behaviour of a Bus." International Journal for Traffic and Transport Engineering, Vol. 4,pp. 231 – 244,2011.

[5] Desta M., M. K. Bhiwapurkar, V. H. Saran , S. P. Harsha , "Bio-dynamic modelling and simulation of seated human subjects exposed to vertical random vibration," National Conference on Advancements and Futuristic Trends in Mechanical and Materials Engineering, pp.19-20 February, 2010.

[6] Zulkifli Mohd Nopiah et al, "Linear Programming: Optimization of Noise and Vibration Model in Passenger Car Cabin", International Journal of Soft Computing And Software Engineering, Vol.2, No.1, pp.1-13, 2012.

[7] Claudiu Valentin Suciu, Tsubasa Tobiishi, and Ryouta Mouri, "Modeling and Simulation of a Vehicle Suspension with Variable Damping versus the Excitation Frequency"Journal of telecommunication and information technology,pp.83-89,2012.

[8] C. B. Patel, P. P. Gohil and B. Borhade, "*Modeling and vibration analysis of road profile measuring system"*, International Journal of Automotive and Mechanical Engineering, Volume 1, pp. 13-28, January-June 2010.

[9] Vikas Kumar, V. H. Saran and RajKumar Pawar, "Biodynamic response to random whole body vibration in standing posture" 1 International and 16 National Conference on Machines and Mechanism. , pp. 306-311, Dec 18-20 2013.

[10] Shivakumara B. S, Sridhar V., "Study of vibration and its effect on health of the motorcycle rider" Online J Health Allied Scs.,Vol.09, pp.July2010.

[11] Yasmin Garcia-Mendez, B. S, Jonathan L. Pearlman, Rory A. Cooper, Michael L. Boninger, "Dynamic stiffness and transmissibility of commercially available wheelchair cushions using a laboratory test method" , JRRD, Volume 49, pp.7-22 ,Number 1, 2012.

BIOGRAPHIES

Harshada G. Deshmukh is currently doing M.E.in design from Padmabhooshan Vasantdada Patil Institute of Technology Pune, India.She received B.E. degree from Government college of Amravati in 2009. She has completed a certified course from DESIGNTECH SYSTEMS LTD Pune in Unigraphics NX (7.5) version. First prize winner in international level poster competition

S. G. Dambhare is currently working in Padmabhooshan Vasantdada Patil Institute of Technology Pune, India. He has done B.E. in 1996 and M.E in 2005. and registered for Phd. He has published 8 papers in international journal and presented more than 10 papers in national and international conferences. He is member of SAE and ISTE. His topic of interest are sustainable manufacturing, production management and process modelling.

M. R. Phate is currently working in Padmabhooshan Vasantdada Patil Institute of Technology Pune, India. He has completed B.E. in 2002,M.tech in 2005 and MBA in 2008.Now his Phd thesis is submitted.16 international papers were published in various reputed journals by him. Life member of ISTE. Also gold medalist in Mtech 2005 exam.

ISSN: 2278 – 7798