© 2019 IJSRSET | Volume 6 | Issue 1 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology
DOI : https://doi.org/10.32628/IJSRSET196174

Some Design Analysis and Simulation Problems in Manufacturing Engineering Using Matlab

T. S. R. Murthy
Mechanical Engineering Department, Sreenidhi Institute of Science and Technology, Yamnampet, Ghatkesar, Hyderabad, India

ABSTRACT

In mechanical engineering, particularly mechanical and manufacturing engineering, in Academic or Research Institutions, one has to solve many problems for which there will be no established methods or solutions. Though similar problems were solved three decades ago with FORTRAN and other methods, the use of MATLAB in the recent days has helped in obtaining the solution faster and easier, in tune with the fast-changing environment. Though we have not explored the complete capabilities of MATLAB, we explored to some extent its capabilities while solving some of the typical problems. In this paper it is proposed to highlight some of the design and manufacturing related problems and how MATLAB has helped in obtaining the solution.

Keywords : MATLAB, Calibration, CAR.

I. INTRODUCTION

MATLAB has been used extensively for various design, analysis and simulation applications. Some of the applications where it has been used by the author in the recent days are:

Offline inverse kinematics solution of 6 axes robot with graphical based logical approach, Simulation of guided chain drive for optimum design of the guided profile, Tent fit algorithm and vision system calibration, Flatness evaluation of large circular rings, Simulation and computing setting parameters for Camber grinding on conical surfaces conical surfaces, Evaluation of paraboloid surfaces, Cyclic autoregressive models for the manufacture of cams, Evaluation of spindle running accuracy using best fit sine wave, Simulation of lobing behaviour in center less grinding, Simultaneous interrelated tolerance evaluation etc.,

In this paper it is proposed to highlight the critical areas in some of the above topics where the simulation has helped in visualizing and solving the complex problems. The intermediate graphical visualization/animation had helped in correcting the mistakes in the algorithm and arriving at a better solution.

II. PROBLEMS AND SOLUTIONS

A. **Off line inverse kinematics**: Inverse kinematics (IK) problem of a six axes robot with non intersecting wrist axes has been solved off line using MATLAB. Though D-H notation and matrix notations are well established, one has to spend enough time to ensure that long equations involving lot of sine and cosine are derived and translated correctly in to any program. During the process the graphical representations of the solution of the equations involved have helped in verifying the correctness of the equations and helped in correcting the errors during derivations. The details of this method are given in [1].

B. Camber grinding on conical surfaces

Generally the cylindrical pulleys are made to take the slight barrel shape and the amount of deviation is called camber. Recently there was a requirement to provide camber on the conical surface of the order of 10 to 30 microns. Though it is possible to do it on a cylindrical grinding machine with plunge grinding, by dressing the grinding wheel with the required profile alternative methods have been tried. One of the alternatives is to use a universal tool room-grinding machine with conical cup shaped grinding wheel. With this arrangement the problem is to determine whether it is feasible to obtain the desired requirement, and if so what is the location and orientation of the work piece with respect to grinding wheel axis to get the required camber on the conical work-piece.

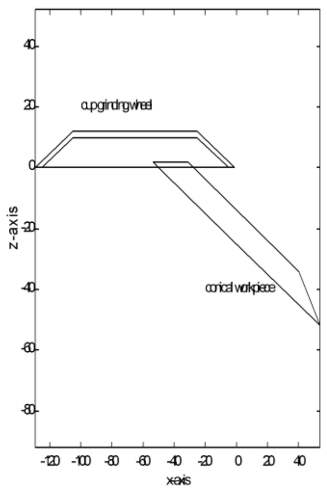

Figure 1: Arrangement for grinding.

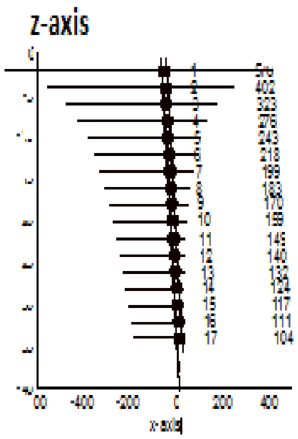

Figure 2: Grinding wheel size and location

Figure 1 shows the arrangement with details of the work-piece and grinding wheel for camber grinding on the conical surface. Figure 2 shows the size of the wheel and its location with respect to work-piece computed and plotted using MATLAB. Mathematical analysis with more details is given in [2].

C. Evaluation of Paraboloid surfaces:

Present day communication is through dish antennas. The dish antennas are paraboloid in shape. It is said that if the shape of the paraboloid is accurate the size of the dish antenna can be smaller. There was a requirement to evaluate the accuracy of the dish antennas in paraboloid shape. Since there were no established methods for this purpose, a step by step approach to find the axis of the paraboloid surface and then the accuracy of the surface is done by fitting a best fit paraboloid surface. The following matrix equation fits a best-fit quadratic surface. More details given in [3]

$$\begin{bmatrix} \Sigma x^4 & \Sigma x^2y^2 & \Sigma x^2z^2 & \Sigma x^2yz & \Sigma x^3z & \Sigma x^3y & \Sigma x^3 & \Sigma x^2y & \Sigma x^2z \\ \Sigma x^2y^2 \Sigma y^4 & & \Sigma y^2z^2 & \Sigma y^3z & \Sigma xy^2z & \Sigma xy^3 & \Sigma xy^2 & \Sigma y^3 & \Sigma y^2z \\ \Sigma x^2z^2 \Sigma y^2z^2 & & \Sigma z^4 & \Sigma yz^3 & \Sigma xz^3 & \Sigma xyz^2 & \Sigma xz^2 & \Sigma yz^2 & \Sigma z^3 \\ \Sigma x^2yz & \Sigma y^3z & \Sigma yz^3 & \Sigma y^2z^2 & \Sigma xyz^2 & \Sigma xy^2z & \Sigma xyz & \Sigma y^2z & \Sigma yz^2 \\ \Sigma x^3z & \Sigma xy^2z & \Sigma xz^3 & \Sigma xyz^2 & \Sigma z^2x^2 & \Sigma x^2yz & \Sigma x^2z & \Sigma xyz & \Sigma xz^2 \\ \Sigma x^3y & \Sigma xy^3 & \Sigma xyz^2 & \Sigma xy^2z & \Sigma x^2yz & \Sigma x^2y^2 & \Sigma x^2y & \Sigma xy^2 & \Sigma xyz \\ \Sigma x^3 & \Sigma xy^2 & \Sigma xz^2 & \Sigma xyz & \Sigma x^2z & \Sigma x^2y & \Sigma x^2 & \Sigma xy & \Sigma xz \\ \Sigma x^2y & \Sigma y^3 & \Sigma yz^2 & \Sigma y^2z & \Sigma xyz & \Sigma xy^2 & \Sigma xy & \Sigma y^2 & \Sigma yz \\ \Sigma x^2z & \Sigma y^2z & \Sigma z^3 & \Sigma yz^2 & \Sigma xz^2 & \Sigma xyz & \Sigma xz & \Sigma yz & \Sigma z^2 \end{bmatrix} \begin{bmatrix} A \\ B \\ C \\ F \\ G \\ H \\ U \\ V \\ W \end{bmatrix} = \begin{bmatrix} \Sigma x^2 \\ \Sigma y^2 \\ \Sigma z^2 \\ \Sigma yz \\ \Sigma zx \\ \Sigma xy \\ \Sigma x \\ \Sigma y \\ \Sigma z \end{bmatrix}$$

D. Cyclic auto regressive model:

AR and ARMA models are developted and used for most of the problems where the data is available as a function of time. But in case of radial cams the available time data is periodic. So to use effectively the A models, they have to account for periodic nature. This has been done by incorporating the periodic nature in the derivation of the equations and the model derived is named as Cyclic Auto Regressive (CAR) model. More details are given in [4].

E. Vision system calibration:

Any vision system is required to be calibrated before it is put into use. Since the location of the light source and its plane of view changes for different applications, its calibration has to be done almost for every situation for accurate results. For this purpose generally 8 holes of known size marked at 3x3 grid locations are used. But a different approach has been tried for its calibration. Accurately drawn grid lines in the form of a graph sheet is placed in the view of the vision system and an image is captured. In the image it is observed that there is some trend in two mutually perpendicular directions dividing the area in to 4 parts. This trend prompted us to fit a tent like surface for its calibration. Figure 3. shows a tent fit for the random data. More details are given in [5].

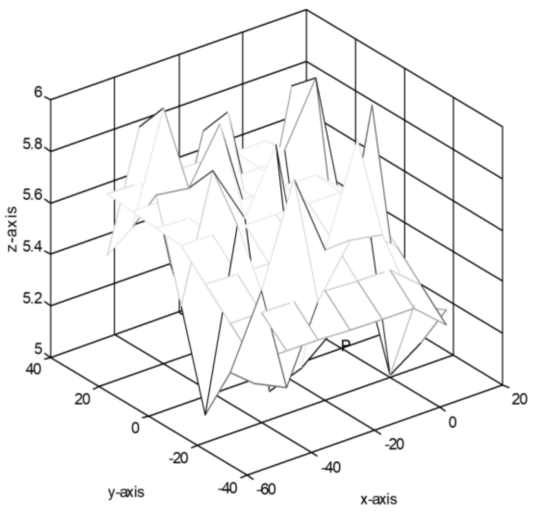

Figure 3. Tent fit surface

F. Piston ring manufacture:

Piston ring is the most important functional element in any internal combustion engine. Since the piston ring has to be circular in its closed form, its form is non circular in its open form with a discontinuity of slope at the junction where it is going to be slit after its manufacture. Sine the junction is going to be slit, it is smoothened by different methods to reduce acceleration during manufacture. Details are given in [6]

G. Lobingbehaviour in centerless grinding:

The accuracy of work-piece in centerless grinding depends up on proper selection of process selection parameters namely setup angle α, and center height angle β. The effect of these parameters can be characterized by the process stability parameters namely work holding stability, regenerative chatter stability and lobing stability. The work holding stability (work piece jumping) is taken care of by selection of proper blade angle. The chatter stability is minimized by operating grinding process as far away from natural frequency as possible. The lobing behaviour is characterized by the root location of the characteristic equation of the lobing loop given by:

$$K(1-e^{-2\pi u}) + [1-K_1 e^{-\alpha u} + K_2 e^{-(\pi-\beta) u}] = 0$$

The root branches are approximately calculated from a first order Taylor's series approximation:

$$u_{2k-1} = j(2k-1) + \frac{-1+K_1 e^{-j\alpha(2k-1)}+K_2 e^{j\beta(2k-1)}}{2\pi K+K_1\alpha\, e^{-j\alpha(2k-1)}+K_2(\pi-\beta)e^{j\beta(2k-1)}}$$

$$u_{2k} = j(2k) + \frac{-1+K_1 e^{-j\alpha(2k)}+K_2 e^{j\beta(2k)}}{2\pi K+K_1\alpha\, e^{-j\alpha(2k)}+K_2(\pi-\beta)e^{j\beta(2k)}}$$

where k is an integer number.

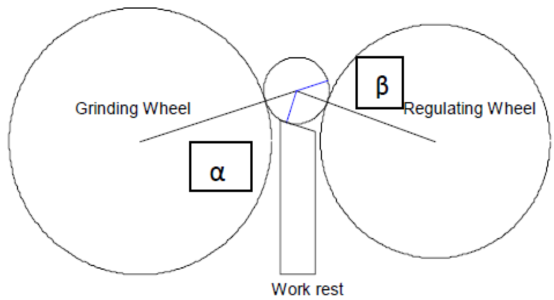

Figure 4 : Centerless grinding arrangement

Using the above equations the effect of different parameters like K, α, and β and lobbing behaviour is simulated and stability diagrams are plotted as in Fig.5

H. Guided chain drive

Chain drives with shorter center distance and with few links of longer length cause a lot of problems in their design and application. Consider that each long link is carrying a storage tube to carry a tool etc in an automatic storage and retrieval system (ASRS).

Fig. 6 shows one symmetrical arrangement of the ASRS for 10 tube locations with 10 links connected by rollers (marked 1 to 10) and carrying the tubes. The path or guide (center of rollers 1 to 10) in this case is similar to belt drive or conveyor type. This is one of the symmetric arrangements, which helps in deciding the total chain length and the overall size in x-direction. The total chain length also depends on other parameters like the radii of the guiding profile and the distance between the straight paths.

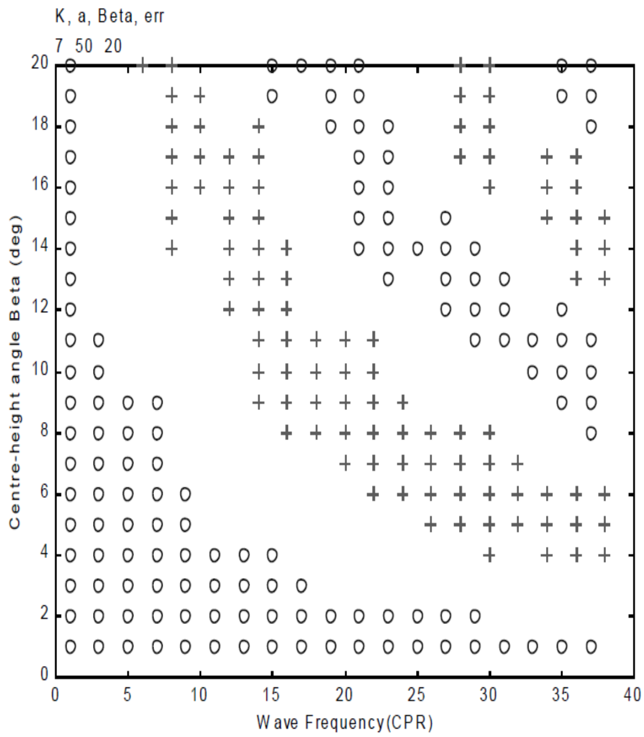

Figure 5: stability diagram

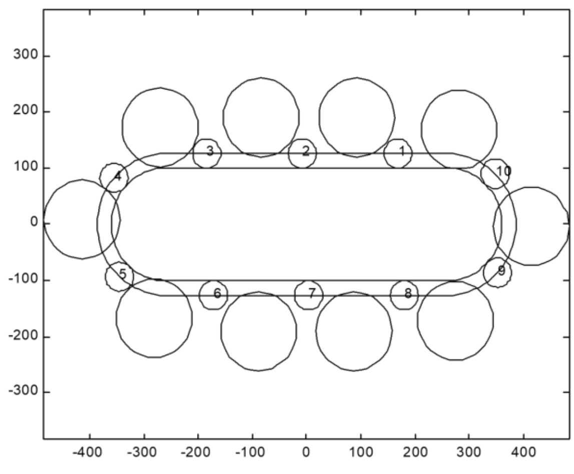

Figure 6 : Arrangement of ASRS for 10 locations

Fig.7 shows another symmetrical arrangement, which comes during indexing. The total chain length for this arrangement is different from the one shown in Fig.1

The chain length variation or the center distance between the pulley locations as in case of belt drive can be easily derived with the help of Figures 8 and 9 where the link length *l* is same as the pitch diameter *D* of the sprocket (or pulley considering the diameter of roller connecting the links)

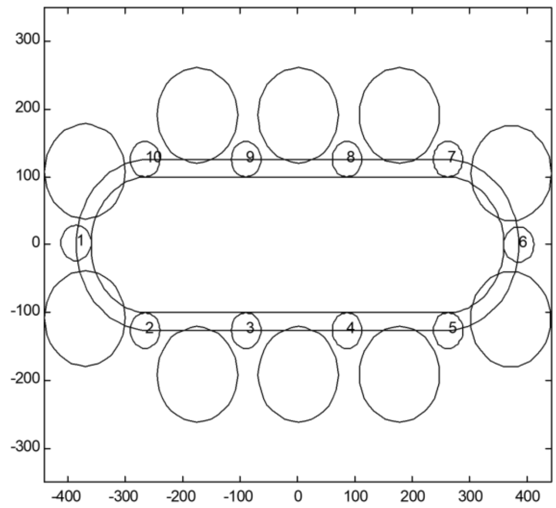

Figure 7 : A second symmetrical arrangement of tube locations

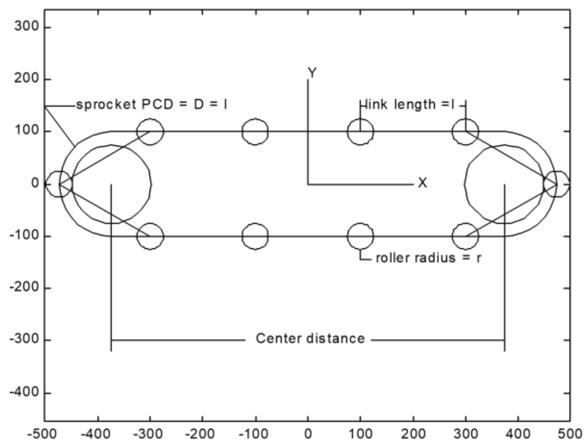

Figure 8 : First arrangement with link length and pulley diameter equal

From Fig. 9, the center distance is4*l* where as from Fig. 8, the center distance is (3+√3)*l* i.e., 4.732*l*. Thus the difference in center distance is 0.732*l* or 73% of the link length. Thus one may select the shorter center distance and calculate total chain length on longer center distance basis for its satisfactory function with sagging if acceptable, as a parameter.

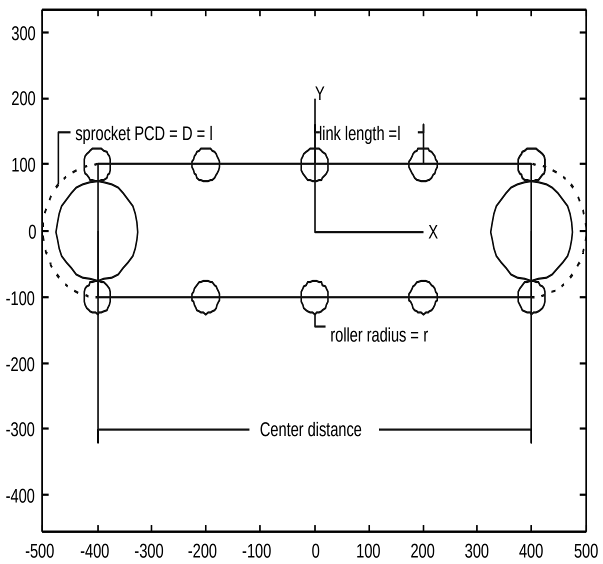

Figure 9 : Second arrangement with link length and pulley diameter same

Now the present problem is as follows:

1) Is it possible to design a guide or path supporting the rollers of the chain such that the center distance between the centers of the end guiding arcs is same in both the extreme cases?

Here we consider some intuitive profiles and optimize them based on the minimum chain length variation. The center distance is fixed based on the least center distance criterion corresponding where two of the links occupy exact vertical positions. Fig.8 and 9 suggests that the distance 2*d* between the top row of rollers and bottom row of rollers to be considered as a parameter for the guide. Because of the size of the tubes carried on the links, the size of the links is fixed and cannot be considered as a variable. Thus a symmetrical guide with r_1, r_2, r, and d as the parameters is considered as shown in Fig. 9 or Fig 11, where r_1 is the radius of the arcs at both ends of the guide, r_2 is the radii of the 4 arcs tangential to the circle with radius r_1 and the horizontal straight line separated by distance d. The limiting profiles are as in Fig. 10 and 11.

III. CONCLUSION

Computation of chain length variation:

As the rollers of the chain move over the guide the positions of all the 10 rollers have to be calculated. This is done by the similar procedure mentioned above for all the 10 rollers considering the respective roller locations on the guide. Finally the distance between the roller 1 and roller 10 is computed. If this happens to be exactly l then there is no chain length

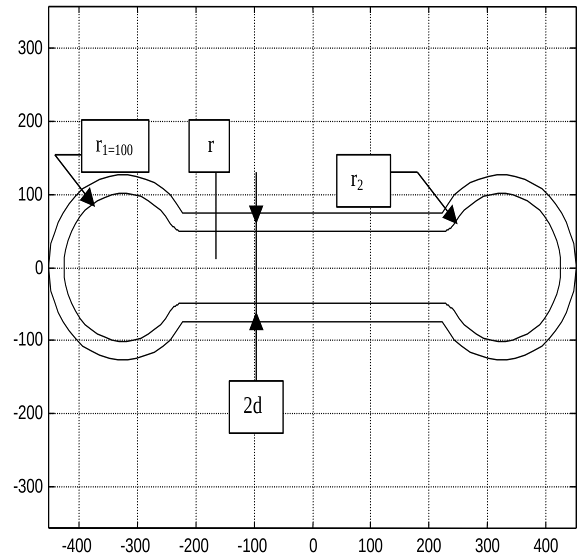

Figure 10 : Limiting guide when r_2 = r=26, d = 49 and r_1= 100

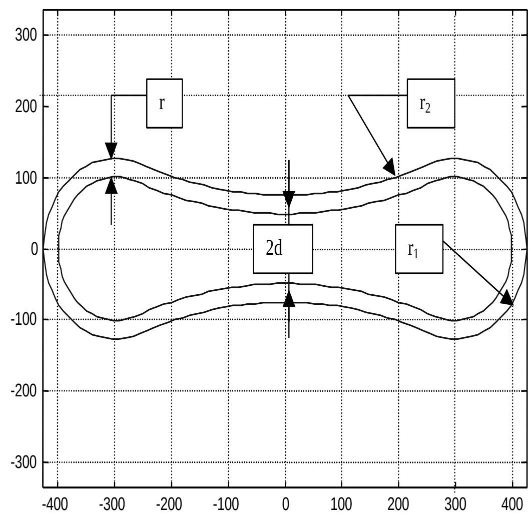

Figure 11 : Limiting case where the horizontal straight line portion seen in fig. 7 is absent, r_1=100, r_2 = 784,

and d = 49 (Profile with only four arcs)

variation. But as expected the length of the last link (between rollers 1 and 10) is different from l. This last link length is computed for different locations of the first roller location as it moves from one end to the other end on the quarter guide profile. This procedure is repeated by varying r_2 only keeping d=45 and r_1=105.8, r=30, and l = 204.38 which were some constraints. When r_2 = 680.625 the variation in the last link length was minimum at 3.3866 as shown in Fig. 12.

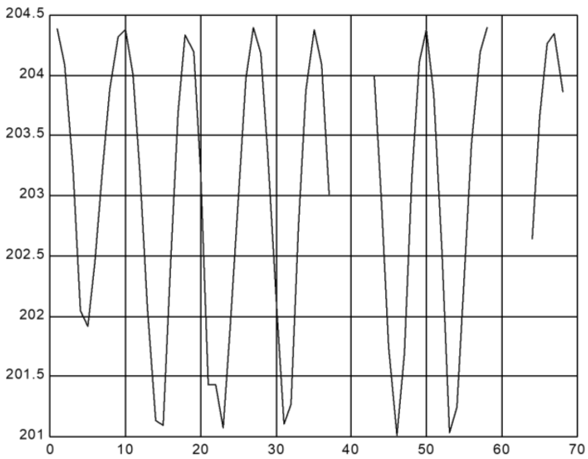

Figure 12 : Last link length variation as the first roller rolls through a quarter of the guide

IV. REFERENCES

[1]. T S R Murthy, A graphical based logical approach for inverse kinematics of a six axes articulated robot for non-intersecting wrist axes. Int Conf on CAD/CAM Automation, Robotics and factories of Future, INCARF'96, New Delhi, Dec 96, p241-222(1996)

[2]. T S R Murthy and P Babin, A method for evaluation of setting parameters for camber grinding on conical surfaces, CIRP International Seminar on Intelligent Computations in Manufacturing Engineering, July 98, p659-664, Capri, Italy (1998).

[3]. T S R Murthy, A method for evaluation of paraboloid surfaces, CIRP International Seminar on Intelligent Computations in Manufacturing Engineering, July 98, p439-445. Capri, Italy (1998)

[4]. T S R Murthy and D R Raghavendra, Application of autoregressive models for control and manufacture of cam profiles, 18th AIMTDR, Dec 98, p 260-264. IIT Kanpur (1998).

[5]. T S R Murthy, A tent fit algorithm for flatness evaluation & vision system calibration, 18th AIMTDR, Dec 98, p 387-391, IIT Kanpur (1998).

[6]. T S R Murthy, Study on the manufacture of piston rings, Int Seminar on manufacturing technology beyond 2000, Nov 1999, Bangalore p137-144, (1999)

[7]. T S R Murthy, Simulation of relationship between setting parameters and lobing behaviour in centerless grinding. Int Seminar on manufacturing technology beyond 2000, Nov 1999, Bangalore p104-111, (1999)

[8]. T S R Murthy, Simulation and computer aided optimum design of a specially guided automatic storage and retrieval system. Ninth National Conference on machines and mechanisms, NaCoMM-99, IIT Bombay Dec 1999, p199-209 (1999).

Cite this article as :

T. S. R. Murthy, "Some Design Analysis And Simulation Problems In Manufacturing Engineering Using Matlab", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), ISSN : 2456-3307, Volume 6 Issue 1, pp. 420-425, January-February 2019. Available at doi : https://doi.org/10.32628/IJSRSET196174

Journal URL : http://ijsrset.com/IJSRSET196174