Design and performance analysis of baffle type moisture separator and its comparison with old existing model

Tanhaji Bhikaji Kokare, Department of Mechanical Engineering, Vishwakarma Institute of Technology Pune, India, Email – tanhajikokare222@gmail.com

Prof. Dr. Dattatray Hulwan, Department of Mechanical Engineering, Vishwakarma Institute of Technology Pune, India, Email – dattatray.hulwan@vit.edu

Abstract —**Moisture contains in steam is one of the main concerns in steam system. It can reduce plant quality, plant productivity, and can cause damage to equipment. To remove moisture contain separator are installed in steam pipeline. In this paper, condensate collected by moisture separator and pressure difference across baffle type moisture separator were evaluated to determine performance of moisture separator. This works explore the design of baffle type moisture separator using numerical method and comparison of experimental results between new designed and existing baffle type moisture separator of size 25 NB.**

Keywords — **moisture separator, baffle plates, dryness fraction, baffle plate angle, condensate, pressure drop**

I. INTRODUCTION

The steam produced in a boiler is almost saturated steam. Still it contains small amount of moisture. There is always a certain amount of heat loss from the distribution pipe, causes steam to condense. These condensed water droplets are settle down at bottom of pipeline. Steam flowing over this water can build up into waves. Moisture content in steam will cause water hammer, wire-drawing, corrosion, scaling of impurities and damage to controlling devices. So to remove suspended water droplets separators are installed in the steam line.

To attain a reasonable quality of steam we could use a high performing moisture separator. Nowadays, process industries and power plants use various types of moisture separators like centrifugal type, coalescence type, and baffle type moisture separators. The centrifugal type moisture separator has a series of fins to generate high speed cyclonic flow. The high velocity centrifugal force causes heavier particle to flow outward and get settle down at bottom. The coalescence type provides an obstruction in steam path. It has demister a demister pad to remove the moisture. These moisture separators needs frequent inspection and maintenance to either repair or replace working material. The baffle type moisture consists of number of baffle plates. Steam passes through the baffle and moisture particle collide to form big droplet, these droplet are fall under the gravity and collected at bottom. Baffle type moisture separator has no moving and better efficiency range over wide range of velocity, so it is widely used in steam line. Only disadvantage in baffle type moisture separator is large pressure drop.

The upper baffle plates with an inclination angle of 106^0 and lower baffle with 90^0 gives optimum condition [1]. Improper functioning of steam trap or improper insulation may result error in measurement of condensate. Efficiency of moisture separator is calculated by finding inlet and outlet dryness fraction of steam.

$$\eta = (x_2-x_1)/x_2(1-x_1)$$

Here x_1 and x_2 are inlet and outlet dryness fraction of steam respectively [2]. G. Mauro & M. Sala developed and tested a highly efficient, low pressure drop and mechanically sturdy steam separator. The separator was tested in an air-water loop and in a steam water loop under prototypical conditions. The developmental effort is described and the experimental results are given. They concluded that these separators have the highest efficiency, and have a very large operational margin [3]. Inertia force is dominant in separating the large droplets, while the fine droplets are separated by eddy droplet interaction. Generation of secondary droplet by the breakup of water film should be taken into account at high inlet velocity Separator with minimum pressure drop and more condensate is considered as performing better as compared to other [4]. The pressure drop coefficient depends on inlet steam quality at separator inlet not on operating pressure. Ideal operating range for all type of moisture separator is an inlet steam quality of 0.7 to 0.8 [5]. Eulerian-Eulerian (E-E) as well as Eulerian-Lagrangian (E-L) multiphase models, available is STAR-CCM+ CFD solver can be used to solve problem in separator [6]. The separation efficiency achieved by the Bangma type webre separator is in the order of 99% and it is sufficient for most processes [7]. More amount of the moisture can be removed in the filter and desiccant chamber can be protected against the contamination. Hence life of system components will increase [8].

In this work, 25NB baffle type moisture separator is designed with 4 numbers of baffles attached from side of

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separator casing and inclined baffle angle of 108^0 with vertical axis. The performance of this moisture separator is compared with existing 25NB model with 3 baffle plates attached at top and bottom of casing. Test rig is developed to compare the performance of both separators. Readings are taken for 10 minutes. The condensate collected and pressure drop across separator is measured for different steam velocities and operating pressure.

II. METHODOLOGY

These woks explore the numerical design and experimental testing of baffle type moisture separator.

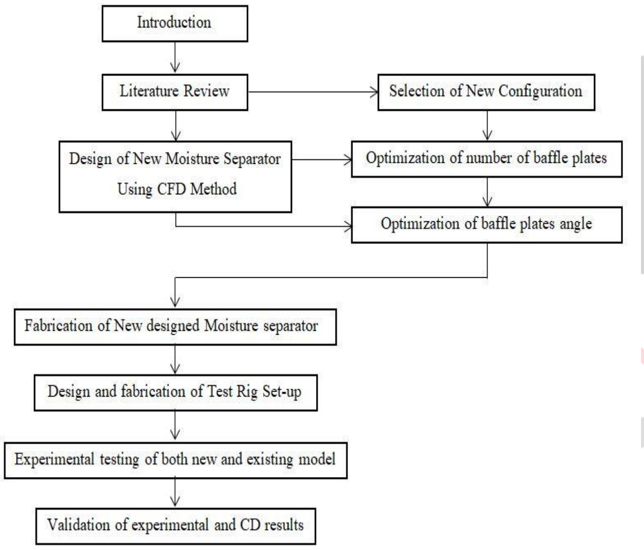

Fig.1 Flow chart project

Fig.1 shows flow chart of project methodology in more detail. It includes:

1. Design of new 25NB moisture separator.
2. Fabrication of 25 NB baffle type moisture separator.
3. Design and fabrication of test rig of 25mm ID pipe line.
4. Experimental testing of separator for different mass flow rate of steam and operating pressure.
5. Comparison of experimental and CFD results.

III. DESIGN OF NEW MOISTURE SEPARATOR

In order to improve the efficiency of moisture separator new moisture separator is designed. Moisture separator is designed such it should give minimum pressure drop and maximum condensate.

Fig.2 Old Existing Model

Fig.2 shows arrangements of baffles in existing model. Here inclined angle of baffle to horizontal axis is 120º.

A. Configuration of baffle plates

The configuration of baffle plate is changed such that baffle plate are attached to side plates of casing instead of attaching it to top and bottom curve of casing.

B. Number of baffle plates

For finding out optimum number of baffle plate CFD Analysis is carried out on 2, 3, 4 and 5 numbers of baffle plates.

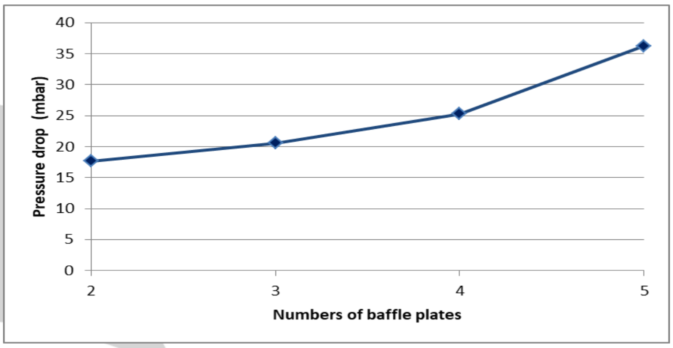

Fig.3 Selection of numbers of baffle plates

Fig.3 shows pressure drop across moisture separator goes on increasing gradually with increase in number of baffle plate but after 4 number of plate further increase in plate pressure drop increases very high from 25.3 to 36.21 which causes considerable loss of energy. So 4 number of baffle plates are selected as optimum combination.

C. Baffle plate angle

In moisture separator even number of plate is always kept to perpendicular to horizontal axis and odd plates are tilted to some angle to horizontal axis of moisture separator.

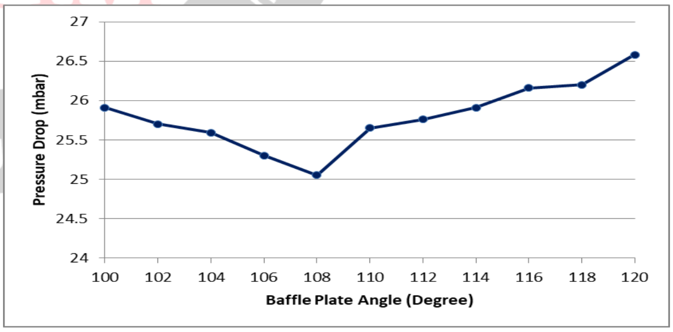

Fig.4 Bafle plate angle v/s Pressure drop

CDF analysis for pressure drop across moisture separator carried out for different angle of baffle plate from 100º to120º keeping other parameter same. Results are as shown in Fig.4. Baffle plate with angle 108º gives minimum pressure drop. So this angle is selected for fabrication.

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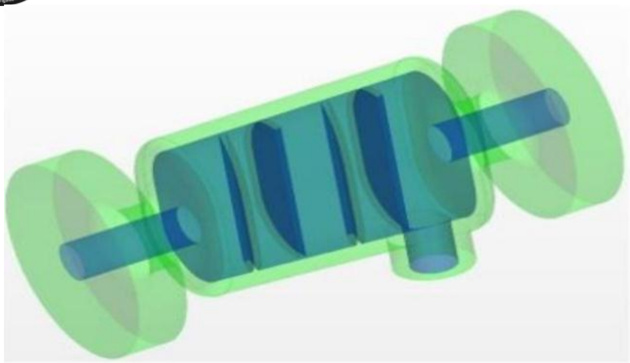

Fig.5 New Designed Model

Fig.5 shows new designed model of moisture separator. It has 4 baffle plates with 1st and 3rd plate has 108º angle.

IV. Test Setup

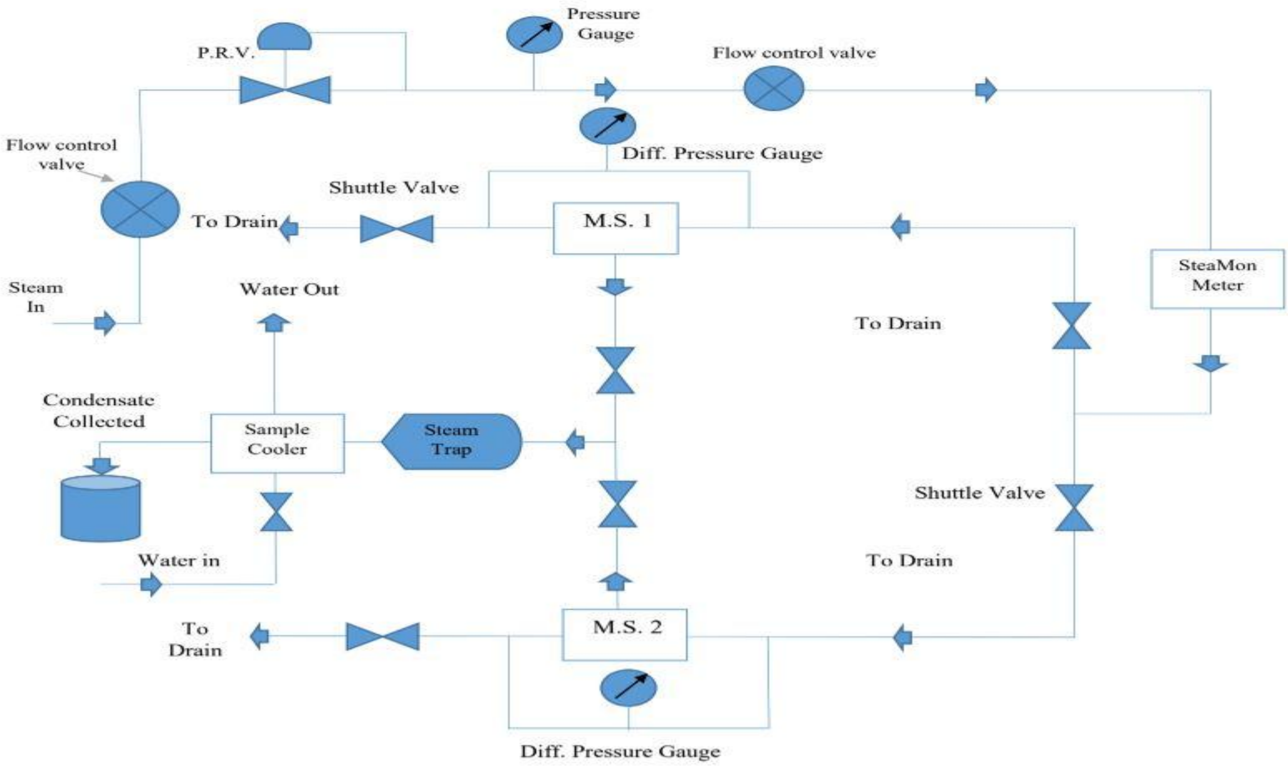

Fig.6 Test set-up

Fig.6 shows experimental test setup consists of two moisture separator MS1 (Existing moisture separator) and MS2 (new designed). Spring operated PRV is used to adjust pressure. Steamon meter reads the flow rate of steam. The condensate is collected at bottom of moisture separator though steam trap and weighted. Sample cooler is used to avoid flashing of condensate. Differential pressure gauges are connected parallel across the both moisture separator to measure the pressure drop. Calculated amount of steam with certain pressure is passed though each separator to check the individual performance at a time.

V. Result and Discussions

4 numbers of baffle plates and odd plate with 108º angles moisture separator is fabricated for testing purpose. Result of condensate collected and pressure drop at different velocity of steam flow are plotted as following.

A. Comparison of new moisture separator with existing model

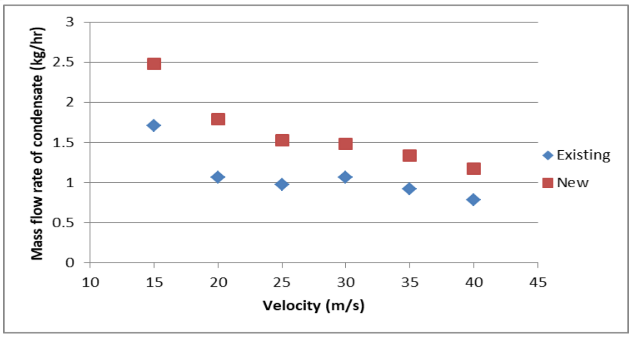

Fig.7 Condensated collected at 1 bar

Mass of condensate calleted at 1 bar are shown in Fig.7. It shows that amount of condensate callected by new moisture separator are more than exsting one. With increase in

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velocity condensate got reduced for both moisture separators.

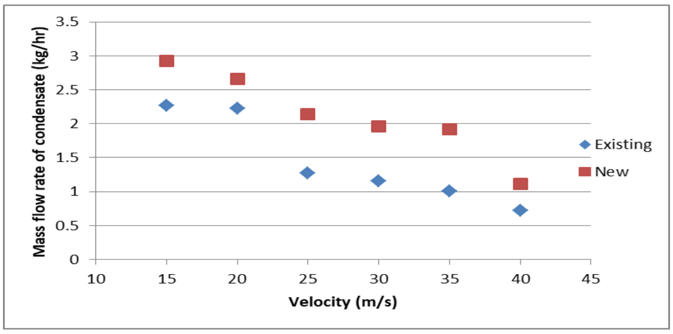

Fig.8 Condensated collected at 2 bar

As shown in Fig.8 condensate collected at 2 bar slightly increases but not significant change.

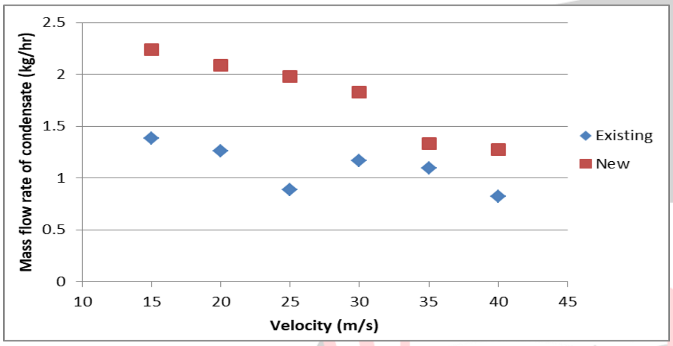

Fig.9 Condensated collected at 3 bar

Fig.9 shows condensate collected at 3 bar pressure. It also has same trends as that of 1 and 2 bars.

Ratio of pressure drop by new over existing moisture separator at different range of velocity and pressure are shown in Fig.16.

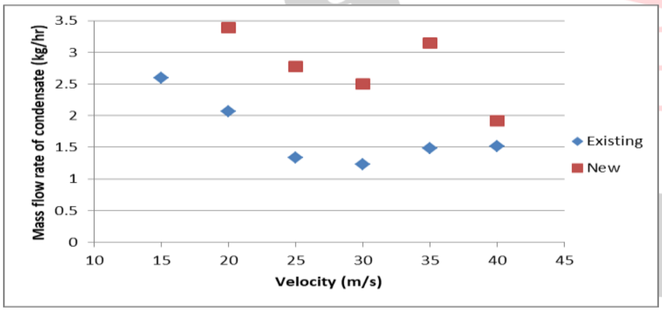

Fig.10 Condensated collected at 4 bar

If we see all Fig.7, 8, 9 &10 it is founded that with increase in working pressure condensate collected increases slight.

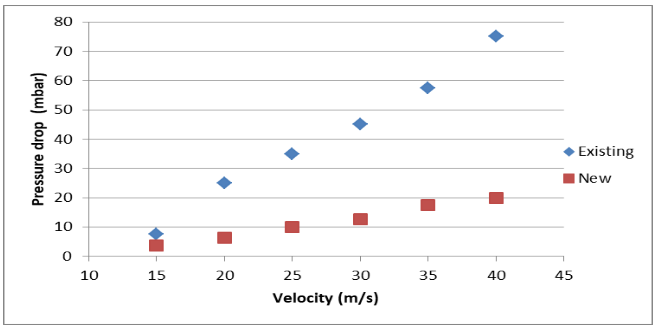

Fig.11 Pressure drop at 1 bar

Fig.11 shows that Pressure drop across the moisture separator at 1 bar working pressure. It shows that pressure drop increases with both increase in velocity for both moisture separator and it is found to be less for new moisute separator as compared to existing one for all combinations.

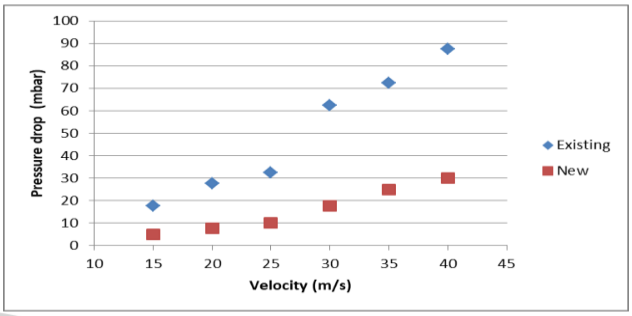

Fig.12 Pressure drop at 2 bar

For 2 bar pressure drop is greater than that of 1 bar. It can be say that pressure drop across the MS goes on increasing with increase in working pressure.

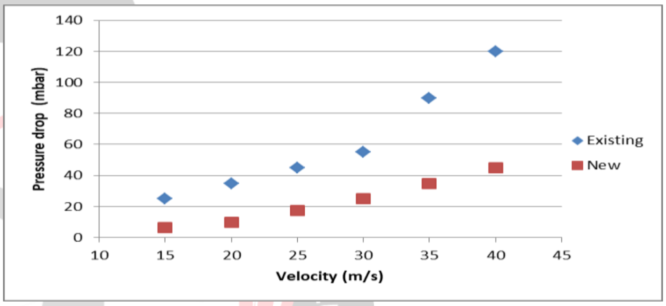

Fig.13 Pressure drop at 3 bar

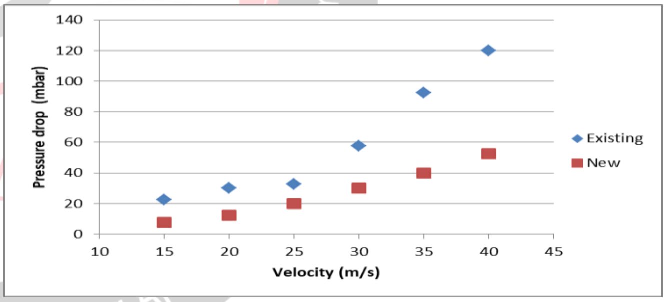

Fig.14 Pressure drop at 4 bar

Same result are found at 3 bar and 4 bar as shown in Fig.13 and 14. There is slightly increase in pressure drop with increase in working pressure is observed.

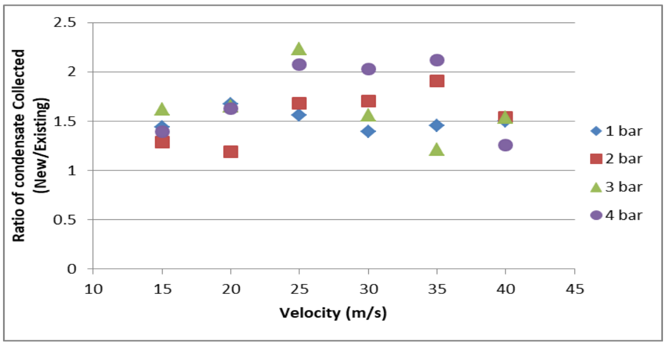

Fig.15 Ratio of ondensate collected by new over existing moisture separator V/S velocity

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Ratio of ondensate collected by new MS over existing MS at different range of velocity and pressure are shown in Fig.15. It shows that ratio of all combination found between 1 to 2.5. it indicates that new moisture separator is better in efficiency as compare to existing one.

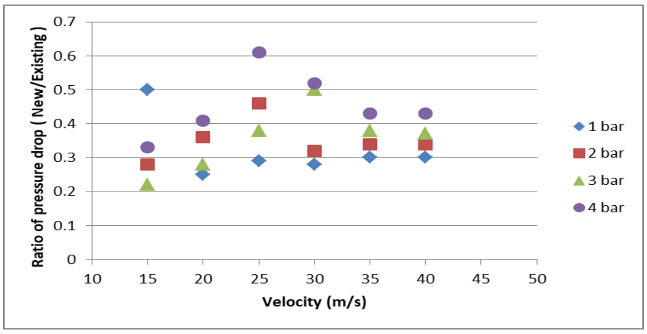

Fig.16 Ratio of pressure drop by new over existing moisture separator V/S velocity

Fig.16 shows that ratio of pressure drop for all combination found between 0.2 to 0.7 indicates that new moisture separator has less pressure drop as compared to existing one. Means new design is better in energy saving.

B. *Validation of Experimental result with CFD*

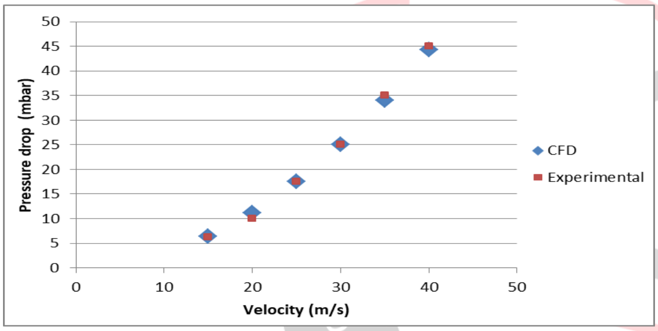

Fig. 17 Experimental &CFD result of pressure drop across new MS at 3bar.

Fig.17 shows Experimental &CFD result of pressure drop across new MS at 3bar. Both results match in every aspect and follows same trends. Maxium Error between Experimental &CFD results is found to be 13.7%.

IV. CONCLUSION

In this work new moisture separator is designed using CDF method in Star CCM+ and experimental testing is carried out on both new and existing model to compare the performance. It is found that baffle type moisture separator with 4 numbers of baffles and odd number of baffle with 108° angle is found to be optimum condition in design of moisture separator. While testing it is found that amount of condensate decreases with increase in velocity of steam in both the moisture separators. Amount of condensate found to be more for new designed moisture separator for all range of pressure and velocities. Pressure drop increases with increase in pressure and velocity for both moisture separator and it is found to be less for new moisute separator as compared to existing one for all combonations. Hence new design moisture separarator is better in both case of energy saving and seperation efficiency.

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BIOGRAPHIES

Tanhaji Bhikaji Kokare
Student
M.Tech (Heat-Power Engineering)
Department of Mechanical Engineering
Vishwakarma Institute of Technology
Pune

Prof. Dr. Dattatray Hulwan
Professor
Department of Mechanical Engineering
Vishwakarma Institute of Technology
Pune

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