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Review on Enhancement of Centrifugal Pump Performance with the Help of Various Methods

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Abstract: The paper reviews the journalism available related to the enhancement of efficiency of centrifugal pump. For variety of applications like water distribution plants, sewage treatment, chemical plants, oil refineries, etc, centrifugal pumps are extensively used on a large scale. Due to this reason, there may be a deterioration in their performance over a period of time. This paper discusses the available resources associated with the performance development through various parameters.
Keywords: Centrifugal pump, efficiency, performance, improvement, coating, etc.

I. INTRODUCTION

A centrifugal pump is one of the most used equipment in any process plant. They are used to convey the flow of fluids by converting the rotational energy driven from a prime mover into kinetic energy of fluids. They consist of various components like stuffing box, packing, shaft, shaft sleeve, vanes, casing, impeller, casing wear ring and discharge nozzle. The casing is a hydraulic component that collects the fluid imparted from the impeller and directs it towards the discharge side of the pump. The fluid first enters the pump through its inlet, then flows towards the impeller blades and is then pumped out passing through the volute chamber. Pumps can handle large amounts of fluids and can perform efficiently at higher flow rates with the ability to adjust their flow rates over a wide range. But, they can suffer from numerous physical and mechanical problems, including corrosion, cavitations and reliability associated with poor efficiency or performance. All these parameters may affect the power consumption of the equipment which may increase the running cost considerably. Minimizing the performance and efficiency deterioration is a major factor of consideration for pump manufacturers and users. Current review summarizes research and investigation on the research on pumps and the various methods related to improvement of pump performance.

II. LITERATURE REVIEW

Mr. Amitkumar Bhimrao Salunkhe et al. [1] have reviewed the different ways that affect the efficiency of a centrifugal pump through modifications in its suction manifold. Different researches regarding the same were studied and certain conclusions were drawn out. First of all, it was seen that formation of vortices and cavities introduce reduced efficiency of the pump. Also, if the intake flow pattern of the pumping station is not desirable, it affects the operation of the pump. For this purpose, it requires a uniform flow distribution. Proper use of CFD models served as an important tool to analyze the performance of pump by bringing about changes in various parameters affecting the efficiency and neatly optimizing the pump sump geometry. It can be seen from Fig.1 that at flow rate of 1 litre/sec, the highest value of head is 5.6 m with a total efficiency of 47%, furthermore, as the flow rate increases, the head decreases and total efficiency increases. It was also concluded that proper re-engineering of the suction side of the pump proved to be fruitful in enhancing the flow rate and thus improving the overall performance of the pump.

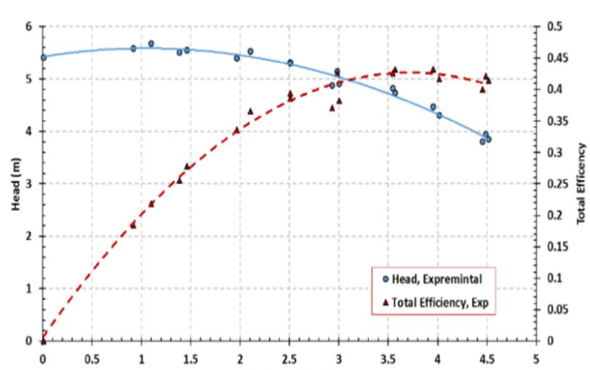

Fig.1 Head vs Flow Rate vs Total Efficiency[1]

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Gamal R.H. Abo Elyamin et al. [2] carried out a research to show how the number of blades on impeller affected the overall performance of a centrifugal pump.For this purpose,they tested 3 different impellers with 5,7 and 9 blades in order to determine the optimum blade number at a speed of 2800 rpm. CFD commercial code was used for this work. The numerical analysis for all three types of impellers was carried out. A comparison was made between the numerical results and a similar turbulence model. The authors concluded that increasing the number of blades decreased the pitch ratio and resulted in more flow inside the channels. It also led to a rise in the friction losses, which in turn affected the efficiency of the pump.

Referring Fig. 2 and Fig. 3, the head coefficient and efficiency were higher for the impeller with 7 blades with just above 1 as compared to the other 2 cases of 5 and 9 blades with both below 1. This is because, for the case of 5 blades, the secondary flow elevates with an increase in the discharge. In contrast, in case of 7 blades, the increase in discharge leads to a decrease in the loss coefficient.Lastly, for the case of 9 blades, the efficiency is almost constant for low and moderate discharge but decreases sharply at high discharge coefficients. Finally, it was concluded that the case of impeller with 7 blades was the best case with hydraulic efficiency of around 60% followed by the one with 5 blades at 50% and the last one with 9 blades at 45%, being the worst amongst all.

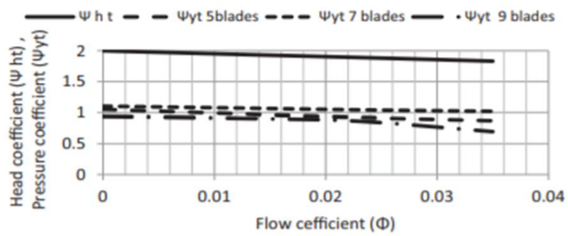

Fig.2 Effect of Number of Blades on the Performance in thePump[2]

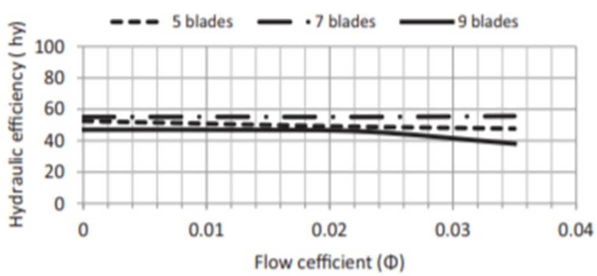

Fig.3 Effect of Blade Number on the Hydraulic Efficiency for Different Flow Coefficients[2]

W Z Kang et al. [3] have performed the analysis of backflow effect in a centrifugal pump. The authors estimated the backflow phenomenon using SST K-omega turbulence model and Rayleigh-Plesset cavitations model. It was seen that backflow led to generation of cavities which in turn affected the inlet flow rate and head of the pump. They made the calculations on a single stage centrifugal pump with pre-defined parameter values. Authors observed that the reverse flow plays a major role in the flow rate of the pumps. It can be seen from the pressure analysis in Fig.4 that, as the time increases, the pressure distribution near the pipe wall decreases to 3540 Pa from its higher value of around 40000 Pa. Due to the decrease in pressure, water bubbles are formed which travel and burst in the high pressure regions i.e. on the pipe walls. It leads to formation of cavities from inlet to the impeller. Also, the oscillation of cavity volume was the main factor for affecting the general performance of the pump.

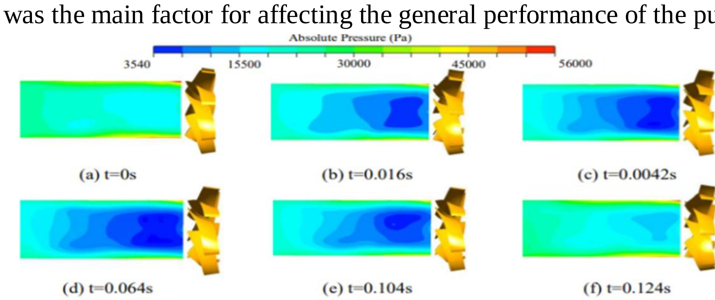

Fig.4 PressureDistribution in Inlet Pipe[3]

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Dong Liang, Zhao Yuqi, Dai Cui and Wang Yong el at. [4] presented a method that compared the experimental results with numerical simulation results in cavitation bubbles distribution images to optimize the accuracy of acoustic field simulation using CFD along with Light hill acoustic analogy. Initially, based on pump product test system and high speed photography, a closed visual testing system was established. Then, the cavitation performance under the rated operating conditions was calculated using various cavitation models.

Based on high speed photography experiment and external characteristics experiment, the appropriate cavitation model for unsteady numerical calculation was selected. Based on vapour volume distribution and cavitation performance curve, four points representing four different cavitation coefficients were selected for further analysis. Various characteristics of cavitation-induced noise at different cavitation coefficients were calculated by using direct boundary element method. Further, the pressure pulsating frequency domain signals were analysed to study the influence of pressure pulsation on acoustic field. From Fig.5,it can be seen that, for cavitation coefficient ranging from 0.4 to 1.0, the head value is constant i.e. 8m. The results showed that, the effect of pressure pulsation is primarily focused on discrete eigen values.

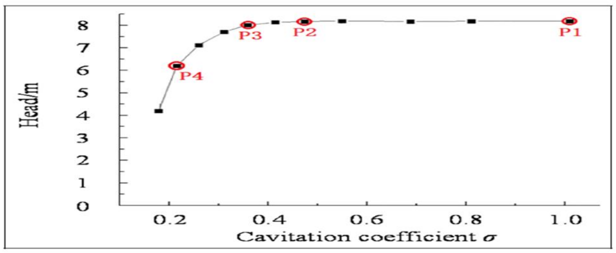

Fig. 5 CavitationPerformance Curve[4]

Erik Gudbjerg et al. [5] represented the results of research projects and information collected in the areas related to energy consumption and the coatings applied to pumps and ventilators in Denmark. Project participants where pump and ventilator suppliers, suppliers of coating material who participated in field tests. Danish industrial companies make use of coating for maintenance purposes. In recent years, they also discovered that coating can increase energy efficiency of pumps and ventilators.

Efficiency varies depending upon the application of different coating materials. Author showed in this paper that, there is the potential for savings especially with respect to maintenance cost and electricity consumption. This study is based on an analysis of the relevant literature, a series of laboratory test with various types of coatings and operations and also side fields tests which include measurements before and after coating. This study has been able to show an increase in energy efficiency of upto 20% for pump use and also a significant extension of pump life. From Fig.6,for small low pressure new pump, it can be seen that for flow rate of 35 m^3/hr, the highest obtained efficiency is 58%.

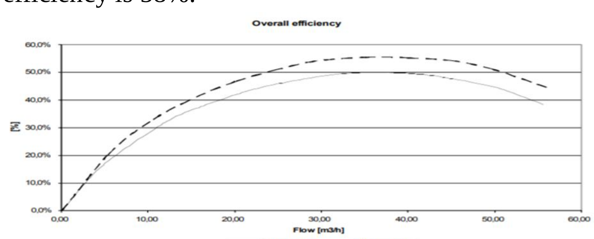

Fig.6 OverallEfficiency, Small Low Pressure New Pump[5]

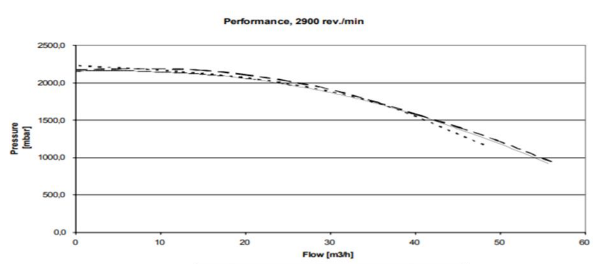

Fig.7 PumpPerformance, Small Low Pressure New Pump[5]

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Krisna Eka Kurniawan et al. [6] suggested that one of the ways to improve pump efficiency is to make modification in the design or the number of impeller blades of centrifugal pump. The main aim of this modification is to increase pump efficiency, decrease cross flow, cut down secondary incidence flow and reduce backflow portions at outlets of impeller. Three splitter blades are added in impeller. Speed of rotation of impeller is 2400 rpm and blade angle at the outlet is 20 degrees. The added splitter blades are 0.25, 0.375 and 0.5 times the length of actual blade. The splitter blades are placed on the outer side of the impeller. Adding the splitter blade with 0.5 length of the original rises pump head till 22 % and the hydraulic efficiency is 38.66 %. From Fig. 8, it was observed that the best efficiency was 40% at a flow rate of 3.02*10^-3 at 2400 rpm for 0.5L splitter blade. The values for other blades were comparatively low with efficiency of blade with no splitter being 8%.

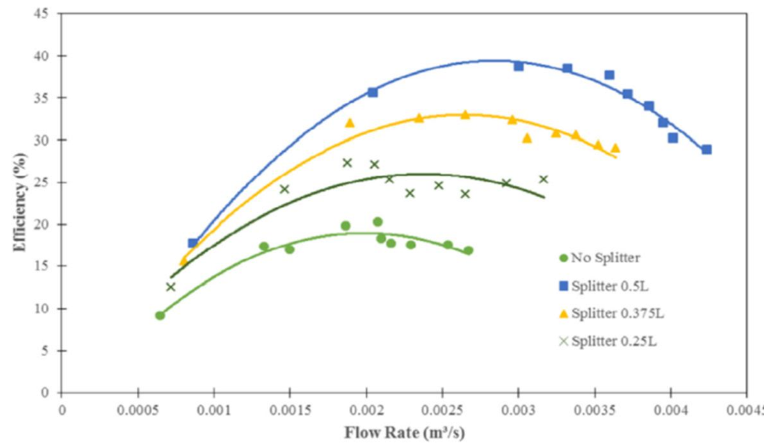

Fig.8 EfficiencyAgainst Flow Rate at 2400 rpm[6]

Shikha Parashar et al. [7] have concluded that sand blasting method can be used to remove all the impurities present on the surface. Sand blasting is known as act of projecting fine pieces of material at high velocity. Generally, this process is used to clean the surface before any treatment on surface and it is done at room temperature with proper safety gear. Firstly, all powder coating, spray galvanization and metals are needed to be sandblasted according to surface. Pressure at the starting is kept 5kg/cm^2 with a profile margin of SA 2.5. For best sand blasting result 250 to 335CFM compressor is used with 6.5 to 7.5 kg pressure.

Use of different kinds of material generates different kinds of material generates different types of surface results. Substances like steel, concrete, wood, glass, plastic etc. and blasting materials create concluding efforts and solutions. Sandblasting process combines the effect of high velocity of air which forces large amount of sand towards the surface of metal eliminating rust. Thus, authors have concluded that sand blasting is effective method to remove all the corrosive material present on the surface. Following Fig. 9 depicts comparison between before and after sandblasting of surfaces.

Fig.9 Comparison Between Surfaces Before and After Sandblasting[7]

Parmar Karan et al.[8] havereviewed on the improvement of efficiency of centrifugal pump by altering design parameters. Nowadays, all kinds of dynamic machineries are being researched for more efficient work. Centrifugal pump are often used for applications like drainage and drinking water systems, chemical industries etc. Centrifugal pumps are classified into single stage and multistage. These pumps are popular because of high speed electric motor and steam turbines etc. Hence to get more optimal performance wide range of parameters are there to be work. In this article authors are dealing with improvement of efficiency of centrifugal pump by modifying its design parameters. Mainly those parameters are impeller and casing. Hydraulic design of impeller was optimised by changing input design of impeller like vane angles tendency length.

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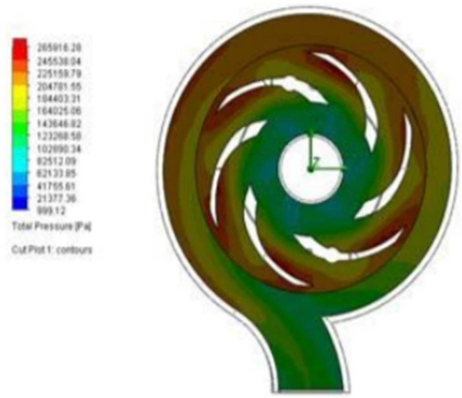

Fig.10 Design&Analysis of Pump Impeller[8]

X B Huang et al. [9] considered four parameters; cutwater gap(δ), blade no.(z), impeller outlet width(b) and blade outlet angle(β) to scrutinize the brunt on external individuality of single stage and single-suction centrifugal pump. Orthogonal test method was taken to carry out the project. L16(4^5) array was selected according to the principle of selecting orthogonal array and 16 models were planned. To compute head and efficiency under diverse commercial CFD software CFX was used.The parameters taken into account were rated flow Qr=194.44kg/s, rated head H=50m, rated rotational speed n=1480 r/min, blade number z=7, impeller diameter D=409mm, cutwater gap δ=36mm, impeller outlet width b=41mm and blade outlet angle β=30.The results showed that 5% deviation was considered and 3 conditions were chosen; Q/Qr=1, 1.25 and 1.375.

variable	1			2			3		
	Q/Q_{opt}=1	Q/Q_{opt}=1.25	Q/Q_{opt}=1.375	Q/Q_{opt}=1	Q/Q_{opt}=1.25	Q/Q_{opt}=1.375	Q/Q_{opt}=1	Q/Q_{opt}=1.25	Q/Q_{opt}=1.375
Δz	1	1	1	1	1	1	1	1	1
$\Delta\delta$ (mm)	4.2	3.2	3.5	5.7	4.9	7.2	5.9	6.8	5.2
Δb (mm)	2.1	1	0.6	6	4.1	2	7	2.7	1.5
$\Delta\beta$ (°)	4.2	4.2	2	4.2	3.4	1.9	4.2	4.2	4.2

Fig.11 Estimated Maximum Allowable Variation of Geometric Parameters[9]

Finally the prototype values were compared with experimental data and L16(4^5) was successfully constructed.

A. Wong et al. [10] put a major focus on pump efficiency, pump performance and Coating performance. The project was carried out by applying anti-Corrosion based coating at internal surfaces and comparing the results between before and after coating of two pumps A and B for a 10 years period. Pump A was coated with ceramic filled epoxy and Pump B with epoxy. Graphs were plotted for Head Vs Flow rate, Efficiency Vs Flow rate and Efficiency vs Flow rate for pre-post maintenance for pump. It can be seen from Fig. 12 that, for pump A, for values of flow rate ranging from 100 to 190 L/s, the efficiency of uncoated new pump(purple line) was lesser as compared to that of coated pump(orange line). The highest obtained efficiency of coated pump was 84%.

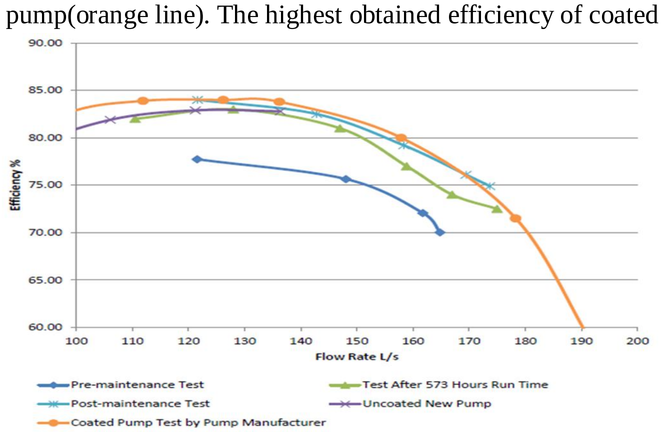

Fig.12 Graph of Flow Rate vs Efficiency for Pump A[10]

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From Fig. 13, for pump B, for values of flow rate ranging from 50 to 150 L/s, the efficiency of uncoated new pump(green line) was higher initially as compared to that of coated pump(red line). At flow rate of 70 L/s, the efficiencies of both, coated and uncoated pump, was same i.e. 82%. Further, the efficiency of coated pump was higher compared to the uncoated one. The highest obtained efficiency of coated pump was 83%.

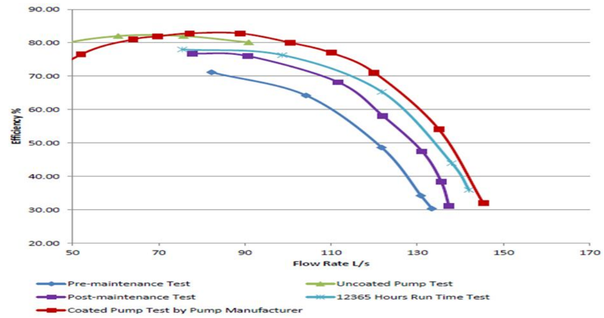

Fig.13 Graph of Flow Rate Vs Efficiency for Pump B[10]

It was seen that for Pump A when compared between before and after coating of pump, there was 2% increase in efficiency, shutoff head was increased upto 7.4m, annual saving upto $3425 and 5% Increased in pre-post maintenance of pump.The final comparison for all parameters of pump A and B were made and was concluded that ceramic filled epoxy performed well in abrasive environment, increased the life of pump, increased the life of pump, increased over hauling time and improved efficiency than epoxy based coating. Finally this project concluded that for increasing pump efficiency, coating of new pumps should be done with ceramic filled epoxy which will reduce the hydraulic and frictional losses and give best performance result for succeeding 10 years of service life.

Jeremie Maillard et al. [11], in a research, gavemajor focus at increasing pump performance as most of the pumping systems focus on 20% worlds electrical demand and 95% of cost to run pumping equipment. Belzona Polymerics Ltd. have more than 50 years experience of formulation. Belzona1341 Supermetalglide gives a unique hydrophobic surface coupled with high erosion-corrosion resistance which reduces friction losses.Belzona1341 increased the new pump efficiency by 6% which was performed in the National Engineering Laboratory.Further in the paper, genesis of problem which were faced in pumps efficiency reduction were found, which were mechanical losses caused due to friction in bearings, worn wear rings, etc and solutions to these problems were stated as proper material selection and coating technology.

Solvent free epoxy coatings were the most compliant one to make pump more erosion-corrosion free. This coating reduced the internal turbulence in the flow, gave extra smooth surface and increased hydraulic efficiency.It can be seen from Fig.14 that Head-Efficiency for values of Flow Rate from 150 to 1100 m3 /hr are more for coated pump than uncoated pump with highest value of head reaching 32 m and efficiency reaching a peak of 90%. Using correct method of coating, performance of the old pump had been improved as compared to its new condition.

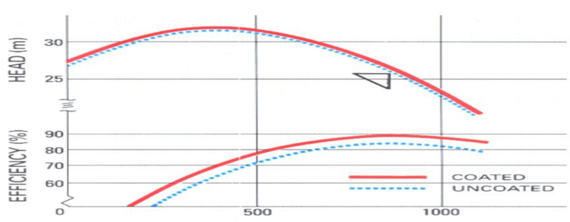

Fig.14 N.E.L. Performance Curve[11]

III. SUMMARY

The above research and review papers provide concise information about various alterations and improvements carried out in order to enhance the efficiency and performance of centrifugal pump. Clear explanation is made with the help of graphs, CFD models and calculations wherever required. Thus, it can be summarized that the performance of pumps can be improved by applying anti-corrosive coatings, adding splitter blades, altering various design parameters and suction manifold. It has been observed that pre-surface treatment and sand blasting have also been useful to reduce the impurities and cavitations caused in the pump, thereby increasing its life and performance.

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REFERENCES

[1] Mr. Amitkumar Bhimrao Salunkhe, Mr. Ranjit Ganaptrao Todkar, Mr. Kedar Madanrao Relekar, "A Review on Improvement of Efficiency of Centrifugal Pump Through Modifications in Suction Manifold", International Journal of Innovation in Engineering Research and Technology , Volume 2, Issue 12, pp.1-6,2015.

[2] Gamal R.H. Abo Elyamin, Magdy A. Bassily, Khalil Y. Khalil, Mohamed Sh. Gomaa, "Effect of Impeller Blades Number on The Performance of a Centrifugal Pump", Alexandria Engineering Journal, pp.39-48,2019.

[3] W Z Kang, L J Zhou, Z W Wang, W Wang, , "Analysis of Backflow Effect in a Centrifugal Pump", IOP Conf. Series 240, pp.1-9,2019.

[4] Dong Liang, Zhao Yuqi, Dai Cui, Wang Yong, "Research on Cavitation Acoustic Characteristics of Centrifugal Pump Based on Fluid-Acoustic Field Coupling Method", Advances in Mechanical Engineering, Vol.10(5), pp.1-13,2018.

[5] Erik Gudbjerg, Hans Andersen, "Using Coatings to Reduce Energy Consumption in Pumps and Ventillators", ECEEE, pp.1533-1540,2007.

[6] Krisna Eka Kurniawan, Budi Santoso, Dominicus Danardono Dwi Prija Tjahjana," Improvement of Centrifugal Pump Performance Through Addition of Splitter Blades on Impeller Pump", AIP Conference Proceedings 1931, 030053, pp.1-5,2018.

[7] Shikha Parashar, Anil Kumar Parashar,"Presurface Treatment of All Materials by Sandblasting", International Journal of Advance Engineering and Research Development, Volume 2, Issue 1, pp.38-43,2015.

[8] Parmar Karan, Vasava Himanshu, Paramar Amit, "A Review on Improvement of Efficiency of Centrifugal Pump by Altering Design Parameters", IJSRSET, Volume 4, Issue 5, pp.606-611,2018.

[9] X B Huang, Z Q Liu, "Research of Factors Influencing Centrifugal Pump External Characteristics Based on Orthogonal Test", IOP Conf. Series 52, pp.1-6,2013.

[10] Jeremie Maillard, "Coating Technology Increases Pump Performance", BELZONA, Runcom, U.K., pp.1-10,2008.

[11] A Wong, P Vince, E Gamboa, "The Economics of Applying Internal Coatings to Pump Casings", Corrosion & Prevention Paper 122, pp.1-12,2012.

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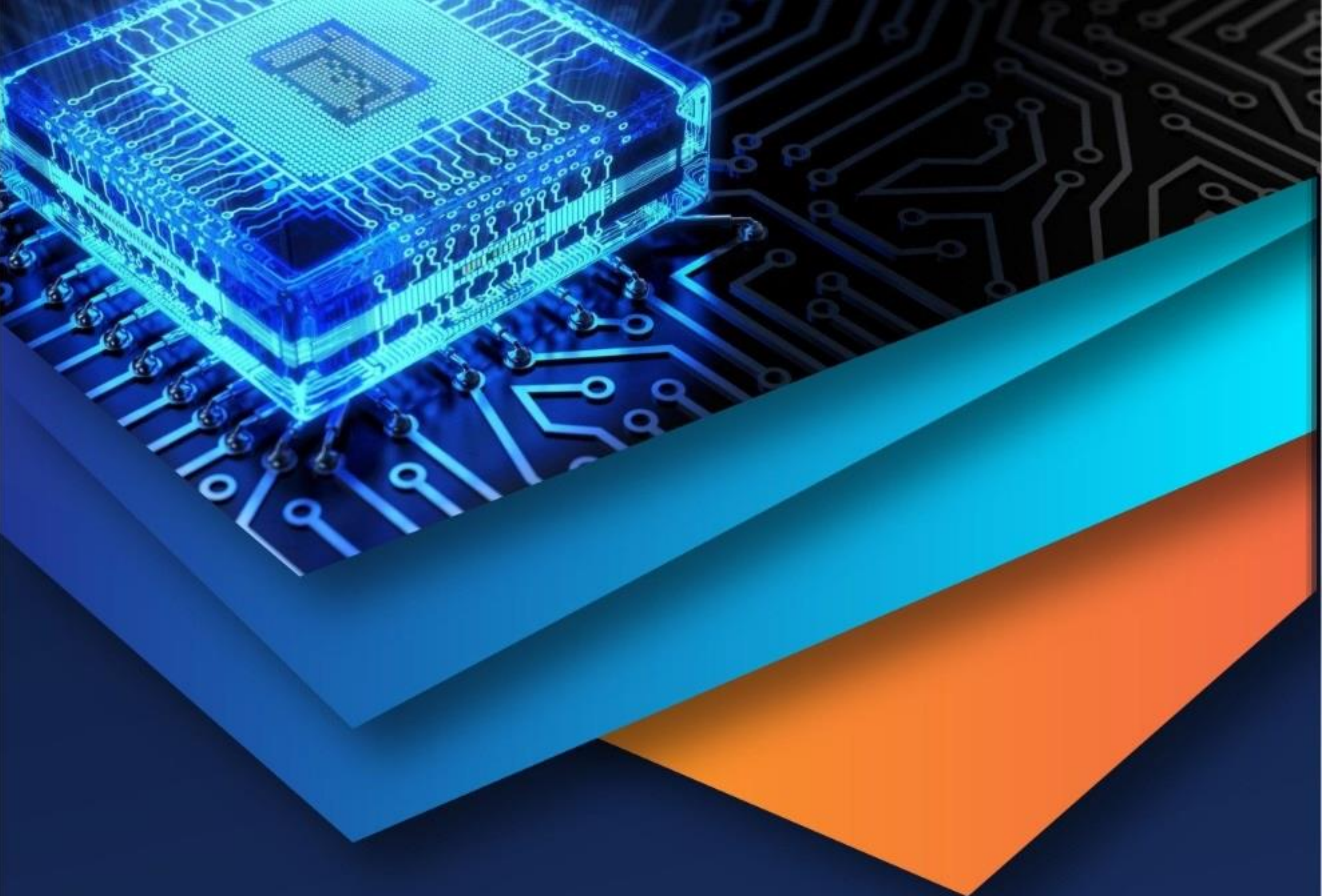

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