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Optimization of Gating and Feeding System for Sand Casting of Connecting Rod using Casting Simulation

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Abstract: ***Casting is a low cost manufacturing process, in which liquid metal is poured into the mould cavity with the help of gating and feeding system. For good quality and defect free casting, the design of gating and feeding system plays an important role. For optimizing casting of connecting rod the first step is to find out the 'hotspot', because most of the casting defects occur due to the hotspot.***
Hotspot is nothing but the part of casting which solidifies last. This paper review optimization of sand casting of connecting rod. The main focus is on the design of gating and feeding system.
The gating and feeding yield is increased also the defects like shrinkage porosity, blow hole are shifted towards the gating and feeding system and hard zone get reduced.
Keywords: Casting Simulation, AutoCast X1, Gating yield, hotspot, Casting defects

I. INTRODUCTION

Casting is one of the oldest, low cost manufacturing processes, by which a molten material such as metal or plastic is poured into the mould cavity and allowed to solidify within the mould. Then removed or broken out to make a fabricated part. The casting process is optimized by using casting simulation software like Autocast X1.Casting simulation is nothing but the process of visualizing casting phenomena with the help of mathematical model in computer program. It gives information about mould filling, solidification with different colour coding, defects and its optimization. By using casting simulation, it is possible to manufacture good quality casting with better yield.

This helps in increasing productivity of company by reducing shop-floor trials. The component casted before casting simulation contains various types of defects, such as blowhole, shrinkage porosity and hard zone. This defect is eliminated by designing proper gating and feeding system.

Casting simulation helps us to design the gating and feeding system also it helps us to identify hotspot. In this study, a connecting rod (sand casting component) was chosen for improving the yield and quality of casting component. The gating system is optimized with the help of AutocastX1 Software.

Yield Ratio: Yield is defined as the ratio of total weight of casting to the total weight of metal poured into the mould. The yield of casting is always less than 100%. While optimizing the casting process, yield ratio is very important. Because it affect on total cost of casting. Lower yield in casting means lower productivity and lower profitability.

II. METHODOLOGY

In this study, for optimization of casting process, the casting simulation software (AUTOCAST X1) is used for visualizing casting process like mould filling, solidification and identification of defects. This software is used for optimization of gating and feeding system for yield improvement.

After finishing the simulation it understand the position of hotspot region and the type of defect produced. By making modification in gating and feeding system the defects are minimized and yield of casting can be increased.

AutoCAST is a software used for casting methods design, simulation and optimization developed by IIT Bombay. It uses geometric reasoning for automating the design of casting elements like cores, mould cavity layout, feeders and gating channels. Fast and intelligent simulation technology is employed to visualize mould filling and casting solidification in near-real time.

III. SIMULATION

The flow analysis was done for gating and feeding system based on calculations and gating as well as feeding system was optimized. The major objective was to produce a casting having good quality and zero defects. Casting designers can often produce a good quality casting by following number of trials for designing gating, runners, risers by calculating its dimensions accurately.

A. Simulation 1

The part dimensions and other inputs based on the calculations was given to the software then simulation was started automatically by the autocast software itself.

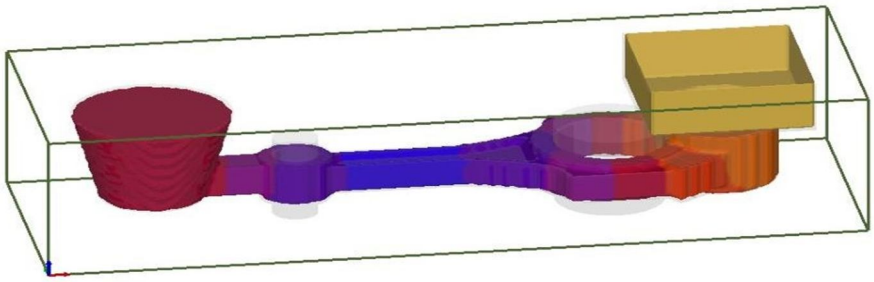
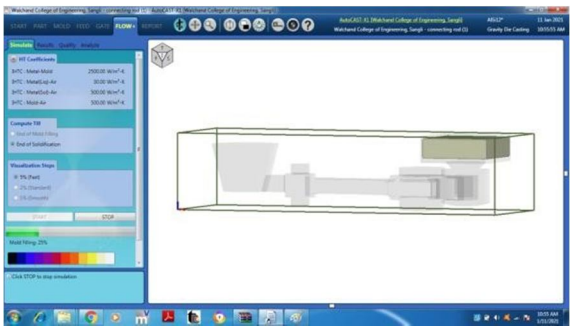


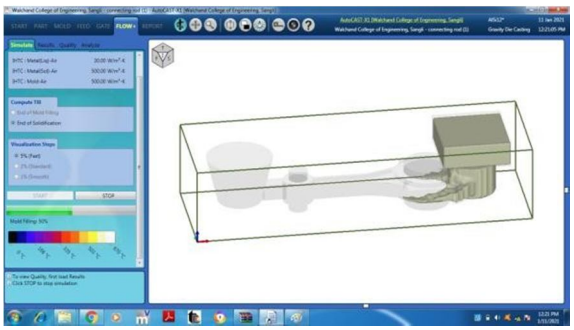
Fig 1. Simulation 1in AutoCast X1

1) Mould Filling

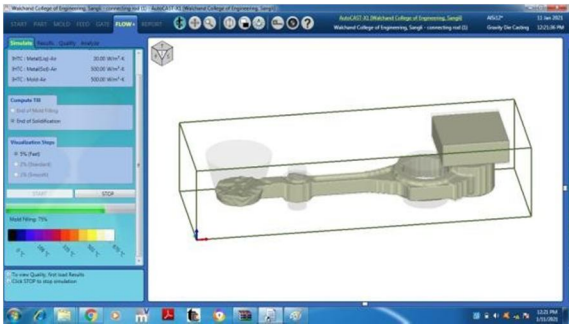
As the simulation was started the simulation Autocast X1 software showed the actual filling of molten metal in the cavity.



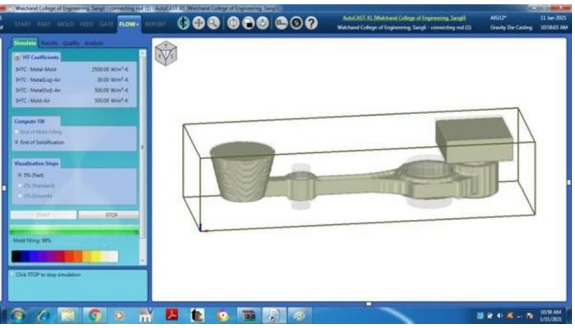
25% mould filling



50% mould filling



75% mould filling

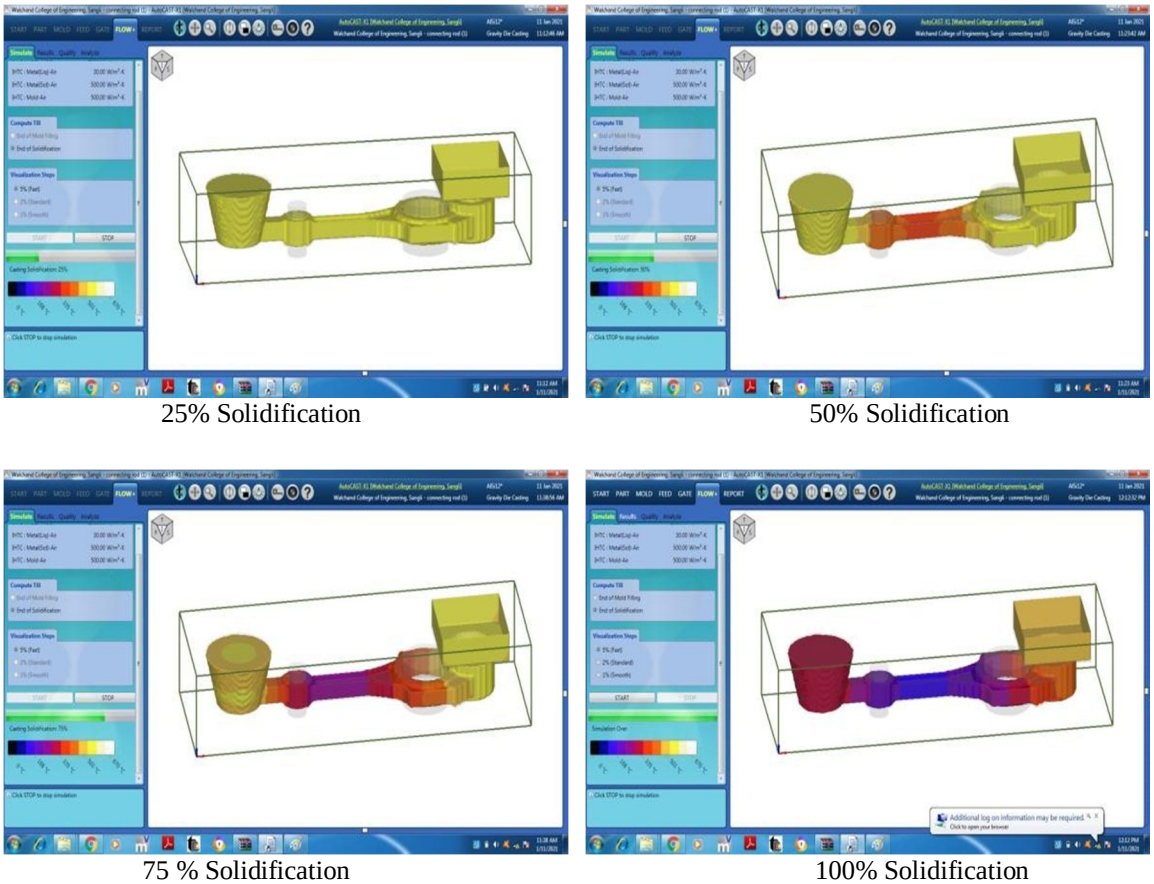


98% mould filling

Fig 2. Mould filling in simulation 1

The fig. 2 shows filling of molten metal in the mould. The mould filling is observed at different time intervals. The careful observation is required at corner or circular part .because for good quality casting it is very important to fill each and every part of the casting component. The time required for mould filling is depending on the shape and size of the component to be casted.

2) *Solidification of Casting:* In simulation software (AutoCast X1), the solidification of casting component was also shown by step by step. The identification of the area where the chances of defects is maximum can be done by only observing the solidification process. During the solidification process, the AutoCast X1 software showed the temperature change as change in the colure. If we want to check exact temperature in digital format, there is facility on the basis of colour change.



25% Solidification 50% Solidification

75 % Solidification 100% Solidification

Fig. 3. Solidification in Simulation 1

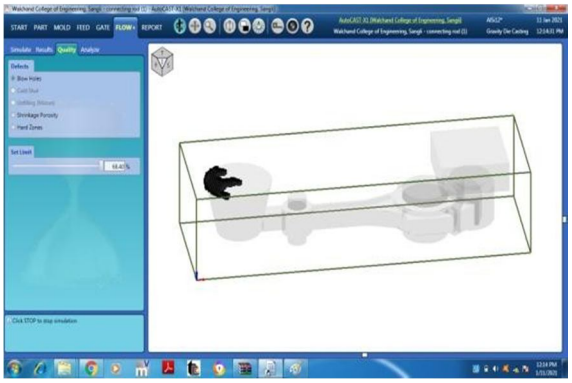
The fig. 3 shows that solidification of casting component was uneven. The outer part of the casting was solidified first as compared to the part where large thickness and the corners are present. Due to this the temperature distribution among the component was uneven. The outer part having low temperature and the part which is at centre of the component having maximum temperature. This results into formation of the defects as well as the residual stress were increased.

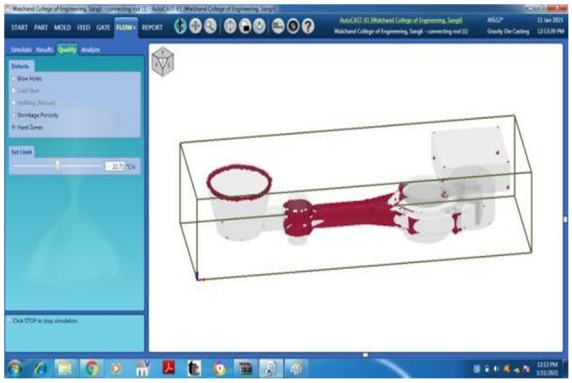
3) *Results of Simulation 1*

The molten material was not completely filled all the part of component. Due to the following reasons

a) The material selected for casting has low melting point.
b) The dimensions of gating system (including feeding system) are not proper.
c) The position of feeder is not correct.

Due to the above reasons the defect in the component generated, that also observed in the AutoCast software. The defects like blow hole, hard zone, Shrinkage was generated at various location in the components. The shrinkage observed at two locations i.e. at basin and feeder. Due to these defects the quality of connecting rod casting was affected. The blowhole was created due to uneven distribution of temperature. The total yield observed was 37%. Also the gating and feeding yield was 28 % and 41 % which is low. Due to these low gating yield the cost required for casting one component get increased.


Blow holes


hard zone

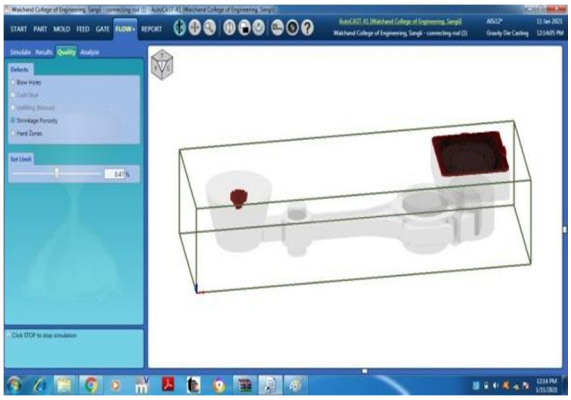

Shrinkage

Fig. 4. Defects in Simulation 1

B. Modification in First Simulation

In the first simulation, three defects were generated in the component which are blowhole, hardzone and shrinkage porosity. By observing the result of simulation we understand that the above defects was generated due to selection of improper size of the feeder also the location of feeder was inaccurate and the dimensions of gating system was inaccurate. The main modification in the gating system was the number of runners and in gates was reduced, height of the feeder was reduced and position of feeder was changed and this is shown in Fig.5. .In first gating system large size feeder and sprue was used and in second gating system the size of sprue and feeder was reduced. By changing the location of feeder the hotspot which was generated at the central part of component is shifted in the feeder. Second simulation was carried out after modification in gating system.

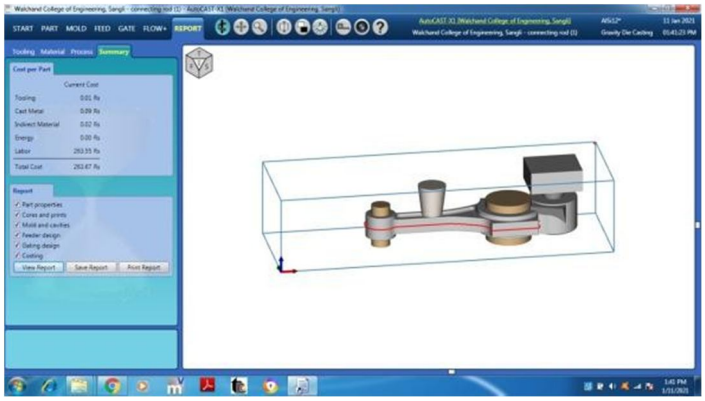
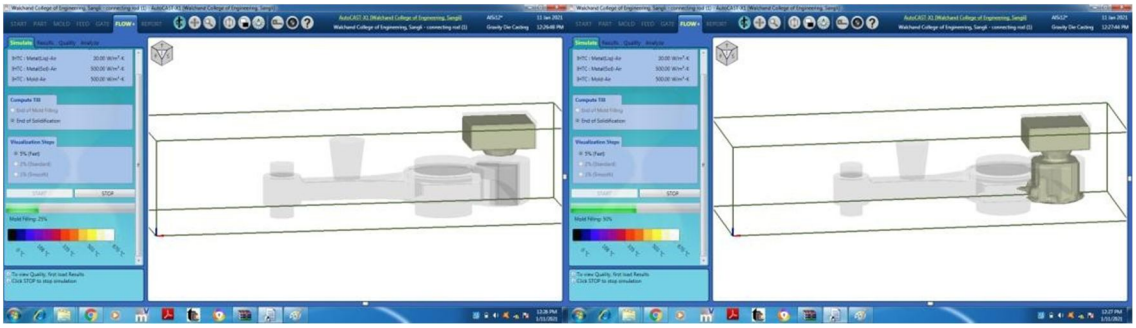

Modification in gating and feeding system

Fig.5. Simulation 2

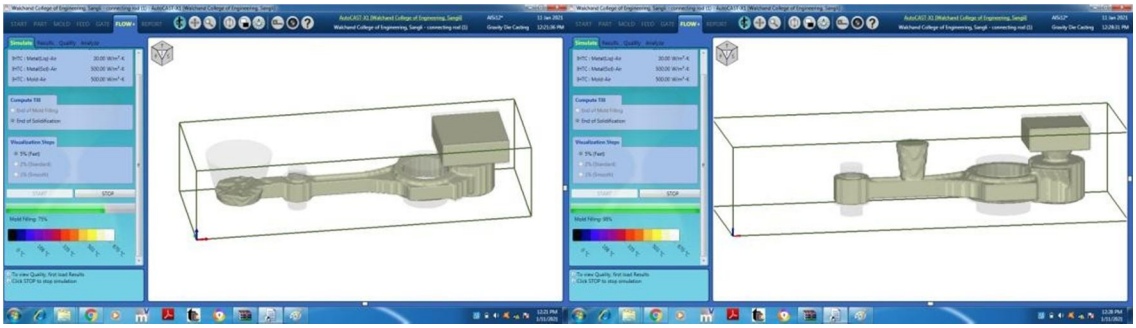
1) Simulation 2

After the modification, the second simulation was performed. This is shown in fig.5

a) Mould Filling: The fig.6 shows the mould filling by molten metal. The mould cavity was completely filled by the molten metal as compared with the result of first simulation and this was because of the modification in feeding system.



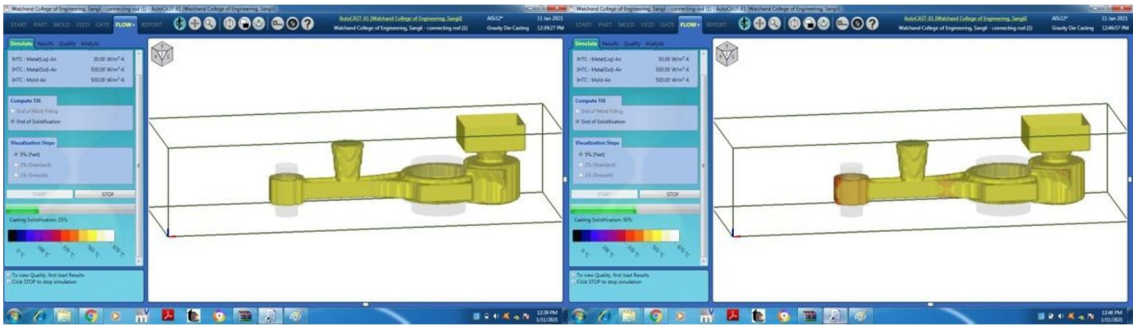
25% mould filling 50% mould filling



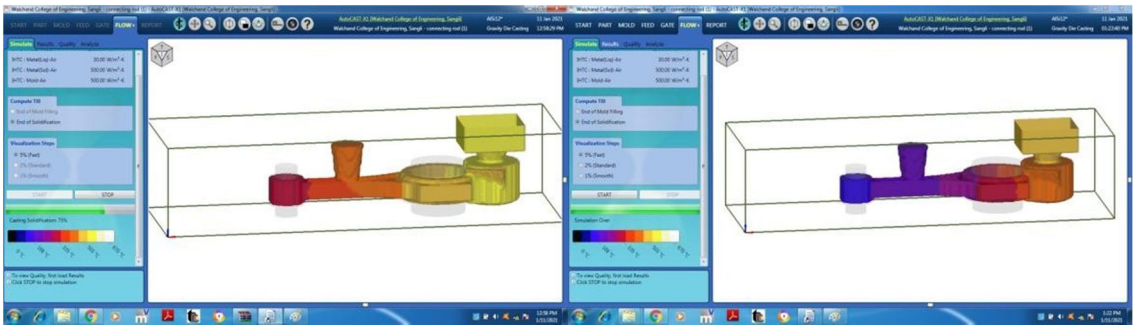
75% mould filling 100% mould filling

Fig.6. mould filling of simulation 2

b) Solidification of cavity: The fig.7 shows the solidification of mould cavity. The mould cavity is solidified with the molten metal. The changes in the temperature is shown by different colure codes.



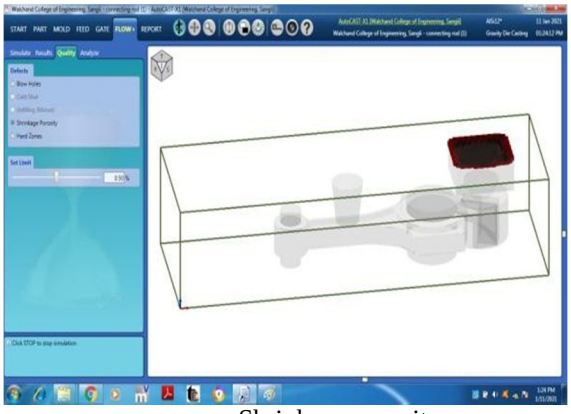
25% solidification 50% solidification



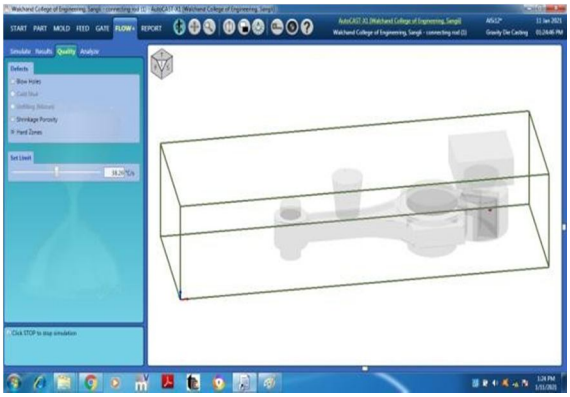
75% solidification 100% solidification

Fig.7. Solidification of Simulation 2

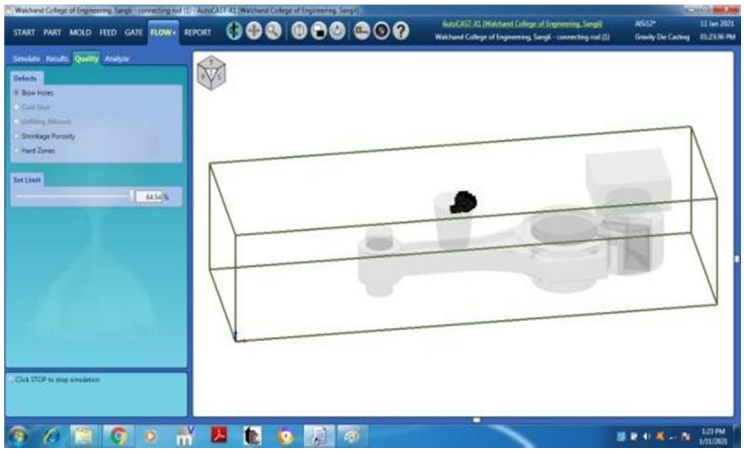
c) *Results of Simulation 2:* The hardzone which is present in simulation 1 are completely eliminated in simulation 2. That is the component casted is totally free from the hardzone. The chances of blowhole was minimized .so the effect of blowhole on quality of casting component get reduced. Also the shrinkage porosity is minimized. After performing number of iterations of Simulation, all defects are eliminated from the casting component. The percentage of hardzone and shrinkage porosity is minimized.



Shrinkage porosity



Hard zone



Blow Holes

Fig. 8 Defects in simulation 2

As the dimensions of gating and feeding system are modified, the yield of casting is improved up to 75%. Also the gating and feeding yield are improved up to 40% and 84% respectively. Due to yield improvement the total cost of casting get reduced. (Especially the cost required for material)

IV. CONCLUSIONS

A. With the help of modified gating system, the connecting rod casting is optimized. The rejection rate and defects are minimized.

B. The simulation method used for casting provides visualization of mould filling and solidification. Therefore material loss due to trial and error method is reduced.

C. Due to the modified gating system, the total time required for making defect free casting is reduced and the total cost of casting is reduced.

D. Yield casting is improved by 38%. Also the gating and feeding yield are increased by 11% and 43% respectively.

V. ACKNOWLEDGMENT

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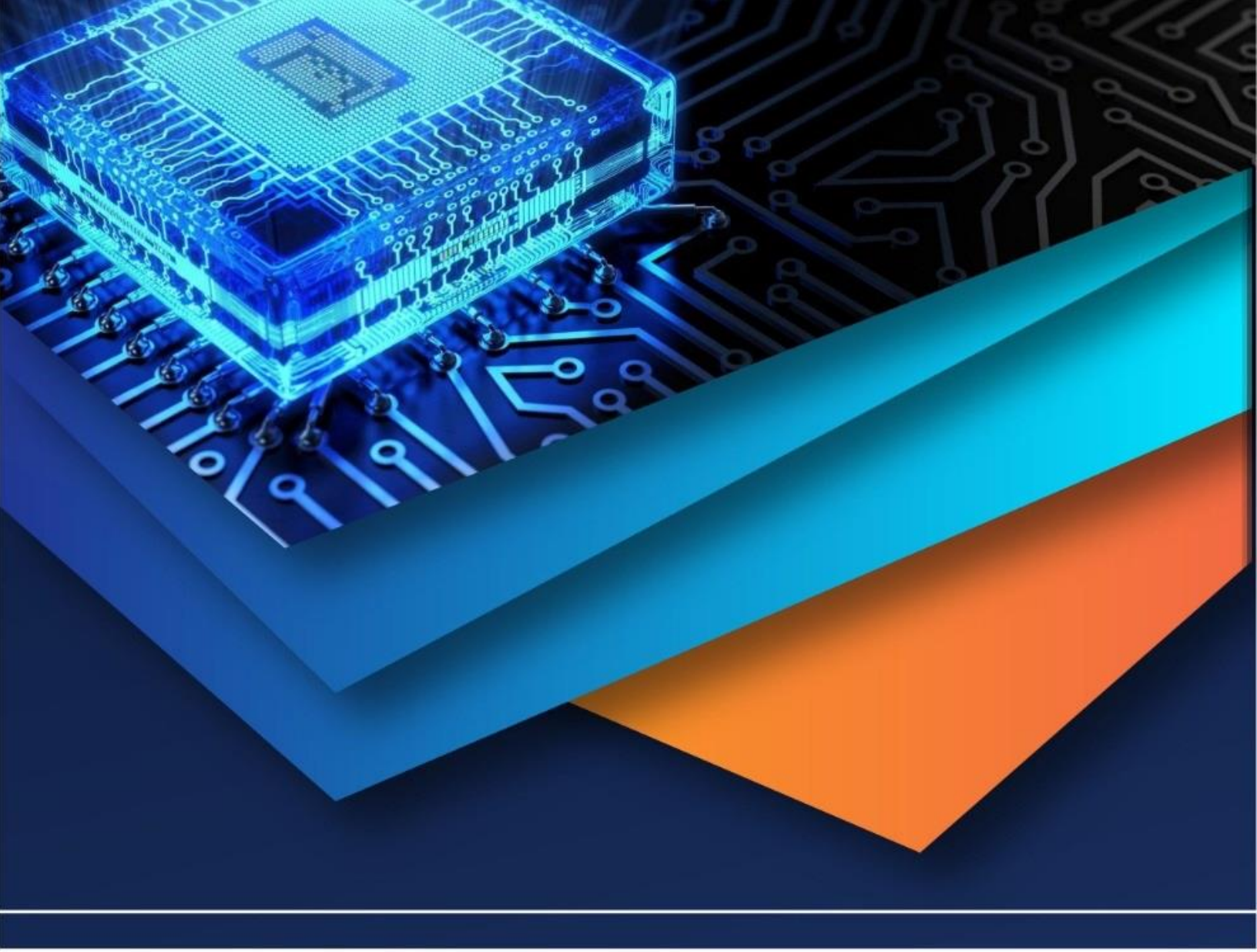

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