

## **REDUCTION IN DEFECTS PER VEHICLE USING MONTE CARLO SIMULATION**

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### **ABSTRACT**

The Monte Carlo technique uses rehashed arbitrary testing to produce recreated information to use with a numerical model. This model frequently originates from a measurable investigation, for example, a planned trial or a relapse examination. To outline a superior procedure, you could gather a pile of information so as to decide how enter variability identifies with yield variability under a mixed bag of conditions. On the other hand, in the event that you comprehend the average conveyance of the data qualities and you have a mathematical statement that models the procedure, you can without much of a stretch produce an unfathomable measure of recreated info values and enter them into the procedure comparison to deliver a re-enacted circulation of the procedure yields. You can likewise effectively change these data appropriations to reply "consider the possibility that" sorts of inquiries. That is the thing that Monte Carlo recreation is about. In the case this work is going to work through, the work will change both the standard deviation and mean of the re-enacted information to enhance the nature of an item. Today, recreated information is routinely utilized as a part of circumstances where assets are restricted or assembling genuine information would be excessively lavish or unrealistic. In this proposed examination undertaking, the imperfections per vehicles might be measured and upgraded utilizing monte carlo recreation. The base work said in the before work might be enhanced utilizing suitable algorithmic methodologies.

Keywords – Defects Avoidance in Automobile Industry, Automotive Industry, Quality Factors and Root Cause Analysis

## **INTRODUCTION**

Manufacturing processes are applicable in all areas of our lives, so much that we often don't realize or think about it. From the cars we drive, the containers our food comes in, the TV's, computers and other devices we use, power tools, heaters, air conditioners, the pipes that deliver our water and the list goes on and on to include just about everything defining our modern society. These things are all manufactured or built from manufactured components. Manufacturing equipment itself must also be manufactured. The manufacturing process used is determined by a variety of factors.

The fundamental idea of manufacturing or production is to create, (or produce), something that has a useful form. This form is most likely predetermined and calculated, with a certain physical geometry. Usually this geometry has certain tolerances that it must meet in order to be considered acceptable. A tolerance outlines the geometric accuracy that must be achieved in the manufacturing process. The "tightness" of the tolerances, or in other words the allowed variance between the manufactured product and the ideal product, is a function of the particular application of the product.

## **REVIEW OF LITERATURE**

Coccia, S., Phillips, R., Bartoli, I., Salamone, S., Rizzo, P., & Lanza di Scalea, F. (2012) - The objectives of this project were (1) to improve the defect detection reliability and (2) to improve the inspection speed of conventional rail defect detection methods. The prototype developed in this work uses noncontact transducers, ultrasonic guided waves, and real-time statistical pattern recognition to improve system reliability. The prototype was field tested seven times with the support of the Federal Railroad Administration (FRA) R-4 hy-railer vehicle. The latest tests at Herzog, Incorporated, in June 2010 showed excellent results. Two blind tests resulted in a defect detection reliability exceeding industry average and American

Railway Engineering and Maintenance-of-Way Association recommendations. These tests also proved the potential for distinguishing good welds from defective welds, an excellent detectability of the vertical split head defect, and the potential for characterizing different rail surface conditions for grinding management purposes. Within this project, a 250-foot-long rail defect farm was also constructed at the University of California–San Diego, with in-kind donations from BNSF Railway, for the development of this and other rail inspection technologies of interest to FRA and to the railroad industry.

Aghaee, M., & Fazli, S. Selecting Effective Factors Contributing to Evaluation of Optimized Maintenance System Strategy in Vehicle Industry. In the current competitive environment, managers have been making attempts to convert organizations under their supervision into competitive and responsive through creating capability of timely delivery of quality products and services. In line with this, maintenance as a system plays a basic role in achieving these goals. The present research aims at selecting the effective factors contributing to evaluation of optimized maintenance system strategy and determining criteria, factors preferences and their relationships. In this descriptive - survey research, at first, the initial criteria were classified into four groups including security, cost, strategic and technical requirements through using five maintenance experts and Delphi method. The sample group is comprised of sixty six managers and specialists of maintenance system in the vehicle companies working with four great companies in Iran including “Iran khodro”, “Iran Khodro Diesel”, “Saipa” and “Saipa Diesel”. One - sample T - test and a confirmative factor analysis were used for selecting the final effective criteria contributing to evaluation of optimized maintenance strategy. Finally, Pearson’s correlation factor and Friedman’s tests were used for determining the relationships between the factors and ranking of them, respectively. Based on the results of this research, security, cost, strategic and technical requirements are effective on selecting optimized maintenance strategy

Sau, J. D., & Sengupta, K. (2014). Suppressing defect production during passage through a quantum critical point. *Physical Review B*, 90(10), 104306 - We show that a closed quantum system driven through a quantum critical point with two rates  $\omega_1$  (which controls its

proximity to the quantum critical point) and  $\omega_2$  (which controls the dispersion of the low-energy quasiparticles at the critical point) exhibits novel scaling laws for defect density  $n$  and residual energy  $Q$ . We demonstrate suppression of both  $n$  and  $Q$  with increasing  $\omega_2$  leading to an alternate route to achieving near-adiabaticity in a finite time for a quantum system during its passage through a critical point. We provide an exact solution for such dynamics with linear drive protocols applied to a class of integrable models, supplement this solution with scaling arguments applicable to generic many-body Hamiltonians, and discuss specific models and experimental systems where our theory may be tested.

Zhu, X., Chen, R., & Zhang, Y. (2014, July). Automatic Defect Detection in Spring Clamp Production via Machine Vision. In *Abstract and Applied Analysis*(Vol. 2014). Hindawi Publishing Corporation - There is an increasing demand for automatic online detection system and computer vision plays a prominent role in this growing field. In this paper, the automatic real-time detection system of the clamps based on machine vision is designed. Its hardware is composed of a specific light source, a laser sensor, an industrial camera, a computer, and a rejecting mechanism. The camera starts to capture an image of the clamp once triggered by the laser sensor. The image is then sent to the computer for defective judgment and location through gigabit Ethernet (GigE), after which the result will be sent to rejecting mechanism through RS485 and the unqualified ones will be removed. Experiments on real-world images demonstrate that the pulse coupled neural network can extract the defect region and judge defect. It can recognize any defect greater than 10 pixels under the speed of 2.8 clamps per second. Segmentations of various clamp images are implemented with the proposed approach and the experimental results demonstrate its reliability and validity.

Yun, J. P., Choi, D. C., Jeon, Y. J., Park, C., & Kim, S. W. (2014). Defect inspection system for steel wire rods produced by hot rolling process. *The International Journal of Advanced Manufacturing Technology*, 70(9-12), 1625-1634 - A vision-based inspection system has been investigated in order to improve the quality of products and processes found in various

industries. In this paper, we propose a new defect detection algorithm for steel wire rods produced by the hot rolling process. Because the steel wire rods are long cylinder rods with a circular cross section, the brightness at the sides and center is inconsistent. Moreover, the various types of steel wire rods and the presence of scales affect the reflection properties of the rod surface. In order to resolve the abovementioned difficulties, the use of dynamic programming and a discrete wavelet transform are proposed. An adaptive local binarization method is used to further reduce the effects of scale. The effectiveness of the proposed method is shown by means of experiments conducted on images of steel wire rods that were obtained from an actual steel production line.

Chen, I. C. (2008). *U.S. Patent No. 7,376,497*. Washington, DC: U.S. Patent and Trademark Office - A customer driven process of diagnosing and repairing a vehicle. The process involves temporarily providing a customer with a diagnostic tool that can receive vehicle diagnostic signals from a vehicle on-board computer. The customer then uses the tool to upload diagnostic signals from the car, and returns the tool to the automotive parts/service facility. The vehicle diagnostic signals are communicated to a console, which then accesses a database(s). The database(s) includes information relating to the vehicle malfunction, the repairs needed, and the parts required to complete those repairs. The process also allows automatic scheduling of repairs and purchasing of parts from the automotive parts/service facility. Upon payment of any prescribed fees, the process outputs report information to the customer.

Schulz, T., Radliński, Ł., Gorges, T., & Rosenstiel, W. (2010, September). Defect cost flow model: a Bayesian network for predicting defect correction effort. In *Proceedings of the 6th International Conference on Predictive Models in Software Engineering* (p. 16). ACM - Software defect prediction has been one of the central topics of software engineering. Predicted defect counts have been used mainly to assess software quality and estimate the defect correction effort (DCE). However, in many cases these defect counts are not good indicators for DCE. Therefore, in this study DCE has been modeled from a different perspective. Defects originating from various development phases have different impact on

the overall DCE, especially defects shifting from one phase to another. To reduce the DCE of a software product it is important to assess every development phase along with its specific characteristics and focus on the shift of defects over phases. The aim of this paper is to build a model for effort prediction at different development stages. Our model is mainly focused on a dynamic DCE changing from one development phase to another. It reflects the increasing cost of correcting defects which are introduced in early, but found in later development phases. The modeling technique used in this study is a Bayesian network which, among many others, has three important capabilities: reflecting causal relationships, combining expert knowledge with empirical data and incorporating uncertainty. The procedure of model development contains a set of iterations including the following steps: problem analysis, data analysis, model enhancement with simulation runs and model validation. The developed Defect Cost Flow Model (DCFM) reflects the widely used V-model, an international standard for developing information technology systems. It has been pre-calibrated with empirical data from past projects developed at Robert Bosch GmbH. The analysis of evaluation scenarios confirms that DCFM correctly incorporates known qualitative and quantitative relationships. Because of its causal structure it can be used intuitively by end-users. Typical cost benefit optimization strategies regarding the optimal effort spent on quality measures tend to optimize locally, e.g. every development phase is optimized separately in its own domain. In contrast to that, the DCFM demonstrates that even cost intensive quality measures pay off when the overall DCE of specific features is considered.

Shibata, H., Cheldelin, B., & Ishii, K. (2003, January). Assembly quality method: integrating design for assembly cost-effectiveness (DAC) to improve defect prediction. In *ASME 2003 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (pp. 299-306). American Society of Mechanical Engineers - The complexities in assembly processes have a strong correlation with the occurrences of defects. This paper develops a design-based complexity factor derived from the “Design for Assembly” method for evaluating assembly to augment factors not captured by the process-based complexity factor proposed by the authors. The authors collected extensive field data including consumer audio equipment assembled at various manufacturing sites around the

world, and used defect data for validating the metrics. The quantitative correlation between the design-based complexity factor and defect rates will provide mechanical designers with guidelines for improving the original design.

Zhang, X., Niu, S., Zhang, D., Wang, G. A., & Fan, W. (2015). Predicting Vehicle Recalls with User-Generated Contents: A Text Mining Approach. In *Intelligence and Security Informatics* (pp. 41-50). Springer International Publishing - Vehicle safety issues and component defects result in property losses and fatalities. Our study proposes a new method to predict vehicle recalls based on user generated contents in online discussion forums. Vehicle defects can cause bodily injuries and sometimes deadly consequences. However, vehicle recalls will not be issued until damage has occurred. Online vehicle discussion forums usually contain traits of vehicle defects long before manufacturers and government agencies take investigative actions. We find overlapping components in user generated contents and official recall notices. Our proposed recall prediction method can correctly predict vehicle recalls once in every two recall events. It is our hope that our proposed technique can be used to monitor online vehicle discussion forums and prompt the manufacturers and government agencies to issue recalls before catastrophic accidents occur. Our research has significant practical implications to vehicle and transportation safety.

Liu, X., Lovett, A., Dick, T., Rapik Saat, M., & Barkan, C. P. (2014). Optimization of Ultrasonic Rail-Defect Inspection for Improving Railway Transportation Safety and Efficiency. *Journal of Transportation Engineering*, 140(10), 04014048 - Broken rails are the most frequent cause of freight-train derailments in the United States. Consequently, reducing their occurrence is a high priority for the rail industry and the U.S. Federal Railroad Administration. Current practice is to periodically inspect rails to detect defects using nondestructive technology such as ultrasonic inspection. Determining the optimal rail inspection frequency is critical to efficient use of infrastructure management resources and maximizing the beneficial impact on safety. Minimization of derailment risk, costs of inspection vehicle operation, rail defect repair, and corresponding train delay are all affected by rail inspection frequency. However, no prior research has incorporated all of these factors

into a single integrated framework. The objective of this paper is to develop an analytical model to address the trade-offs among various factors related to rail defect inspection frequency, so as to maximize railroad safety and efficiency. The analysis shows that the optimal inspection frequency will vary with traffic density, rail age, inspection technology reliability, and other factors. The optimization model provides a tool that can be used to aid development of better-informed, more effective infrastructure management and accident prevention policies and practices.

Zhixin, X. I. A. O., Wei, Q., Zhiliang, W. E. I., & Qinglu, C. U. I. (2014). *U.S. Patent Application 14/264,050* - This invention is a method to prevent excessive maintenance to vehicle lubricating system based on detection, to overcome the defect in maintenance procedure. Technical measures are as follows: it is a method to prevent excessive maintenance to vehicle lubricating system based on detection, with oil detection module 1 and host controller 4. Its working principle is to detect the aging degree of lube before maintenance, and decide whether to change the lube according to detection result. It will help to prevent excessive maintenance, reduce maintenance cost for car owners, and decrease the waste of resource. Oil detection module 1 includes oil chamber sensor 2, capacitance detection chip 3 etc. Host controller 4 is connected to oil detection module 1 by cables.

Al Bulushi, I., Edwards, J., Davey, J., Armstrong, K., Al Reesi, H., & Al Shamsi, K. (2015). Heavy vehicle crash characteristics in Oman, 2009-2011. *Sultan Qaboos University Medical Journal* - In recent years, Oman has seen a shift in the burden of diseases towards road accidents. The main objective of this paper, therefore, is to describe key characteristics of heavy vehicle crashes in Oman and identify the key driving behaviours that influence fatality risks. Crash data from January 2009 to December 2011 were examined and it was found that of the 22,543 traffic accidents that occurred within this timeframe, 3,114 involved heavy vehicles.

While the majority of these crashes were attributed to driver behaviours, a small proportion was attributed to other factors. The results of the study indicate that there is a need for a more thorough crash investigation process in Oman. Future research should explore the reporting

processes used by the Royal Oman Police, cultural influences on heavy vehicle operations in Oman, and improvements to the current licensing system

### **PROBLEM FORMULATION**

- The classical methods of identification of the defects per vehicle are not sufficient and effective
- The proposed work is based on monte carlo simulation
- The monte carlo simulation is able to generate a test data set from a small set of records.
- Using the proposed model and simulation, the effective production as well as analysis of dataset related to the vehicle defects in the automotive industry can be done.

### **TOOLS FOR SIMULATION / IMPLEMENTATION**

- MATLAB
- Dia - The Flowchart / Diagram Generation Tool
- Notepad++

The proposed work is based on the following parameters and paradigms for the effective and overall performance base results in the automotive industry

- Random Number Generators
- Monte Carlo Simulation
- Dynamic Data Sets Generation

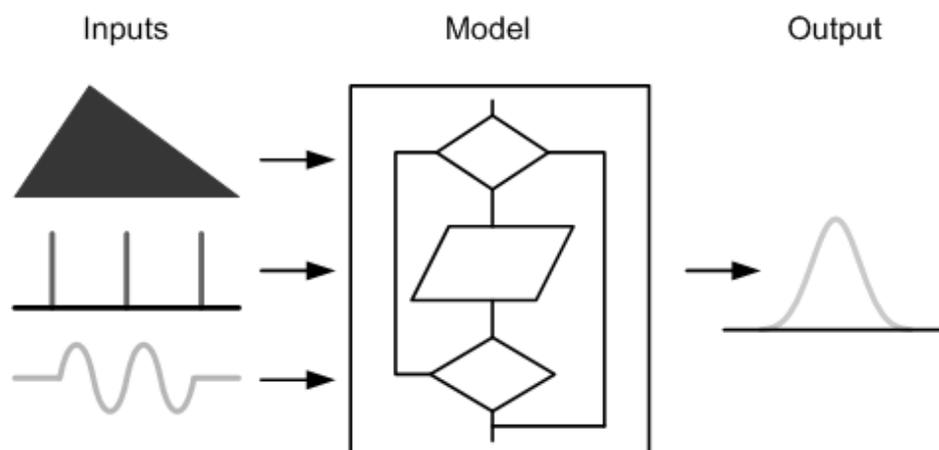
Monte Carlo methods (or Monte Carlo experiments) are a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results. They are often used in physical and mathematical problems and are most useful when it is difficult or impossible to use other mathematical methods. Monte Carlo methods are mainly used in three distinct problem classes: optimization, numerical integration, and generating draws from a probability distribution.

In physics-related problems, Monte Carlo methods are quite useful for simulating systems with many coupled degrees of freedom, such as fluids, disordered materials, strongly coupled solids, and cellular structures. Other examples include modeling phenomena with significant uncertainty in inputs such as the calculation of risk in business and, in math, evaluation of multidimensional definite integrals with complicated boundary conditions. In application to space and oil exploration problems, Monte Carlo-based predictions of failure, cost overruns and schedule overruns are routinely better than human intuition or alternative "soft" methods.

In principle, Monte Carlo methods can be used to solve any problem having a probabilistic interpretation. By the law of large numbers, integrals described by the expected value of some random variable can be approximated by taking the empirical mean (a.k.a. the sample mean) of independent samples of the variable. When the probability distribution of the variable is too complex, we often use a Markov Chain Monte Carlo (MCMC) sampler. The central idea is to design a judicious Markov chain model with a prescribed stationary probability distribution. By the ergodic theorem, the stationary probability distribution is approximated by the empirical measures of the random states of the MCMC sampler.

## RESULTS

Using MATLAB, the implementation of proposed algorithm designed is accomplished with the better and effective results for improvements in the automotive industry in terms of defects per vehicle.

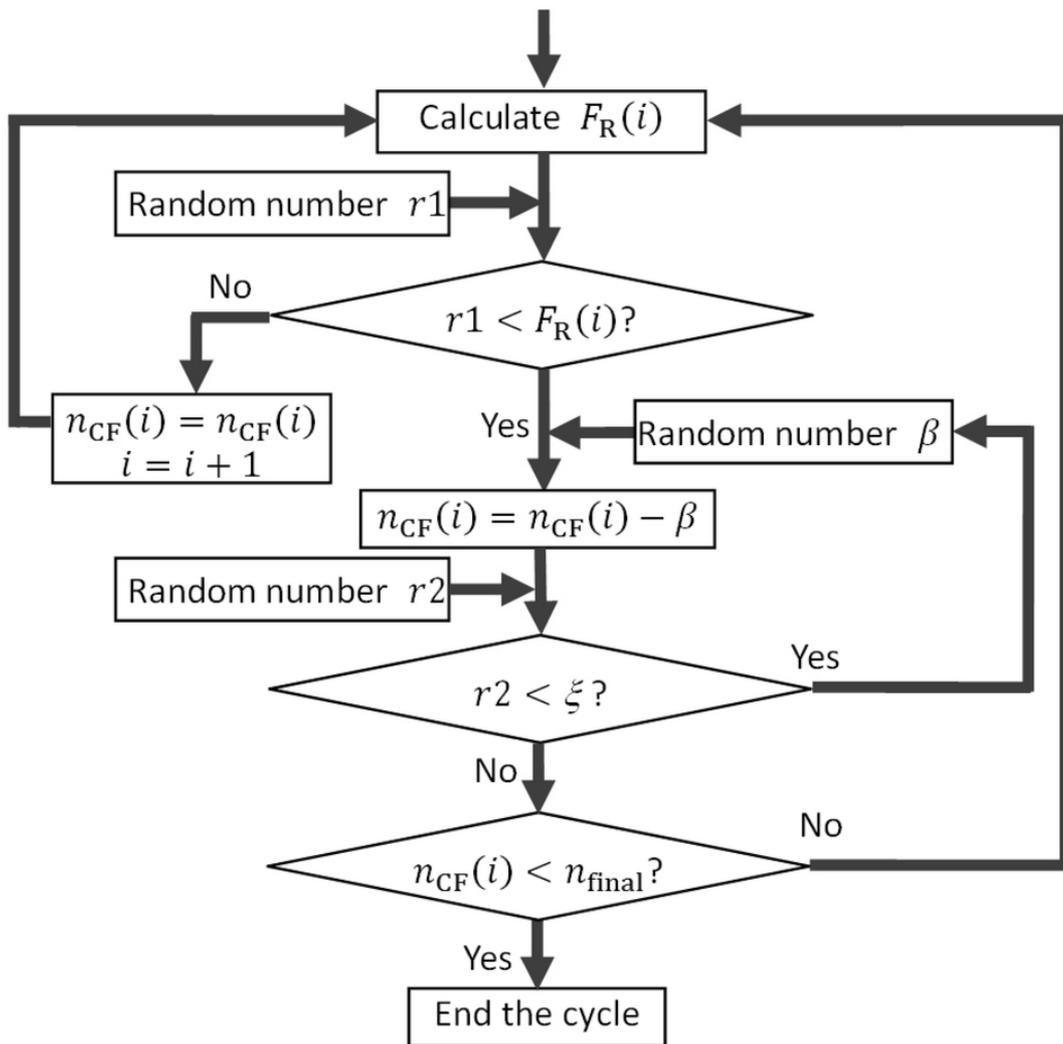


**Figure 1 - Monte Carlo Simulation Process**

Monte Carlo routines are broadly utilized as a part of building for affectability investigation and quantitative probabilistic examination in procedure outline. The need emerges from the intelligent, co-straight and non-direct conduct of run of the mill process recreations. Case in point,

- In microelectronics designing, Monte Carlo systems are connected to investigate associated and uncorrelated varieties in simple and computerized coordinated circuits.
- In geostatistics and geometallurgy, Monte Carlo strategies support the outline of mineral preparing flowsheets and add to quantitative danger investigation.
- In wind vitality yield examination, the anticipated vitality yield of a wind homestead amid its lifetime is computed giving distinctive levels of vulnerability (P90, P50, and so forth.)
- Impacts of contamination are mimicked and diesel contrasted and petrol.
- In Fluid Dynamics, specifically Rarefied Gas Dynamics, where the Boltzmann mathematical statement is understood for limited Knudsen number liquid streams utilizing the Direct Simulation Monte Carlo strategy in blend with exceedingly productive computational calculations.
- In self-governing apply autonomy, Monte Carlo confinement can focus the position of a robot. It is frequently connected to stochastic channels, for example, the Kalman channel or Particle channel that structures the heart of the SLAM (Simultaneous Localization and Mapping) calculation.
- In information transfers, when arranging a remote system, outline must be demonstrated to work for a wide assortment of situations that depend predominantly on the quantity of clients, their areas and the administrations they need to utilize. Monte Carlo systems are regularly used to produce these clients and their states. The system execution is then assessed and, if results are not agreeable, the system outline experiences an advancement process.
- In unwavering quality designing, one can utilize Monte Carlo reenactment to create interim in the middle of disappointments and interim to repair for segments.

- In sign preparing and Bayesian surmising, molecule channels and successive Monte Carlo strategies are a class of mean field molecule systems for inspecting and registering the back dissemination of a sign procedure given some loud and halfway perceptions utilizing collaborating observations



**Figure 2 – Flowchart of the Monte Carlo Simulation**

Table 1 – Comparison of Classical and Proposed Approach

| <b>Classical Approach</b> | <b>Proposed Approach with Monte Carlo Simulation</b> |
|---------------------------|--|
| 40                        | 78   |
| 50                        | 69   |
| 30                        | 50   |
| 60                        | 88   |

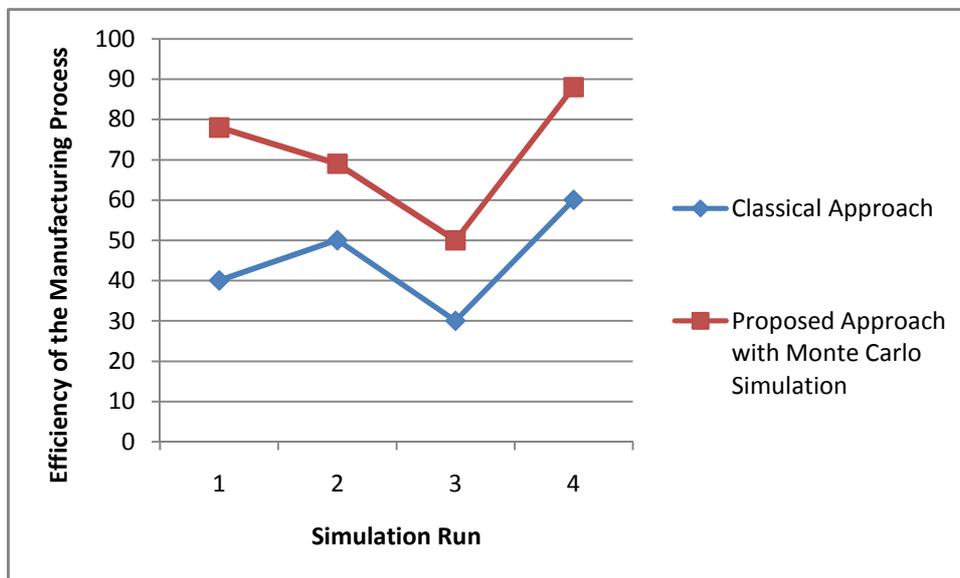


Figure 3 – Comparison of Classical and Proposed Approach

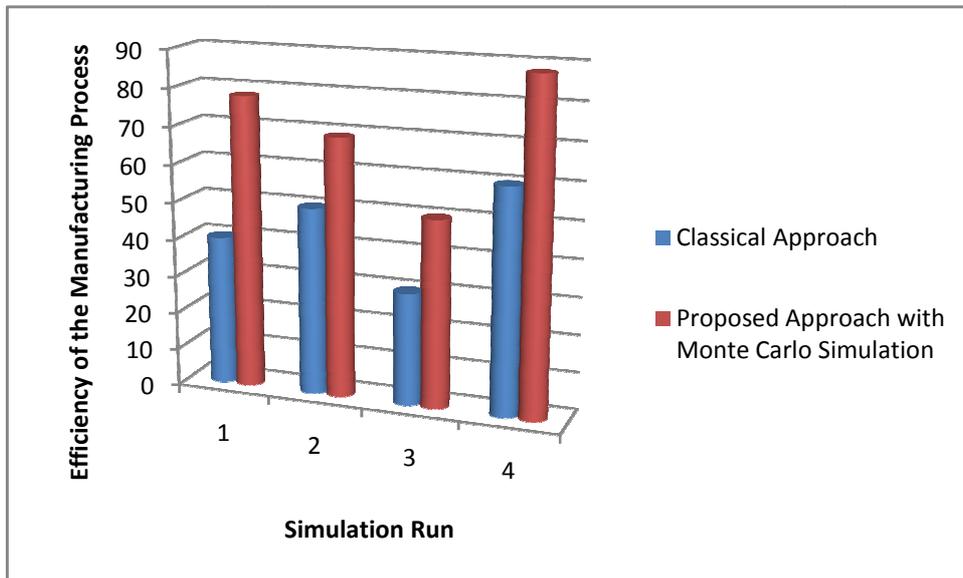


Figure 3 – Comparison of Classical and Proposed Approach

Table 2 – Comparison of Classical and Proposed Approach

| Classical Approach | Proposed Approach with Monte Carlo Simulation |
|--------------------|---|
| 60                 | 40  |
| 70                 | 50  |
| 50                 | 40  |
| 89                 | 49  |

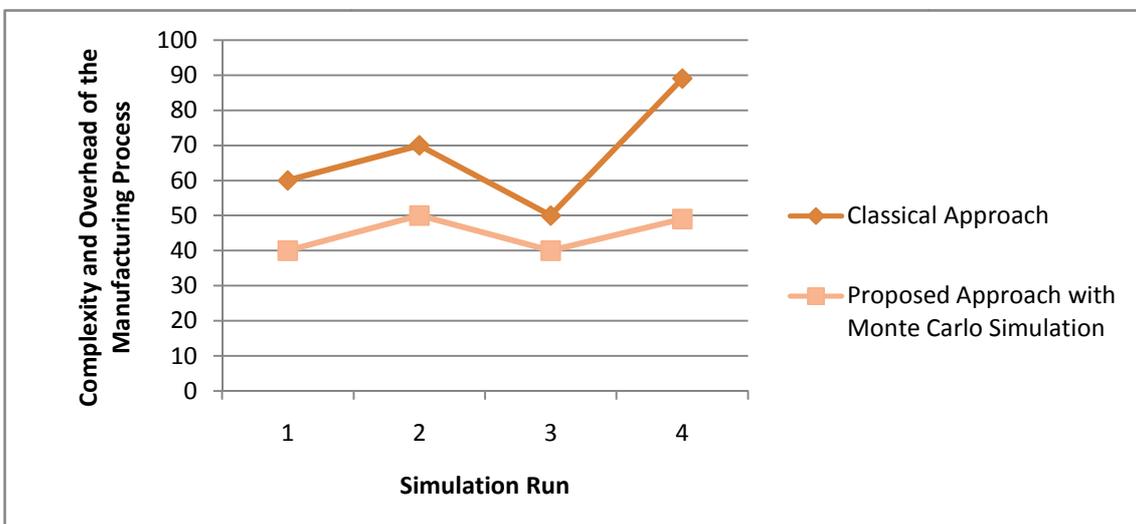


Figure 5 – Comparison of Classical and Proposed Approach

## **CONCLUSION AND FUTURE SCOPE**

In this research work, the defects per vehicle in the automobile industry is measured based on the assorted parameters using monte carlo simulation technique. Monte Carlo methods or Monte Carlo experiments are a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results. They are often used in physical and mathematical problems and are most useful when it is difficult or impossible to use other mathematical methods. Monte Carlo methods are mainly used in three distinct problem classes: optimization, numerical integration, and generation of draws from a probability distribution. In physics-related problems, Monte Carlo methods are quite useful for simulating systems with many coupled degrees of freedom, such as fluids, disordered materials, strongly coupled solids, and cellular structures. Other examples include modeling phenomena with significant uncertainty in inputs such as the calculation of risk in business and, in math, evaluation of multidimensional definite integrals with complicated boundary conditions. In application to space and oil exploration problems, Monte Carlo-based predictions of failure, cost overruns and schedule overruns are routinely better than human intuition or alternative "soft" methods.

For future scope of the work, following techniques can be used in hybrid approach to better and efficient results –

- Artificial Neural Networks
- Simulated Annealing
- Honeybee algorithm
- Prominent Swarm Intelligence Techniques

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