# COMPUTER SIMULATION FOR PREVENTIVE MAINTENANCE PREDICTION

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Received: June 03,2011; Accepted? November 14,2011

**Abstract**

*This study concerns the role of computer simulation as a device for conducting scientific experiments on preventive maintenance prediction of machines and equipment in a manufacturing outfit. Preventive maintenance reduces machine downtime and ensures production of a specified product on scheduled at a minimum cost and thereby facilitates effective and efficient accomplishment of production objectives of an organization. Poisson distribution was used to predict the probability of machine breakdown in the study while test data were gotten from a manufacturing company and same were simulated. The results generated were used to predict a real life situation and have been presented and discussed. A computer program was designed and implemented using Turbo Pascal programming language, due to its capability and flexibility as a scientific programming language far the model. It was observed that failure to practice preventive maintenance usually leads to under-utilization of installed capacity of a manufacturing outfit. It is therefore, recommended among others, that preventive maintenanceprediction should be embraced in order to fully utilize the installed capacity of manufacturing outfits,*

*Keywords: Simulation, maintenance, manufacturing, downtime, model, capacity.*

## INTRODUCTION

Simulation can be defined as a numerical technique for conducting experiments on a digital eamputer, which involves certain types of mathematical and logical models that describe the behavior of a business or economic system (or some components thereof) over extended periods of real time while a model can be defined as an object or ujnctmt that k us»d to represent something else. It *is* readily scaled down and converted to a f Orm that we can comprehend (Neelamkevil, 1987). The IViinsnn distribution 13 a discrete distribution. Tr it nrVtm nuuil aie a miiclpl fur the number of events such as the numfcer of telephone calls at a business, numbrr nf rustomers in waiting ImCtJ, number Of dwfwre in a Riven eurfaru *xrwA*, airplane arrivals, or the number of accidents at an intersection in a specific time period (Levin, 19^4). ThC3C CXamplCS 1 w vy u wuimon element fnr the fart that they can be described by a discrete random variable that takes mi inirgrivoluc(l),L2,a,4,betc.).Itia also useful in ui'iiluyii *A* viudies, e g, to model the number of PrairiC dOSB found in a square mile of prairie The major difterencc bchVCCft POiSSOn and Binomial ilis.1 i!l in linnsis that the Poi33On dOCD not hftVG a fiXCd number of trials. Instead, it uses the Fixed interval of time or space in which the number of successes is recorded (Levin, 1984). Preventive maintenance is regular, repetitive work done to keep equipment in good working order and to optimise its efficiency and accuracy. ThiS activity involves regular, routine cleaning, lubricating, testing, calibrating and adjusting, checking for wear and tear and eventually replacing components to avoid breakdown (Raby, 2009). Maintenance practices are set of measures or steps taken to ensure that a given piece of capital asset, machines or infrastructure is kept in good operational order until it attains its maximum possible life span (Eze«gwe,1990). A very important branch in the organizational tree is the maintenance function. Machines and equipment need to receive planned attention after so many hours. The maintenance department is the responsibility of the plant engineer, and he employs engineers, technologists, technicians, craftsmen and more general personnel, The most enlightened managements now adopt *preventive maintenance* schemes which is all about regular servicing of machines and equipment and replacement of seemingly perfect parts *before* they fail (Batty, 1979). Preventive maintenance is a carefully devised scheme, calculated from probability and past records. It eliminates most breakdowns, but obviously not accidents or misuse. One advantage of this scheme is that inspection and replacement can be performed during normal shutdown periods, whereas breakdowns occur during working hours when the machine is mostly required. It is essential to keep proper records of breakdowns in order to modify the scheme where necessary (Batty, 1979).

A sound maintenance culture also reduces "down-time", which may result from machine breakdown in industrial setting and hence, enhances productivity (Clifton, 1974). Preventive maintenance usually balances the certain cost of inspection labour and throwing away seemingly good components, against the probability of greater cost in damage and loss of production should the machine break down later (Batty, 1979). Frequent maintenance (overhauls) may reduce costs by avoiding expensive breakdowns and replacements. Unfortunately, the more frequently the maintenance (overhaul) the lower the availability of the machines, so that direct production costs will increase (Lockyer, 1983). There are a number of maintenance strategies which can be practised separately or in combination, and they include: routine maintenance/ preventive maintenance, predictive maintenance and breakdown maintenance (Aideloje and Musa, 2010). The developments that have made the performance demand of maintenance ever more challenging are: emerging trends of operation strategies, change in place and organization systems, toughening societal expectations and technological changes (Tsang, 2002).

The greatest undoing of run-to-failure (breakdown) maintenance approach are: high spare parts inventory cost, high overtime labour costs, high machine downtime and low productive availability (Emovon *et al*, 2007). The most Important reason for » preventive maintenance programme ia reduced coats *as* seen in these many ways: reduced production downtime, better conservation of assets and increased life expectancy of aaacta, reduced overtime costs, timely routine repairs,, redueei] rust *nt* repairs, reduced product rujwty, rework and scraps/ identification of equipment with excessive maintenance costs and Improved safety <md quality conditions (Emovon *et a].,* 20071. After the prediction exercise, a preventive maintenance schedule should be prepared for the machines in the factory. The schedule should be **based on a** study which **should** include the fnltnwiiiK: type of maintenance, frequency of occurrence, time required, materials and parts required, total cost, shutdown time if any, safety farttirK inuiiluBtl and whether the trouble could have Seen corrected by preventive maintenance or not A preventive maintenance check list is also required and it should include: items inspected, individual part3 inspected, checking column for each part inspected, date of inspection, remarks and recommendations and actions taken. Preventive maintenance does involve risk. The risk here refers to the potential for creating defects of various types while performing the preventive maintenance task (Worsham, 2007). The following errors or damage usually occur during preventive maintenance and other types of maintenance outages: damage to an adjascent equipment during a preventive maintenance task, damage to the equipment receiving the preventive maintenance task, reintroducing infant mortality by installing new parts or materials and damage due to an error in reinstalling equipment into its original location (Emovon *etal*, 2007).

The main objectives for embracing preventive maintenance include the following: to minimize cost of maintenance, to prevent waste of tools, spare parts, and materials, maximizing utilization of resources and decreasing downtime, less involuntary layoffs of production workers and consequently better employer-employee relations, greater safety and better working conditions for employees, and improved protection for the factory and the machines therein.

MATERIALS AND METHODS

Production is usually machine intensive. Machine breakdown prediction is an important aspect for which computer simulation can be applied to predict machine breakdown and to minimize machine same.

The popular statistical model 'Poisson distribution' is being employed here. According to Levin (1984), if the expected number of occurrences in a given interval is *e. (lamda)*, then the probability that there are exactly occurrences ( being a non-negative integer. =0,1,2,3,4,5, etc.) is equal to:

- for -0,1,2, ............................(i)

Parameters: The mean is e. The variance is &6 is the parameter which indicates the average number of events in the given time interval. Where,

- number of occurrences

e" — is the mean number of occurrences per interval of the time

c- 2.71828... (base of the natural logarithm)

- factorial of

The above equation is being employed here to simulate the number of machine breakdowns per week in a machine shop based on the historical record that indicates a mean of five breakdowns per week.

A computer program was designed and implemented using Turbo Pascal programming language due to its capability and flexibility as a scientific programming language for the model represented as program MACHBDOWNPREDCTN in Appendix 1. The following parameters were read into the computer namely; number of occurrences Q, mean number of occurrences (e), and natural logarithm (e). The program generated the probability of having exactly 0,1,2,3f 4 or 5 machine breakdowns in any week.

It is possible to calculate the probability of there being 0, 1, 2, 3, 4 or 5 machine breakdowns and therefore predicting machine breakdown in advance.
It is also possible to calculate the probability of there being 0,1,2,3,4 or 5 machine breakdowns by adding together the probabilities of exactly 0,1,2,3, 4 or 5 breakdowns. The prediction is very useful in carrying out preventive maintenance of the machines in a factory.

**RESULTS AND DISCUSSION**

From the above model. The probability of having exactly 0 breakdown p(0) was calculated to be:

FACQ=1 p(0; 5) = 0.00674

Similarly, The probability of having exactly 1 breakdown, p(l) was calculated to be:

FAC1-1 p(l; 5) = 0.03369

The probability of having exactly 2 breakdowns, p(2) was calculated to be;

FAC2-2 p(2; 5) = 0,08422

The probability of having exactly 3 breakdowns, ***P($*** **WftB Calculated tn be:**

FA«-6 p(3; 5) "0,14037

The probability of having exactly 4 breakdowns p(I) WAS calculated to t»:

PAW - 21 p(4 ; 5) = 0.17547

jnil

Th« probability nf having exactly 5 breakdowns *V* (5) was calculate! tu i»:

FAt&-120 p(9; 5) = 017547

1 Icncc,

p(fl,P.) . n 00674 p(l; 5) = 0.09M9

JfQjW = 0,0*111

p(3;5) - O.HTO7 . p(4; 5) - 0.17547

p(\ 5)-0.17547

Funhermwn, tliw probability of having less than n machine bMaUflOWne in any wwk was calculated by addiny tngcthcr the prObaWlltiQB of all numbers preceding "- P'" instance, we added the probabilities of p(0} 5), p(l; 5) and p(2; 5) together to obtain the probability of having less than three machine breakdowns in any week, that is, P(<3)-p(0;5)-»-pCl;5)+p(2;5)

- 0.00674 + 0.03369 + 0.08422.

Sirnilai'ly,

p(<4) = 0.00674 + 0.03369 + 0.08422 +0.14037 =

p(0;5)+p(l;5)+p(2;5)+p(3;5) = 0.00674 + 0.03369 + 0.08422 +0.14037 = 0.26502

p(<5) -p(0;5) + p(l;5) + p(2;5) + p(3;5)+p(4;5)

- 0.00674 + 0.03369 + 0.08422 +0.14037 + 0.17547

- 0.44049 and

p(-5) = p(0;5) + p(l;5) + p(2;5) + p(3;5)+p(4;5) + P(5;5)

- 0.00674 + 0.03369 + 0.08422 +0.14037 + 0.17547 + 0.17547

= 0.61596

It is also possible to calculate the probability of having *n* or more machine breakdowns in any week, that is, *p(* = n) by subtracting the sum of probabilities of all'the numbers proceeding *n* from 1 by using the formula:

p(-n) = 1 p(<n)....................................(ii)

Since the sum of the probability of occurrence and non-occurrence of an event is equal to 1,

p + if-1…..............................................(ill)

Similarly,

p-1 *n* ..... ...........................................(iv)

and,

?"l-p.............................. ...................(v)

A machine that requires maintenance is either maintained immediately or must await maintenance until one of the maintenance men is free to maintain it. Otherwise, the machines are assumed to run continuously. The fewer the number of machine breakdown, the lower the probability and this translates to: fewer number of maintenance men maintaining fewer machines, less maintenance completion time and reduction in maintenance cost.

**CONCLUSIONS**

A lot of money is being spent on acquisition of machines in manufacturing outfits hence there is a need for preventive maintenance of machines. The reason being that preventive maintenance reduces machine down-time and ensures production of a specified product on scheduled at a minimum cost and thereby facilitates the effective and efficient accomplishment of production objectives of an organization.
Production and operations management usually ensures effective and efficient utilization of resources at disposal of an organization, that is, men, machines, money, method and materials and also paves way for the creation of valuable and quality product on schedule and at minimum cost. It is expected that frequent breakdown will be minimized and as a result of this, production of a specified product on schedule and at minimum cost



will be achieved. Preventive maintenance usually promotes the goodwill of an organization because

its customers will always derive satisfaction from its product(s) in terms of quality. The result shows that the test used for the experiment is acceptable as useful and suitable for its purpose taking predictions made into consideration. In view of the aforementioned points, the importance of preventive maintenance in a manufacturing outfit is paramount hence it cannot be overemphasized. To derive maximum benefits from the capital invested in a manufacturing outfit and in order to fully utilize the installed capacity of a manufacturing outfit, the following recommendations are made: Preventive maintenance should be adopted instead of run-to-failure (breakdown) maintenance because it saves time and cost, and also ensures that a machine or utility attains its predicted life span. Nigeria is still a developing country therefore she should embrace manufacturing and processing activities, in order, to achieve her Millennium Development Goals by the year 2015 and her Vision 20:2020.
Computer simulation is a universal and important tool because it promotes automation and the success of industrialization depends largely on it hence it should not be relegated to the background but it should be seriously considered and favoured as a very Important tool for the industry especially, in the area of preventive maintenance prediction, in order, to minimize machine downtime and consequently increases productivity. A factory manager should be greatly concerned. afout machine breakdown and repair of machines wh««\ tha H4dd a*ie«§ so as to ensure that machines and utilities meant for production are always in perfect working condition at all times.

**T hereby show iny profound gratitude to the management of Hi-Tech Industry, Ibadan, Nigeria *far* the opportunity given me to make use of their organization for the study' and as well their technical asilstance and advice.**

**APPENDIX 1**
**Machbdownprcdctn**

```
Program Machbdownpredctn^nput, output);
  vai x, facO, fad, fac2, fac3, fac4, fac5, j, lamda:
integer,
 var pQ, pi, p2, p3, p4, p5: real;
 begin: - fac3 : - fac4 : - fac5 : -1
   pO: = exp(-5);
 writeln ( 'Enter the value of lamda or' );
 writeln ( 'Press Control + C to quit' );
 forj:»lto5do
   read(lamda);
   x:-l;
   facl:-facl*x;
   pi : - (lamda *exp(-5))/facl;
 forx:-lto2do
   fac2:-fac2*x;
   p2 : - (sqr(lamda) * exp(-5)) / fac2;
 forx:-lto3do
   fac3:-fac3*x;
   p3 : • (sqr(lamda) * lamda *exp(-5)) / fac3;
 forx:-lto4do
   fac4:*fac4*x;
   p4 : - (sqr(lamda) * sqr(lamda) * exp(-5))/fac4;
 forx:-lto5do
   fac5:-fac5*x;
    p5 : - (sqr(lamda) * sqr(lamda) * lamda * exp(-
5))/fac5;
 writeln('facO-',facO:V     pO-',pO:7:5);
 writeln('facl-',facl:l,'     pl-',pl:7:5);
 writeln('fac2 - ',fac2:l, ' p2 - ',p2:7:5);
 writeln('fac3 - ^ac3:l, ' p3 - ',p3:7:5);
 writeln('lfac4'"4ac4:l,'     p4-l,p4:7:5);
 writeln('fac5 - '^ac5:l, ' p5 - ',p5:7:5);
 end.
```

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