Suez Canal University

Faculty of **Faculty of Computers**

# Simulation and Modeling

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## 1. Introduction

In our problem, we will perform the simulation work on Excel Sheet to perform the following Simulation of the following system (Simulation on reliability problem):

There are three different bearings on a large milling machine which fall into operation. The cumulative distribution function of each bearing 's life is similar to that shown in the table. When a roller fails, the mills stop, a repair person is called and a new roller is installed. The delay time of the repairer to arrive at the milling machine is also a random variable, with the distribution given in the table 2. Downtime is estimated to be 5 $per minute for the mill. The Repairperson 's direct on-site cost is 15 $per hour. Changing one bearing takes 20 minutes; changing two bearings for 30 minutes; and changing three bearings for 40 minutes. The bearings cost 16$ each. There was a plan to replace all three bearings any time a bearing

fails. Management needs assessment of this proposal

Table 1: Random Digit Assignment for Bearing life

| Bearing life (Hours) | Probability | Cumulative Probability | Random Digit Assignment |
|---|---|---|---|
| 1000 | 0.10 | 0.10 | 01-10 |
| 1100 | 0.13 | 0.23 | 11-23 |
| 1200 | 0.25 | 0.48 | 24-48 |
| 1300 | 0.13 | 0.61 | 49-61 |
| 1400 | 0.09 | 0.70 | 62-70 |
| 1500 | 0.12 | 0.82 | 71-82 |
| 1600 | 0.02 | 0.84 | 83-84 |
| 1700 | 0.06 | 0.90 | 85-90 |
| 1800 | 0.05 | 0.95 | 91-95 |
| 1900 | 0.05 | 1.00 | 96-00 |

Table 2: Random Digit Assignments for Delay Time

| Delay Time (Minutes) | Probability | Cumulative Probability | Random Digit Assignment |
|---|---|---|---|
| 5 | 0.6 | 0.6 | 1-6 |
| 10 | 0.3 | 0.9 | 7-9 |
| 15 | 0.1 | 1.0 | 0 |

## 2. Research items

- Simulate the problem over 20000 operating hours. Calculate the following:
- The Bearings Costs
- The Cost of delay time
- The Cost of downtime during repairs
- The Cost of repairpersons
- The Total cost

## 3. Research

Table 1: Random Digit Assignment for Bearing life

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| 1700 | 0.06 | 0.90 | 85-90 |
| 1800 | 0.05 | 0.95 | 91-95 |
| 1900 | 0.05 | 1.00 | 96-00 |

Table 1: Because a rather coarse 100 hour grid was used. In this example, it will be assumed that the times are never exactly the same, and therefore, at any breakdown, no more than one bearing is changed. Sixteen modifications to bearings 1 and 2, but only 14 changes to bearings were needed for bearing 3. This calculates the expense of the new program as follows:

- The Repairpersons' Cost = 46 bearings × 20 minutes/bearing × 15$/60 minutes= 230$
- The Bearings Costs = 46 bearings × 16$/bearing = 736$
- The Delay time's Cost = (95 + 110 + 125) minutes × 5$/minute = 1650$
- The Downtime during repairs' Cost = 46 bearings × 20 minutes/bearing × 5$/minute = 4600$
- The Total cost = 230$ + 736$ + 1650$ + 4600$ = 7216$

**The followig Table** is showing Bearing Replacement Using Current Method:

| | Bearing 1 Accumulated | | | | | Bearing 2 Accumulated | | | | | Bearing 3 Accumulated | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Random Digit (RD | Life (Hours) | Life (Hours) | Random Digit (RD) | Delay (Minutes) | Random Digit (RD) | Life (Hours) | Life (Hours) | Random Digit (RD) | Delay (Minutes) | Random Digit (RD) | Life (Hour | Life (Hours) | Random Digit (R | Delay (Minutes) |
| 1 | 67 | 1,400 | 1,400 | 2 | 5 | 70 | 1,500 | 1,500 | 0 | 15 | 76 | 1,500 | 1,500 | 0 | 15 |
| 2 | 8 | 1,000 | 2,400 | 3 | 5 | 43 | 1,200 | 2,700 | 7 | 10 | 65 | 1,400 | 2,900 | 2 | 5 |
| 3 | 49 | 1,300 | 3,700 | 1 | 5 | 86 | 1,700 | 4,400 | 3 | 5 | 61 | 1,400 | 4,300 | 7 | 10 |
| 4 | 84 | 1,600 | 5,300 | 7 | 10 | 93 | 1,800 | 6,200 | 1 | 5 | 96 | 1,900 | 6,200 | 1 | 5 |
| 5 | 44 | 1,200 | 6,500 | 8 | 10 | 81 | 1,600 | 7,800 | 2 | 5 | 65 | 1,400 | 7,600 | 3 | 5 |
| 6 | 30 | 1,200 | 7,700 | 1 | 5 | 44 | 1,200 | 9,000 | 8 | 10 | 56 | 1,300 | 8,900 | 3 | 5 |
| 7 | 10 | 1,000 | 8,700 | 2 | 5 | 19 | 1,100 | 10,100 | 1 | 5 | 11 | 1,100 | 10,000 | 6 | 5 |
| 8 | 63 | 1,400 | 10,100 | 8 | 10 | 51 | 1,300 | 11,400 | 1 | 5 | 86 | 1,700 | 11,700 | 3 | 5 |
| 9 | 2 | 1,000 | 11,100 | 3 | 5 | 45 | 1,300 | 12,700 | 7 | 10 | 57 | 1,300 | 13,000 | 1 | 5 |
| 10 | 2 | 1,000 | 12,100 | 8 | 10 | 12 | 1,100 | 13,800 | 8 | 5 | 49 | 1,300 | 14,300 | 4 | 5 |
| 11 | 77 | 1,500 | 13,600 | 7 | 10 | 48 | 1,300 | 15,100 | 0 | 15 | 36 | 1,200 | 15,500 | 8 | 10 |
| 12 | 59 | 1,300 | 14,900 | 5 | 5 | 9 | 1,000 | 16,100 | 8 | 10 | 44 | 1,200 | 16,700 | 2 | 5 |
| 13 | 23 | 1,100 | 16,000 | 5 | 5 | 44 | 1,200 | 17,300 | 1 | 5 | 94 | 1,800 | 18,500 | 1 | 5 |
| 14 | 53 | 1,300 | 17,300 | 9 | 10 | 46 | 1,200 | 18,500 | 2 | 5 | 78 | 1,500 | 20,000 | 7 | 10 |
| 15 | 85 | 1,700 | 19,000 | 6 | 5 | 40 | 1,200 | 19,700 | 8 | 10 | | | | | |
| 16 | 75 | 1,500 | 20,500 | 4 | 5 | 52 | 1,300 | 21,000 | 5 | 5 | | | | | |
| | | | | | 110 | | | | | 125 | | | | | 95 |

Check it out this table in Online Excel Sheet to verify from: Link

And, at the following table Bearing Replacement using Proposed Method:

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | | Bearing 1 | Bearing 2 | Bearing 3 | First Failure (Hours) | Accumulated Life (Hours) | RD | Delay (Minutes) |
| 2 | 1 | 1,400 | 1,500 | 1,500 | 1,400 | 1,400 | 3 | 5 |
| 3 | 2 | 1,000 | 1,200 | 1,400 | 1,000 | 2,400 | 7 | 10 |
| 4 | 3 | 1,300 | 1,700 | 1,400 | 1,300 | 3,700 | 5 | 5 |
| 5 | 4 | 1,600 | 1,800 | 1,900 | 1,600 | 5,300 | 1 | 5 |
| 6 | 5 | 1,200 | 1,600 | 1,400 | 1,200 | 6,500 | 4 | 5 |
| 7 | 6 | 1,200 | 1,200 | 1,300 | 1,200 | 7,700 | 3 | 5 |
| 8 | 7 | 1,000 | 1,100 | 1,100 | 1,000 | 8,700 | 7 | 10 |
| 9 | 8 | 1,400 | 1,300 | 1,700 | 1,300 | 10,000 | 8 | 10 |
| 10 | 9 | 1,000 | 1,300 | 1,300 | 1,000 | 11,000 | 8 | 10 |
| 11 | 10 | 1,000 | 1,100 | 1,300 | 1,000 | 12,000 | 3 | 5 |
| 12 | 11 | 1,500 | 1,300 | 1,200 | 1,200 | 13,200 | 2 | 5 |
| 13 | 12 | 1,300 | 1,000 | 1,200 | 1,000 | 14,200 | 4 | 5 |
| 14 | 13 | 1,100 | 1,200 | 1,800 | 1,100 | 15,300 | 1 | 5 |
| 15 | 14 | 1,300 | 1,200 | 1,500 | 1,200 | 16,500 | 6 | 5 |
| 16 | 15 | 1,700 | 1,200 | 63/1,400 | 1,200 | 17,700 | 2 | 5 |
| 17 | 16 | 1,500 | 1,300 | 21/1,100 | 1,100 | 18,800 | 7 | 10 |
| 18 | 17 | 85/1,700 | 53/1,300 | 23/1,100 | 1,100 | 19,900 | 0 | 15 |
| 19 | 18 | 05/1,000 | 29/1,200 | 51/1,300 | 1,000 | 20,900 | 5 | 5 |
| 20 | **Total** | | | | | | | 125 |

Online Excel Sheet to check it out: Link

The bearings are meant to be in order on a shelf, and are sequentially taken and put on the mill. Since the proposed approach uses more bearings than the existing method, the second simulation uses new random digits for generating the additional lifetimes. The random digits that lead to the life of the additional bearings are shown above the slashed line beginning with the 15-th replacement of bearing 3. Approximately 18 sets of bearings were required when the new policy was used. In the two simulations, repairperson delays were not duplicated, but were independently produced using various random digits. The overall costs for the new strategy are estimated as follows:

- The Bearings Costs = 54 bearings × 16$/bearing = 864$
- The Delay time's Cost = 125 minutes × 5$/minute = 625$

- The Downtime during repairs' Cost= 18 sets× 40 minutes/set× 5$/minute = 3600$
- The Repairpersons' Cost= 18 sets × 40 minutes/set × 15$/60 minutes = 180$
- The Total cost = 180$ + 625$ + 180$ + 3600$ = 5269$

The new policy generates a savings of 1,947$ over a 20,000-hour simulation. The estimated time is around 2 and 1/4 years, if the computer runs continuously. Therefore, the savings are about 865$ per year.

## 4. Conclusion

So in my research, I have done a 2 tables to Simulate the problem over 20000 operating hours to calculate: The Bearings Costs, The Cost of delay time, The Cost of downtime during repairs, The Cost of repairpersons and The Total cost

## 5. References

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