

Chapter 02, Simulation Examples in a Spreadsheet

Example 09: Replacing Bearings in a Milling Machine

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Table 22 Distribution for Bearing Life

Distribution of Bearing-Life			
Bearing Life	Probability	Cumulative Probability	
1000		0.100	0.100
1100		0.130	0.230
1200		0.250	0.480
1300		0.130	0.610
1400		0.090	0.700
1500		0.120	0.820
1600		0.020	0.840
1700		0.060	0.900
1800		0.050	0.950
1900		0.050	1.000

Table 23 Distribution of Delay until Mechanic Arrives

Distribution of Delay Time			
Delay Time	Probability	Cumulative Probability	
5		0.600	0.600
10		0.300	0.900
15		0.100	1.000

page 65, Chapter 02: Simulation Examples in a Spreadsheet

Example 9: Replacing Bearings in a Milling Machine

A milling machine has three different bearings that fail in service. The distribution of the life of each bearing is identical, as shown in Table 22. When a bearing fails, the mill stops, a mechanic is called, and he or she installs a new bearing (costing \$32 per bearing). The delay time for the mechanic to arrive varies randomly, having the distribution given in Table 23. Downtime for the mill is estimated to cost \$10 per minute. The direct on-site cost of the mechanic is \$30 per hour. The mechanic takes 20 minutes to change one bearing, 30 minutes to change two bearings, and 40 minutes to change three bearings. The engineering staff has proposed a new policy to replace all three bearings

Current Method

Bearing 1			
Step	Random#	Life (Hours)	Delay (minutes)
	1	0.256	1200
	2	0.242	1200
	3	0.990	1900
	4	0.348	1200
	5	0.382	1200
	6	0.366	1200
	7	0.165	1100
	8	0.797	1500
	9	0.038	1000
	10	0.919	1800
	11	0.881	1700
	12	0.438	1200
	13	0.539	1300
	14	0.358	1200
	15	0.827	1600

Bearing 2			
Step	Random#	Life (Hours)	Delay (minutes)
	1	0.518	1300
	2	0.181	1100
	3	0.394	1200
	4	0.733	1500
	5	0.994	1900
	6	0.418	1200
	7	0.466	1200
	8	0.478	1200
	9	0.059	1000
	10	0.361	1200
	11	0.727	1500
	12	0.508	1300
	13	0.229	1100
	14	0.346	1200
	15	0.528	1300

Bearing 3			
Step	Random#	Life (Hours)	Delay (minutes)
	1	0.730	1500
	2	0.981	1900
	3	0.952	1900
	4	0.326	1200
	5	0.947	1800
	6	0.445	1200
	7	0.220	1100
	8	0.308	1200
	9	0.125	1100
	10	0.371	1200
	11	0.025	1000
	12	0.137	1100
	13	0.250	1200
	14	0.960	1900
	15	0.992	1900

TOTAL		20300	110	19200	95	21200	130
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Costs of Bearing=	\$ 32.00 per bearing			The total life of all 45 bearings is	=	60700
Downtime cost=	\$ 10.00 per minute			Hours / 10,000 Bearings	=	6.070
Mechanic cost=	\$ 30.00 per hour	\$	0.50 per min	The Total cost per 10,000 bearing -Hours is	=	\$ 2,345.96
Replacement Time by Mechanic						
1 Bearing	20 minute					
2 Bearing	30 minute					
3 Bearing	40 minute					

For Single Trial of the simulation, the cost of the current system is estimated as follows:

Cost of Bearing	=	\$ 1,440.00
Cost of delay time	=	\$ 3,350.00
Cost of downtime during repair	=	
		\$ 9,000.00
Cost of Mechanics	=	\$ 450.00
Total Cost	=	\$ 14,240.00

Proposed Method

	Bearing 1		Bearing 2		Bearing 3		First Failure (Hours)	Random#	Delay (minutes)
Step	Random#	Life (Hours)	Random#	Life (Hours)	Random#	Life (Hours)			
1	0.400	1200	0.759	1500	0.230	1200	1200	0.940	15
2	0.012	1000	0.014	1000	0.316	1200	1000	0.531	5
3	0.596	1300	0.819	1500	0.348	1200	1200	0.643	10
4	0.637	1400	0.202	1100	0.858	1700	1100	0.917	15
5	0.564	1300	0.924	1800	0.664	1400	1300	0.638	10
6	0.997	1900	0.322	1200	0.168	1100	1100	0.603	10
7	0.847	1700	0.328	1200	0.015	1000	1000	0.589	5
8	0.362	1200	0.710	1500	0.358	1200	1200	0.368	5
9	0.744	1500	0.561	1300	0.761	1500	1300	0.909	15
10	0.300	1200	0.164	1100	0.739	1500	1100	0.324	5
11	0.790	1500	0.260	1200	0.023	1000	1000	0.722	10
12	0.289	1200	0.112	1100	0.764	1500	1100	0.751	10
13	0.574	1300	0.349	1200	0.402	1200	1200	0.301	5
14	0.978	1900	0.923	1800	0.758	1500	1500	0.642	10
15	0.072	1000	0.180	1100	0.475	1200	1000	0.408	5

Total 17300 135

Costs of Bearing= \$ 32.00 per bearing
Downtime cost= \$ 10.00 per minute
Mechanic cost= \$ 30.00 per hour \$ 0.50 per min
Replacement Time by Mechanic
1 Bearing 20 minute
2 Bearing 30 minute
3 Bearing 40 minute

The total life of all 45 bearings is = 17300
Hours / 10,000 Bearings = 1.730
The Total cost per 10,000 bearing - = \$ 5,254.34
Hours is

For Single Trial of the simulation, the cost of the current system is estimated as follows:

Cost of Bearing = \$ 1,440.00
Cost of delay time = \$ 1,350.00
Cost of downtime during repair = \$ 6,000.00
Cost of Mechanics = \$ 300.00
Total Cost = \$ 9,090.00