Life Cycle Cost Analysis of Vertical Broaching Machine

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Abstract— In this paper, the life cycle cost of Vertical Broaching Machine is optimized based on certain reliability improvement measures. These measures are suggested based on design calculations, selection of components, maintenance policy and discussion with experts from industries. Based on the reliability improvement measures, improved MTBF is estimated. The improved life cycle cost is also estimated. The results of improved MTBF and LCC are tabulated at the end.

Key words: Life Cycle Cost Analysis, Vertical Broaching Machine

I. Introduction

In failure analysis of Vertical Broaching Machine, we found that most of failures are caused by the breakage or failure of components, and the outsourcing components take large proportion. It means the reliability of the components that were selected in the course of designing and manufacturing is relatively poor, and the reliability of the Vertical Broaching Machine is difficult to be assured because of the earlier ageing of the components. Thereby, when the reliability improvement design is done the component control scheme and preferred components inventory to relevant components should be reformulated, standardized components with guarantee of reliability should be selected first. At the same time, a series of testing scheme for screening and examining components should be made also, and the concept of batch quality assurance be formed. The early stage test on reliability of the Vertical Broaching Machine should be done before being dispatched from factory to get rid of the early failure. In this way, the accidental failure period can be extended and the reliability of Vertical Broaching Machine can be increased.

A. Preventive Maintenance Policy based on RAM Analysis

Vertical Broaching Machine deteriorates with usage and can fail. If Vertical Broaching Machine fails, it would have a great effect on the product quality and performance. In order to guarantee the reliability, appropriate maintenance should be paid on Vertical Broaching Machine. Action to control (or reduce) equipment degradation are called preventive maintenance. In order to improve the utilization of Vertical Broaching Machine, the user should develop the items of preventive maintenance. There are generally two kinds of methods for preventive maintenance of Vertical Broaching Machine: one is routine inspection, the other is regular inspection.

The goal of routine inspection of Vertical Broaching Machine are mainly used to examine whether there is enough lubricating oil, enough coolant liquid and whether bolts, key connections are loosened and whether there are leakage of oil, and so on. The routine testing items are shown in table 1. There is regular inspection besides routine inspection for Vertical Broaching Machine. The regular inspection items are shown in table 2.

Sr. No.	Testing part	Testing items
1	Oil level gauge of the lubricate parts	– If there is enough oil
		– If the oil is contaminated
2	Surface Of Coolant Liquid	– If amount of the coolant liquid is fit
		– If the coolant liquid is obvious contaminated
		– If the filter is clogged
3	Retrieval System	– If there is up and down movement problem
		– If the column is not lubricated
		– If the limit switch is off
4	Pressure Gauge	– If the pressure is proper
5	Limit Switch	– If there is entry of oil in it
		– If there is loose connection
6	Pipe And Appearance	– If there is the leakage of the hydraulic oil
		– If there is the leakage of the coolant liquid
		– If there is the leakage of the lubricant
7	The Moving Parts	– If there are noise and vibrations
		– If the parts move smoothly
8	Control Panel	– If functions of the switch and push button are normal
9	Electric Wire	– If there is disconnection
		– If the insulated coat is wearing out
10	Rotating Part	– If there are noise and vibrations
		– If there is abnormal heat
11	Cleaning	– Clean the surface of the main plate, cross head, column of machine.
12	Work Piece	– If the machining center keeps the machining accuracy under the control

Table 1: Routine Inspection Item

Sr. No.	Check point	Inspection frequency.
1	Check the machine for any oil leakage	180 Days
2	Check the machine vibration during job cutting operation	180 Days
3	Level of the flatness of face plate with spirit level	180 Days
4	Check for proper mounting of all motors	180 Days
5	Check hydraulic pump for abnormal noise	180 Days
6	Check for working and mounting of limit switch	90 Days
7	Check for oil lubrication line	180 Days
8	Check for proper working of lubrication pump.	90 Days
9	Check coolant pump for abnormal noise	180 Days
10	Check condition of hydraulic oil and replace	180 Days
11	Clean hydraulic power pack and surrounding	180 Days
12	Clean filter so that it should not chock up	180 Days
13	Check side guide ways for proper lubrication, wear	180 Days
14	Check for loose connections in the contacts & earthing	180 Days
15	Check for proper working of push button switches.	180 Days
16	Check all lubricating points for proper functioning	180 Days
17	Check all piping condition and leak	180 Days
18	Check the gap between retrieval pump and mptor pulley and adjust it	180 Days
19	Check the input for all limit switch and push buttons	180 Days
20	Check all overload relay	180 Days
21	Run the machine in auto condition and check for any abnormal noise from column and cross head	180 Days
22	Tight all connection on motor, contactor, limit switch, push button	90 Days
23	Check the concentricity between broach ram bore and face plate bore	360 days
24	Check the perpendicularity of vertical movement of broach w.r.t. clamping surface	180 days

Table 2: Regular inspection item

II. IMPROVED MTBF OF COMPONENTS

An effective implementation of above suggested measures will improve reliability of components and ultimately reliability of the system. Table 3 shows the approximate improvement in MTBF of components.

Sr. No.	Component	Earlier MTBF (Hours)	Improved MTBF (Hours)
1	Coolant Pump	14316	20000
2	Filter	57336	70000
3	Hydraulic Oil Seal	5616	12000
4	Limit Switch	10227	15000
5	Hydraulic Pipe	20660	30000
6	Relay	15516	25000
7	Push Button	27262	36000
8	Hydraulic Power Pack Motor	22682	30000
9	Connector	12092	18000

Table 3: Improved MTBF

The improved MTBF of the system will be approximately as given below,
System MTBF = 17000 hours.

III. IMPROVED LIFE CYCLE COST

A. Acquisition Costs

The acquisition cost of the Vertical Broaching Machine includes management cost, engineering design and manufacturing, material costs, production costs, engineering data, spare parts and logistics, initial training and service during warranty period etc.

Acquisition costs, Cu = Design costs + production costs + assembly costs + spare parts cost + qualification and certification costs + packaging and warehousing costs + initial training cost + documentation costs + logistics costs + warranty costs + other cost = 40,000 + 20,000 + 20,000 + 2, 95,000 + 10,000 + 10,000 + 15,000 + 10,000 + 40,000 + 70,000 + 50,000
Acquisition costs, C_u = Rs. 5,80,000.

Thus, there will be an increase of Rs. 10,000/- in the acquisition cost on account of improved measures.

B. Operation Costs

The annual operating cost remains as it is,
Annual operating cost, C_o = Rs. 2, 06,304.

C. Failure Costs

Table 4 shows improved failure cost. The MTBF is estimated for all the components. Labour charges for repair are considered as Rs. 400 per hour.

Annual failure cost = (failures per year * repair hours * activity cost) + part cost + logistic cost.
The failure cost per year = Rs.15,317
Therefore, the total failure cost over the life becomes,
Total failure cost = 15,317 * 07 = Rs. 1,07,219

Expected number of failure events over the life = t_d /MTBF = 07 * 7320/ 17000 = 3.014
Cost per failure = C_f = 1,07,219 / 3.014 = Rs. 35,574

D. Support Costs

Annual preventive maintenance costs can be considered as support costs. Table 5 shows estimation of support cost. The annual preventive maintenance costs may comprise the labour cost associated with the preventive maintenance and the cost of components that are replaced during preventive maintenance. In addition, there is a fixed support costs of documentation required in regard to the maintenance practices.

Fixed support costs = Rs. 3000

The labour cost associated with the preventive maintenance is estimated based on following assumptions.

The preventive maintenance is carried out by a crew of three technicians. The labour rate is Rs. 400 per hour.

The annual mean maintenance hour is assumed to be 3. Therefore, Annual preventive maintenance cost = 3 × 400 = Rs.1200

The annual preventive maintenance cost = 4856 + 1200 = Rs. 6,056

Therefore, the support cost, $C_{s=}$ = fixed support cost + annual support cost =3000 + 6,056

C_s= Rs. 9,056

Component	MTBF	Failures/ Years	Repair Hours	Activity Cost, Rs./hr	Labour Cost Rs.	Part cost, Rs.	Logistics Costs	Total cost Rs./yr
1	**2**	**3**	**4**	**5**	**3*4*5=6**	**7**	**8**	**6+7+8**
Coolant Pump	20000	0.366	2	400	293	4700	470	5463
Filter	70000	0.1045	1	400	42	1700	170	1912
Hydraulic Pipe	30000	0.244	1½	400	147	3400	340	3887
Relay	25000	0.2928	2½	400	293	1300	130	1723
Push Button	36000	0.2033	1	400	81	1080	108	1269
Connector	18000	0.4067	2¾	400	447	560	56	1063
Total								**15317**

Table 4: Failure cost estimation

Sr. No.	Component	MTBF	Cost per unit (C_i)	Frequency per year (f_{pi})	$C_i \times f_{pi}$
1	Hydraulic Oil Seal	12000	400	0.61	244
2	Limit Switch	15000	5200	0.488	2538
3	Hydraulic Power Pack Motor	30000	8500	0.244	2074
Total					4856

Table 5: Support Cost estimation

E. Net Salvage Value

At the end of useful life of the Vertical Broaching Machine, the machine is scrapped. The approximate net salvage value is Net salvage value, S = Rs. 35000

Sr. No.	Cost of element	Earlier cost (Rs.)	Improved cost (Rs.)	Savings (Rs.)	Cost savings (%)
1	Acquisition cost	5,70,000	5,80,000	-10,000	-1.7
2	Operating cost	8,71,531	8,71,531	000	0.00
3	Failure cost	67,305	64,710	2595	3.85
4	Support cost	52,203	41,257	10946	20.9
5	Net salvage value	-15831	-15831	00	0.0
6	Life Cycle Cost	15,45,208	15,41,667	3541	0.3

Table 6: Improved LCC and cost savings

IV. Estimation of Improved Life Cycle Cost

Substituting the values as calculated above in life cycle cost equation.

LCC = 5, 80,000 + [0 + 4.2245 × 2, 06, 304] + [4.2245 × 35,574 × 7320 / 17,000] + [3000 + 4.2245 × 9,056] – 0.4523 × 35000

= 5, 80,000 + 8, 71,531 + 64,710 + 41,257 – 15831

= Rs. 15, 41,667

Thus there is almost 0.30% reduction in life cycle costs. Table 6 shows improved LCC and cost saving.

V. Conclusions

It is found that we can save 20.09% of support cost and 3.85% of failure cost. So, we can save total 0.3% of total life cycle cost. For this data to be made available for reliability and LCC analysis the manufacturer and user should maintain a register for each system. The register should have the following points for maintenance and failure as mean time between failures for each component, failure rate of each component, cost of repair or replacement, frequency of preventive maintenance, labor hours required for preventive maintenance, elapsed time for the preventive maintenance, administrative and logistics delay times, elapsed repair time, number of persons and their skill levels required for maintenance. The records of the data maintained in this way will help the life cycle cost of the existing product or system, but also it will be useful in providing a strong base for innovations in machine.

References

[1] H. Paul Barringer, "Why you need practical reliability details to define life cycle costs for your products and competitors products?" www.barringerl.com. Maintainability Engineering" Tata McGraw-Hill,

[2] Charles E. Ebling. "An introduction to Reliability and Maintainability Engineering" Tata McGraw-Hill, Edition 2000.

[3] Sukhwinder Singh Jolly, S.S.Wadhwa, "Reliability, availability and maintainability study of high precision special purpose manufacturing machines", Journal of Scientific & Industrial Research, Vol.63, Page no. 512-517, June 2004.

[4] Rajkumar Patil, “Reliability Analysis and Life Cycle Cost Optimization of Band Saw Cutting Machine.” Dissertation of ME Design, Shivaji University, Kolhapur, June-2013.
[5] Wang Ji Ming, Huang Min, Yi Jun, Liu Xue Jun, “The Study of Process Reliability of Aircraft Engine”, Procedia Engineering, Volume99, Page no.835-839, 2015.
[6] H. Paul Barringer, “Life Cycle Cost Tutorial”, Fifth International Conference on Process Plant Reliability, October 2-4, 1996.
[7] Yiqiang Wang, Richard C.M. Yam, Ming J. Zuo, Peter Tse. “A comprehensive reliability allocation method for design of CNC lathes”. Reliability Engineering and System Safety, Volume 72, Page no.247-252, 2001.
[8] G.S.Engineers, Yadrav,Ichalkaranji
[9] Logistics Management Institute, “Life Cycle Costing in Equipment Procurement”.