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REDUNDANCY ALLOCATION PROBLEM:JAYFE CYLINDER MANUFACTURING PLANT

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ABSTRACT

To increase the reliability of the system, Redundancy Allocation Problem (RAP) is formulated which determines the constituent reliability and the level of redundancy for each subsystem. The RAP is a non-linear integer type optimisation problem. The main objective is to optimize reliability of JAYFE Cylinder manufacturing plant within a given cost bracket. The Heuristic algorithm used to solve the problem of redundancy allocation with cost constraint in the system is described and used to assign redundancy in the manufacturing plant. Heuristic algorithm is useful to come across an efficient redundancy approach. Role of this algorithm is to give the achievable solution for the given problem.

Keywords: Redundancy, heuristic method, reliability, optimization.

1. INTRODUCTION

The key objective of redundancy allocation problem (RAP) is to optimize the reliability of the manufacturing system.It is highly necessary to design reliable systems as there is a great demand for those products that offer high quality and safety. Reliability is one of the most important performance measures of any engineering system including manufacturing production systems, power systems, telecommunication systems and so forth. Reliability optimizationaims to find the best way to increase the reliability.

Kumar[2010] exemplified the heuristic method for solving redundancy allocation in complex systems.Rajbala&Garg [2019] discussed about the steady state and time dependent availability analysis of a manufacturing plant.Rajbala&Garg [2019] discussed about the Behaviour analysis of alloy wheel plant. Rajbala [2021] discussed the performance analysis of the alloy wheel plant (AWP). The AWP mainly consists of four subsystems in series (Gdc Machine, Cutting Machine, Heat Treatment Machine and Shot Blasting Machine). The failure and repair rates are implicit to be constant and statistically

independent. A transition diagram developed form the interrelationship among the working and failed state. Mathematical modeling of this system is done by applying markov- birth – death processes. These equations are solved by recursive method and optimized reliability is calculated for failure and repair rates. The obtaining result is helpful to improve the overall performance of alloy wheel plant.

Kumar et al. [2019] the main objective of this paper is to an examined analysis of a washing unit in the paper industry utilizing RPGT. Kumar et al. [2018, 2017] have studied the behavior analysis of a bread system and edible oil refinery plant. Kumar et al. [2019]analysed a cold standby framework with priority for preventive maintenance contains two identical subunits with server failure utilizing RPGT.

Chaudhary et al. [2013], Goyal and Goel [2015]have discussed behaviour with perfect and imperfect switch-over of systems using various techniques.Priya et al. [2021] Vedic mathematics in derivatives and integration, differential equations and partial differential equations.Kumari et al. [2021] studied the constrained problems using PSO.

Kumar et al. [2018] discussed the 3:4: G System. Kumari et al. [2021] discussed the profit analysis of an agriculture thresher plant in steady state using RPGT. Anchal et al. [2021] discussed the SRGM model using differential equation has been proposed, in which two categories of faults: simple and hard with respect to time in which these occur for isolation and removal after their detection has been presented.Kumar et al. [2017] studied the behavior analysis in the urea fertilizer industry.

2. SYSTEM DESCRIPTION

The JAYFE Cylinder manufacturing plant consists of four subsystems namely: Cutting machine, spinning machine, threading machine & Milling machine. These machines are arranged in series.

i. **Cutting Machine**: Raw material comes in form of hollow lengthy pipe. Cutting machine is used to cut hollow lengthy pipe in desired length.
ii. **Spinning Machine**: After cutting hollow pipe next is to make cylinder neck and bottom face with help of welding.
iii. **Threading Machine**: When neck and bottom face is completed, and then cylinder is forward for threading on neck.
iv. **Milling Machine**:Milling machine is used for face cleaning of neck and it removes unnecessary material form neck and bottom.

3. PROCESS FLOW DIAGRAM

The process flow diagram of the JAYFEE Cylinder manufacturing plant is as follow:

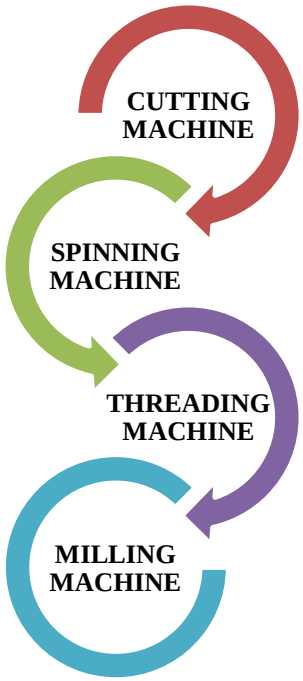

Fig. 1.Process Chart

4. SYMBOLE ANDNOTATIONS

The following and symbols and notations are used in this paper:

- $\mathbf{X_i}$:i^{th} subsystem/component of system
- $\mathbf{S_i}$:Number of subsystems in the plant
- $\mathbf{R_i}$: Reliability of subsystem Xi
- $\mathbf{G_i}$:Total cost of all the subsystems contained in the system

5. RELIABILITY AND COST OF EACH SUBSYSTEM OF JAYFE MANUFACTURING PLANT:

In the case of JAYFE manufacturing plant, the objective is to maximise the reliability with the given cost constraint of INR 1,600,000.

Table 1.Reliability cost of each machine.

Subsystem	CuttingMachine (S1)	MillingMachine (S2)	Spinning Machine (S3)	ThreadingMachine (S4)
Reliability of the Subsystem$R_i(x_i)$	0.9123	0.9041	0.9910	0.99
Costof the subsystem $G(x_i)$	120,000	140,000	125,000	500,000

6. ALGORITHM

- Initialise number of constraint equal to 0.
- Initialisenumber of every subsystem equal to 0.
- Calculate reliability of each subsystem.
- Find the component with minimum reliability.
- Check whether constraint is violated on adding one more redundant system.
- Find the optimal solution.
- Calculate the system reliability.
- If all the subsystems have been removed from consideration the current x_i's are the optimum values of redundant components, then stop the process.

7. FUNCTIONING OF ALGORITHM:

Table 2. Steps in HA

Number of Components in each Subsystem				Consumed Resources	Subsystem Selection Factor			
S1	S2	S3	S4	Cost (G_i, INR)	R1	R2	R3	R4
1	1	1	1	885,000	0.9123	0.9041’	0.9910	0.9900
1	2	1	1	1,025,000	0.9123’	0.9908	0.9910	0.9900
2	2	1	1	1,145,000	0.9923	0.9908	0.9910	0.9900’
2	2	1	2	1,645,000?	0.9923	0.9908’	0.9910	!
2	3	1	2	1,785,000?	0.9923	!	0.9910’	!
2	2	2	2	1,770,000?	0.9923’	!	!	!
3	2	2	2	1,890,000?	!	!	!	!
2		2	2	1,770,000?	!	!	!	!

‘: A redundant component is added to this subsystem.

!: The subsystem is not taken for further consideration as cost constraint is violated on addition of its one more component.

?: Cost constraint is violated.

8. RESULTS:

RAP of the JAYFEE Manufacturing plant is solved by HA using MATLAB. The reliabilities before and after applying HA are shown in the Table 3.

Table 3.Results of reliability using HA.

Machine Name	Reliability Before Applied Algorithm	Reliability After Applied Algorithm	Difference In Reliability
Cutting Machine	0.9123	0.9923	0.0800
Spinning Machine	0.9041	0.9908	0.0867
Threading Machine	0.9910	0.9910	0.0000
Milling Machine	0.990	0.990	0.0000

The redundancy is used by each subsystem are shown in the graphical form in Fig.2.

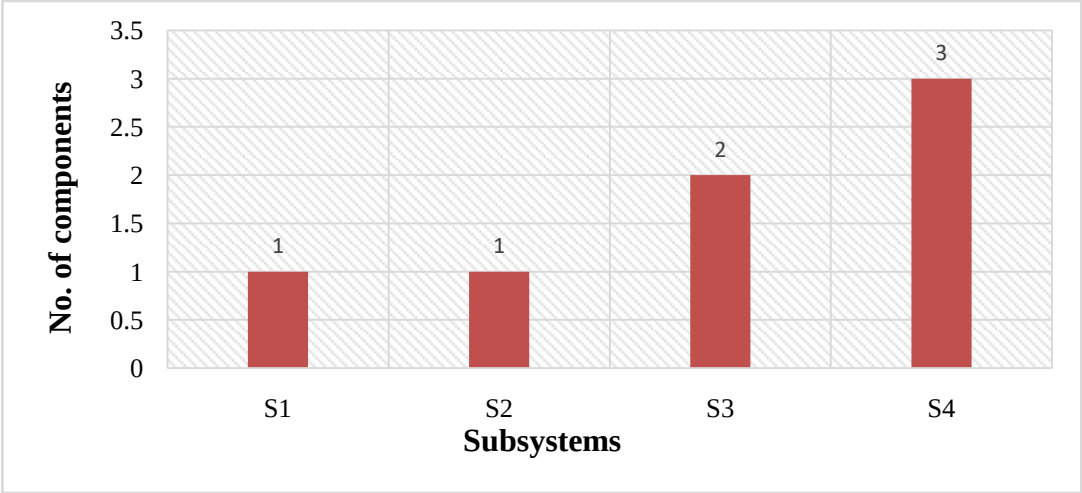

Fig. 2.Redundancy Allocation for different subsystems (Si) after applying HA

9. CONCLUSION

Redundancy allocation problem using heuristic method improves the system reliability that may be optimal solution. The optimal solution of the system obtained by HA is 0.0867.Future researchers may determine the optimal number of redundant components of various manufacturing systems within the budget constraints, which will increase the reliability of the systems with the use of the optimal number of redundant components.

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