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Axiomatic Approach For Journal Bearing Material Selection

Agasti Bhoi[1], Dr.Kalpesh. D.Maniya[2]

[1] Mechanical Engineering Department, C.K.P.C.E.T, Surat,afb.ngpp@gmail.com
[2] Mechanical Engineering Department, C.K.P.C.E.T, Surat

Abstract: *Axiomatic Design principle is practical approach for selection process and improves the design by optimization Tow fundamental Axioms (Information Axiom & Independence Axiom) in Axiomatic Design principle. Information Axiom is using probability density function and gives best from given alternative. Information Axiom is applied for Journal Bearing material selection .There are wide variety of Journal Bearing material are available today for the Journal Bearing design such as Tin Babbitt alloy1,Tin Babbitt alloy2,Lead Babbitt alloy, Lead Babbitt alloy7, and any others. So, final selection is based on understanding of material properties and application requirement. Some of the considerations in the choice of material include Compressive strength, Hardness, Thermal conductivity, Coefficient of frictions, cost etc. In AD, Fundamental Axioms are useful for designers and practicing engineers for best selection and improve existing design of Journal Bearing. A step-by-step procedure, graph and tables are presented to demonstrate the concept and effectiveness of suggested design methodology.*

Keywords: *Axiomatic Design, Information Axiom, Selection, Journal bearing, Probability density function.*

I. INTRODUCTION

A Bearing is machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. Bearing is very use full mechanical component where relative motion is required .By using bearing increasing the life of component by reducing the friction. Now a day bearing is very useful in industrial application. Fundamentally two types of Bearing Rolling contact Bearing and Sliding contact Bearing. Hydrodynamic Journal Bearing is one type of sliding contact Bearing. There are numerous types of bearing being designed, manufactured and used for many different applications now days. The primary function of bearing is load carrying between rotor and the case with as little wear as possible .The use of Journal bearing is specialized for rotating machinery for both high speed and low speed.

Bearing is machine element has widespread application in industries. It gives relative motion between tow mating parts with great accuracy and reducing friction between them. While selecting the bearing for particular application we consider some criteria such as Compressive strength, ultimate tensile strength, Fatigue strength, Thermal conductivity, Coefficient of friction, hardness, and cost. Now a day’s various materials are use for journal bearing. Many materials are available for journal bearing material. So selection of bearing material is important aspect. Very few methods are available for selecting the best material for these criteria.

For the Optimum design of bearing both material and geometrical parameters are taken into consideration. Selection of materials is key issues in optimal bearing design. For the cost reduction and better performance, many materials have long been used in industries are being replaced by newer material. Selection of material many number of factors are taken into consideration and most important factor is usually taken in material selection process are include Compressive strength, ultimate tensile strength, Fatigue strength, yield strength, hardness, Thermal Conductivity, cost etc. Axiomatic approach is very useful for selection Of any product, component, process, service etc. So it is useful for material selection. There is a copiousness of literature on axiomatic design approach few literature journal bearing.

Information Axiom is use for .Selection of better punching machine from given three punching machine [1]. Information Axiom is applied for Industrial Robert arm to get best design and presented advantages of Axiomatic design by compare with Multi criteria decision making (MCDM) techniques[2]. Selection of beast CNC machine from given alternatives is carried out by Information Axiom approach this selection approach is give better solution for given requirement[3].Fuzzy Axiomatic approach is used for selection of porous material for marine application in case of plate of Heat exchanger[4].Selection of material of lubricated journal bearing based on tribological criteria coefficient of friction. Wear rate and contact parameter rank method is used for selection [5].Coefficient of friction and wear is most important factor for journal bearing material selection[6]

II. AXIOMATIC APPROACH

Axioms are most usable principle there are two fundamental design axioms. First Independent design axiom and second is Information design axiom. The Independent Axiom is generating good design alternatives by using relationship between function requirements and design parameter The Information Axiom is related to the probability of achieving the given functional requirements can be used as a criterion for the selection of the best solution among the proposed alternatives in the conceptual or preliminary design stage. These principles are explained below (Suh, 1990; 2001).

AXIOM 1: The Independence axiom;

The Independence Axiom states that the independence of functional requirements (FRs) must always be maintained, where FRs are defined as the minimum set of independent requirements that characterizes the design goals. Mathematically, the relationship between the FRs and DPs are expressed as

$$\{FR\} = [A]\{DP\} \qquad .....(1)$$

Where, {FR} is the functional requirement vector, {DP} is the design parameter vector; and [A] is the design matrix that characterizes the design. In general each entry a_{ij} of A relates the i_{th} FR to j_{th}DP. The structure of [A] matrix defines the type of design being considered. In order to satisfy the independence axiom, [A] matrix should have an uncoupled or decoupled design.

AXIOM 2: The Information axiom: minimize the information content

The Information Axiom states that among those designs that satisfy the Independence Axiom, the design that has the smallest information content is the best design. Information is defined in terms of the information content, I_i, that is related in its simplest form to the probability of satisfying the given FRs. Information content I_i for a given FRi is defined as follows

$$I_i = \log_2 \frac{1}{P_i} \qquad ......(2)$$

Where, P_i is the probability of achieving the functional requirement.

Probability is calculate by using design range and system range As shown in Fig. 1, the overlap between the design range and system range is the region where the acceptable solution exists. Therefore, in the case of uniform probability distribution function P_i can be written as;

$$P_i = \frac{common\ range}{syestem\ range} \qquad ....(3)$$

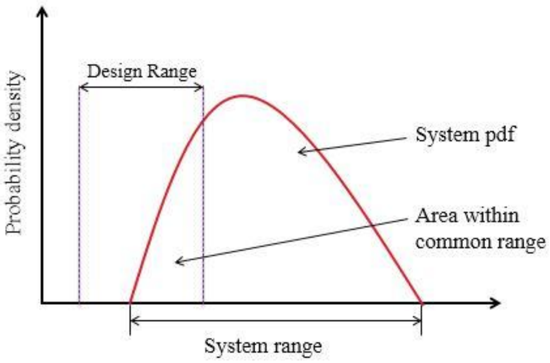


Figure. 1 Relationship between System Range, Design Range, Common Range and Probability Distribution

Methodology

STEP 1: Collect possible Material or Machine or Instruments with necessary characteristics and its data,

Material/Machine	Attributes				
	C1	C2	C3	C4	C5
M1	a	B			
M2	c	D			
M3					
M4					

STEP 2: Select criteria as per requirement (Functional Requirement-FR) is called Design Range.

FR_1, FR_2, FR_3, FR_4………

STEP 3: Find out System Range of each alternative.

STEP 4: Find out Common Range of each alternative from system range and design range using graphical method.

e.g. , To find common range of attribute C1 of alternative M1, System range = 300 – 700 , Design Range = 500 – 1000

STEP 5: Find out Information Content (I) of each alternative,

$$I_i = -\log_2 p_i ;$$ Where P_i = (system range/common range)

STEP 6: Finally Select best alternative based on total information. Material or Machine or Instruments which has less total information is best alternative.

III. CASE STUDY

3.1 Problem Formulation

Hardness', compressive strength, thermal conductivity, coefficient of friction is important parameter for journal bearing selection.

Here, Material M1 is Tin Babbitt alloy 1(White metal), M2 Tin Babbitt alloy3, M3 is Lead-tin Babbitt alloy, M4 is Lead - Babbitt alloy 7,

STEP 1: Various journal bearing Material data

Table 1 Journal bearing material data

Mat. No.	Hardness (BHN)	Compressive Strength (MPa)	Thermal coductivity (W/mK)	Cof	Cost (RS/Kg)
M1	15	64	46	0.01	1150
	22	89	52	0.04	1335
M2	18	102	46	0.01	1150
	29	127	53	0.05	1310
M3	18	98	39	0.01	1275
	26	112	47	0.07	1445
M4	17	36	18	0.01	1500
	23	43	24	0.12	1665

STEP 2: Following criteria are selected as per requirement of users

FR_1 = Hardness of Material is required between 20 to 70 BHN

FR_2 = Compressive strength strength of Material is required between 55 to 103MPa

FR_3 = Thermal conductivity of Material is required between 40 to 60 W/mK

FR_4 = coefficient of friction of Material is required between 0.01 to 0.08

FR_5 = cost of Material is required between 650 to 1500 Rs/Kg

STEP 3: we can find the system range of material M1 to M4 and construct the system range as shown below in Table 2

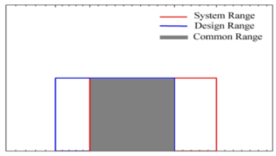
Table 2 System range of materials data

Mat. No.	Hardness (BHN)	Compressive styrength (MPa)	Thermal Conductivity (W/mK)	cof	Cost Rs/Kg
M1	15-22	64-89	46-52	0.01-0.04	1150-1335
M2	18-29	102-127	46-53	0.01-0.08	1150-1310
M3	18-26	98-112	39-47	0.01-0.04	1275-1445
M4	17-23	36-43	18-24	0.01-0.12	1500-1665

STEP:4 Graphical representation of common range using information of system range and design range,

Here, graphical representation of common range of Compressive strength (BHN) of material M3 is shown below.

P_i



55 98 103 112

Compressive strength(MPa) of M3

Figure 2.*Compressive strength vs Prob. Dist. of Material M3*

Table 3 Common range of materials

Sr. No.	Mat. No.	Hardness (BHN)	Compressive styrength (MPa)	Thermal Conductivity (W/mK)	cof	Cost Rs/Kg
1	M1	20-22	64-89	46-52	0.01-0.04	1150-1335
2	M2	20-29	102-103	46-53	0.01-0.08	1150-1310
3	M3	20-26	98-103	40-47	0.01-0.04	1275-1445
4	M4	20-23	0	0	0.01-0.08	0

As shown above procedure we can find the common range of material M1 to M4 and construct the common range Table 3 as shown below,

STEP 5: By using the table 2 and 3 we can compute the information content of each criteria and information content calculation of compressive strength of material M3 shown as under

$$\mathbf{I = \log_2 (1/p_i)} = \log_2 (\text{System Range/Common Range})$$

$$= \{ \log (\text{System Range/Common Range})\}/\log_2$$

$$= \{ \log (14/5)\}/\log_2$$

$$= 1.4854$$

Table 4: information content of materials

Sr. No.	Mat. No.	Hardness (BHN)	Compressive strength (MPa)	Thermal Conductivity (W/mK)	Cof	Cost Rs/Kg	Total
1	M1	1.8037	0	0	0	0	3.128
2	M2	0.2895	4.643	0	0.362	0	5.295
3	M3	0.4150	1.485	0.192	0	0	INF.
4	M4	0.7369	INF.	INF.	0.652	INF.	INF.

STEP 6: Information content of each attribute of each alternative is computed using above step 5 procedure. In the table 4, Total information content of all the attributes of each alternative are shown

- MATERIAL M1 has minimum information content so M1 is better alternative from given six material

VI. CONCLUDING REMARK

- In the Axiomatic Design, Information Axiom is related to the probability of achieving the given requirements, can be used as a criterion for the selection of best solution among the selected alternatives. The information axiom assists to select the best result by quantifying specific design attributes.
- When Information Axiom approach is used for selection of journal bearing material it gives the result in form of information content show in table 4.4
- Material M1 and M2 have low information content so it can satisfy the functional requirement.
- Material M1 is Very less information content so it is better material among four materials for given Functional requirement.

REFERENCES

[1] Kulak O. and Durmusoglu M B..(2005) "Fuzzy multi-attribute equipment selection based on information axiom". Journal of Material Processing Technology vol. 169, pp. 337-345

[2] Mehmet C. B. and Satoglu S. I. (2014) "A novel robot arm selection methodology based on axiomatic design principles" International Journal Of Advanced Manufacturing Technology, vol. 71, pp. 2043-2057

[3] V.V.Patel, J.D.Patel and K.D.Maniya.(2014) "Selection of CNC Lathe Machine by using Axiomatic Principles" Internationa Journal of Advance Engineering and Research development, vol-l.

[4] Kadier. Cicek and Metin .Celik (2009) "Selection of porous materials in marine system design: The case of Heat exchanger aboard ships"Materials and Design, vol-30, pp 4260-4266.

[5] W. J. DE GEE 'SELECTION OF MATERIALS FOR LUBRICATED JOURNAL BEARINGS'Wear, 36 (1976) 33 – 61

[6] Sanjay Kumar1, Dr. S. S. Sen2 'Selection of the Material on the Basis of Wear and Friction in Journal Bearing'ISSN: 2319-8753

[7] Suh, N.P. (1990). "The principles of design". New York: Oxford University Press

[8] Dai G. L., Suh N. P. (2006), "Axiomatic Design and Fabrication of Composite Structures: Applications in Robots, Machine Tools, and Automobiles". Oxford University Press, New York

