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SELECTION OF STRUCTURAL AND INSULATION MATERIAL FOR INFRARED HEATING SYSTEM BY WEIGHED PROPERTY METHOD

Kiran.K [1], Dr.Kiran Kumar P [2], Prof T.Madhusudhan [3]

[1] *M.Tech student, Dept. of Mechanical Engineering, S J B Institute of Technology, Bengaluru, India*

[2] *Professor, Dept. of Mechanical Engineering, S J B Institute of Technology, Bengaluru, India*

[3] *HOD, Dept. of Mechanical Engineering, S J B Institute of Technology, Bengaluru, India*

Abstract - *An infrared radiator or warmth light is a body with a higher temperature which exchanges vitality to a body with a lower temperature through electromagnetic radiation. Contingent upon the temperature of the transmitting body, the wavelength of the crest of the infrared radiation ranges from 780 nm to 1 mm. No contact or medium between the two bodies is required for the vitality exchange. The effectiveness of infrared radiation mainly depends on the type of insulation employed inside the chamber and also there should be a proper structural material for the particular application. In this papers the material considered for structural applications are Mild steel (ASTM A210), Mild steel (ASTM A36), Grey cast iron (ASTM 25), Grey cast iron (ASTM 30), Grey cast iron (ASTM 35) having variable constituents and the materials considered for insulation are Portland cement, refractory clay, glass, concrete, chrome brick and asbestos fiber among these Mild steel (ASTM A210) and refractory clay (ceramic) are selected by weighed property method.*

Key Words: Material, WPM, IR, Mild steel (ASTM A210), Refractory clay (ceramic).

1. INTRODUCTION

Selection of material is a very important task in every product design process traditionally material selections are taken place at a detailed design stage. In the design and development of infrared heating system. The most common type of structural materials used are mild steel and cast iron which are economical compared to stainless steel, aluminum and some composite materials. Again mild steel and cast iron comes up with different grades and composition possessing different mechanical properties like which effect the structure, economy and final product by different means. Again glass is the most common insulating material used it shows high cost and very sensitive in operation. Therefore a standard weighted property method is used for selection of materials. The type of structural material and insulation material inside the chamber covers about 50% of its total weight. The different material considered for structural applications are Mild steel (ASTM A210), Mild steel (ASTM A36), Grey cast iron (ASTM 25), Grey cast iron (ASTM 30), Grey cast iron (ASTM 35) having variable constituents and the materials considered for insulation are Portland cement, refractory clay, glass, concrete, chrome brick and asbestos fiber.There are many methods for selecting optimized material for particular type of application they are Fuzzy logic method, Multi-Criteria Decision Making method, Cost analysis, Limits Property Method and Weighted Property Method. WPM method involve more attributes or property and also considers each and every property into account, but some selection methods like Multi-Criteria Decision Making method (MCDM), Limits Property and Cost analysis method consider only some important properties of the material.

2. LITERATURE SURVEY

WPM is very useful in Selection of material for particular application when there are a large number of important properties to be compare and evaluated. In this method Scaled values of the criteria (β) are multiplied by the weighting index (α). The sum of multiplied scaled properties and weighting factors represents the performance index (γ). The combination of stock material and matching design process with the highest performance index is the optimum solution.

Kasim M. Daws, et.al [3]: He has studied about the automated advisory casting process selection system is designed. Selection of material trusted on specified criteria weighted property index algorithm calculates relative importance of each property. Ranking or for rating of each requirements and alternative process was given by Fuzzy Logic method, which shows optimized alternative process.

Dr. Mohammed Jasim Kadhim, et.al [4]: has made an endeavor to appear, there is no hole in the middle of materials and capacity arranged configuration. Simultaneous subjective determination of materials strategy (CQSM) was created to know the significance of materials properties in the early plan stages. The Weighted Property Method was adjusted from Quantitative technique to Qualitative Method for determination of materials. Weighted element record was figured by Digital Rationale (DL) and contrasted and the conventional strategy, Advanced Logic (DL) strategy indicates precise results because it does not eliminate least important properties.

Suresh talur, et.al[5] : In his paper he mainly studied on the selection of suitable material for wind turbine blades by Weighted Property Method, for manufacturing of small scale Savonius Vertical Axis Wind Turbine (SVAWT),material considered are Aluminium (7020 Alloy), Mild Steel (grade 55), Stainless Steel (A580) and Polycarbonate sheet, among these optimized material is selected based and weighed property method to increase performance of wind turbine , the selected material for SVAWT shows low density, corrosion resistant, economic, good

3. DISCUSSION AND CALCULATION

The below table shows the list of different materials to be investigated for structural and insulation applications and their properties

Table 1.1 properties of structural materials

Materials	Properties							
	Density Gm/cm^3	Corrosion µm/year	Cost $/kg	Thermal conductivity w/m-K	Thermal expansion KN-m/kg	Strength to weight ratio	Ultimate tensile strength Mpa	Young's modulus Gpa
Mild steel (ASTM A210)	7.82	5800	1.8	50	11.8	68	530	210
Mild steel (ASTM A36)	7.8	5800	1.8	50	11	62	480	210
Grey cast iron (ASTM 25)	7.2	6100	3	46	10.5	25	180	102

Grey cast iron (ASTM 30)	7.2	6100	3	46	10.5	29	250	113
Grey cast iron (ASTM 35)	7.2	6100	3	46	10.5	38	270	119

Table1.2 properties of insulation materials

Materials	**Properties**				
	Density (ρ) Kg/m³	Cost Rs/ Kg	Temperature ^{0}c	Thermal conductivity W/m-K	Specific heat (c) J/Kg/K
Portland cement	1900	20	30	0.3024	1130
Refractory clay(ceramic)	1845	12	450	1.036	1089
Glass	2500	23	20	0.7443	670
Concrete	419	22	100	0.1907	1214
Chrome brick	3000	18	200	2.320	840
Asbestos fibre	470	900	50	0.1105	816

Now the weighting factor (α) is obtained by giving relative priorities to the properties of material. This factor is obtained by using the past experience or the digital-logic method. Digital-logic method calculates by the comparison of properties, weighed property method is used in combined properties with having different units. WPM shows each material requirement (or property) is assigned to a certain weight depending on its importance in the design. Value for each weighing factor (α) should be given based on its importance.

Table 2.1 weighed factors for structural materials

SL. NO	PROPERTY	Weight index (α)
1	Density	8
2	Corrosion µm/year	7
3	Cost $/kg	6
4	Thermal conductivity w/m-k	5
5	Thermal expansion KN-m/kg	4
6	Strength to weight ratio	3
7	Ultimate tensile strength Mpa	2
8	Young's modulus Gpa	1

Table 2.2 weighted factors for insulation materials

SL. NO	PROPERTY	Weight index (α)
1	Density	5
2	Cost	4
3	Temperature	3
4	Thermal conductivity	2
5	Specific heat	1

Now, the weighed factor (β) is calculated using the formula Scaled property value for lower value of the property is required example costs, mass loss, etc.

Scaled Property

$$(\beta) = \left(\frac{\textit{lowest value in the list}}{\textit{numerical value of the property}}\right) X100$$

Dimensionless scaled property value for higher value for

the is required for example hardness, tensile strength, etc.

Scaled Property

$(\beta) = \left(\frac{numerical\ value\ of\ the\ property}{highest\ value\ in\ the\ lis}\right) X100$

Table 3.1 scaled properties for structural materials

Materials	**Scaled Properties (β)**							
	Density Gm/cm³	Corrosion µm/year	Cost $/kg	Thermal conductivity w/m-k	Thermal expansion KN-m/kg	Strength to weight ratio	Ultimate tensile strength Mpa	Young's modulus Gpa
Mild steel (ASTM A210)	92.07	100	100	100	100	100	100	100
Mild steel (ASTM A36)	92.07	100	100	100	93	91.17	90.5	100
Grey cast iron (ASTM 25)	100	95	60	92	88	36.76	33.9	48.5
Grey cast iron (ASTM 30)	100	95	60	92	88	42.64	47.16	53.8
Grey cast iron (ASTM 35)	100	95	60	92	88	55.88	50.9	56.6

Table 3.2 scaled properties for insulation materials

Materials	**Properties**				
	Density (ρ) Kg/m³	Cost Rs/kg	Temperature ^{0}c	Thermal conductivity w/m-k	Specific heat (c) j/kg/k
Portland cement	22.1	60	6.66	13.03	93.03
Refractory clay (ceramic)	22.7	100	100	44.65	89.7
Glass	16.7	52.17	4.44	32.04	55.18
Concrete	100	54.5	22.2	8.2	100

Chromebrick	14	66.6	44.4	100	69.19
Asbestos fibre	89.2	1.33	11.1	4.7	67.2

Now the performance index is calculated

Performance Index, γ=Σ (β*α)

Table 4.1 performance value and ranking of structural materials

Materials	**Scaled Properties (β)**									
	Density Gm/cm^3	Corrosion µm/year	Cost $/kg	Thermal conductivity w/m-k	Thermal expansion KN-m/kg	Strength to weight ratio	Ultimate tensile strength Mpa	Young's modulus Gpa	Performance value	Ranking
Mild steel (ASTM A210)	20.25	19.4	16.6	13.8	11.1	8.3	5	2.7	97.15	1
Mild steel (ASTM A36)	20.2	19.4	16.	13.8	10.32	7.5	4.5	2.7	95.0	2
Grey cast iron (ASTM 25)	22	18.43	9.96	12.76	9.76	3.06	1.69	1.34	79	5
Grey cast iron (ASTM 30)	22	18.43	9.96	12.76	9.76	3.55	2.35	1.49	80.3	4
Grey cast iron (ASTM 35)	22	18.43	9.96	12.76	9.76	4.65	2.5	1.59	81.65	3

Table 4.2 performance value and ranking of insulation materials

Materials	**Properties**						
	Density (ρ) Kg/m^3	Cost Rs/kg	Temperature ^{0}c	Thermal conductivity w/m-k	Specific heat (c) j/kg/k	Performance value	ranking
Portland cem	7.29	15.96	1.33	1.69	5.58	31.85	5

ent							
Refractory clay (ceramic)	7.49	26.6	20	5.8	5.3	65.19	1
Glass	5.51	13.8	0.89	4.16	3.3	27.6	6
Concrete	33	14.5	4.4	1.06	6	58.96	2
Chrome brick	4.62	17.7	8.88	13	4.15	48.27	3
Asbestos fiber	29.43	0.35	2.22	0.6	4.03	36.03	4

5. CONCLUSION

Ranking of materials in Weighted factor computed by Digital logic method, among the different types of structural materials Mild steel (ASTM A210), Mild steel (ASTM A36), Grey cast iron (ASTM 25), Grey cast iron (ASTM 30), Grey cast iron (ASTM 35) and the different types of insulating materials Portland cement, refractory clay, glass, concrete, chrome brick and asbestos fiber. The Mild steel (ASTM A210) higher performance of 97.15% and refractory clay with the performance of 65.19 % is selected since; they are showing higher performance than all others.

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BIOGRAPHY

Kiran K

M.Tech (machine design) Student, Department of mechanical engineering SJB Institute of Technology, Bengaluru.

Dr. Kiran Kumar P

Professor, Department of mechanical engineering SJB Institute of Technology, Bengaluru.

Prof. T Madhusudhan

HOD, Department of mechanical engineering, SJB Institute of Technology, Bengaluru.