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Selection of Wishbone Material for Suspension System by VIKOR Method

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ABSTRACT–In a race car for better performance, a comfortable ride, and easy operation it is very important to design a superior suspension system. Suspension system design depends on different facts. It changes with the type and speed of the vehicle. This paper is mainly focused on the suspension system used in student formula vehicles. If the suspension system is not working properly then it became difficult to get maximum performance of the vehicle. Material selection is very important in suspension design. It is a challenging task to select a material with high strength and lightweight. Selecting suitable materials for suspension systems by using the VIKOR method is the main objective of this paper. In the VIKOR method, we can select material as we want by comparing different properties of the material it is then possible to select the perfect material. In this paper, SUPRA 2021 car is used as an example.

Keywords: - Supra SAE, Suspension system, Wishbone, VIKOR Method, Material Selection.

I. INTRODUCTION

Supra SAE is the competition for student formula vehicle design, which is sponsored and conducted by the Society of Automobile Engineering [SAE]. In this competition designing, testing, and manufacturing of formula vehicles is expected from the student. Suspension is a device that connects the body and wheels. Double wishbone suspension with a push rod or pull rod is mostly used in a race car. Thesuspension system is an assembly of the different subsystems in which wishbone arms or A-arm are an important part. For wishbone arms high strength material is necessary. If the material is lightweight the suspension system gives better performance.

OBJECTIVE

The objective of the paper is to select appropriate material for the wishbone arm by comparing its mechanical properties like tensile strength, yield strength, and hardness by using the VIKOR method.

II. LITERATURE REVIEW

1] J.R. San Cristóbalel-al, in this paper, they apply the strategy in the selection of a Renewable Energy project relating to the Renewable Energy Plan dispatched by the Spanish Government.[1]

2] Zhicheng Gaoel-al, in this research another ranking framework philosophy dependent on the weighted VIKOR technique with proposed criteria for ranking bridge projects,is introduced.[2]

3] Mohammad Kazem Sayadiel-al, the point of this paper is to expand the VIKOR strategy for decision-making issues with interval numbers.[3]

4] Vadheel-al, the motivation behind this project isn't just to design and manufacture the suspension system for the vehicle, yet in an addition to give a top to bottom examination in the process taken to show up at the final design.[4]

5] Hiremath Iel-al, in this paper, have planned a sort of front suspension design for Formula racing vehicle, and by utilizing the ADAMS/Car, the front suspension kinematics model is set up and simulated, to upgrade the wheel alignment boundaries.[5]

6] Santosh el-al, in this paperwork optimum values for the suspension stiffness and damping are obtained for good comfort and handling conditions.[6]

III. SELECTION OF MATERIAL BY VIKOR METHOD

The VIKOR strategy, communicated as an MCDM demonstration, was created and enjoys a wide acknowledgment at the display time. This

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strategy centers on ranking and determination of a set of options within the nearness of multiple criteria. It presents the multi-criteria ranking index in view of the degree of 'closeness' to the 'ideal' arrangement.[7]

We selected the following 10 materials by comparing yield and tensile strength and mechanical properties. (AISI 1018, AISI 1020, AISI 1040, AISI 4130, ST35, S550 MC, S 700 MC, AA6063 T6, AA6061 T6)

TABLE I. CRITERIA FOR EVALUATION

Sr.No.	Name	Unit
1	Brinell Hardness	-
2	Tensile Strength	Mpa
3	Yield Strength	Mpa
4	Modulus of Elasticity	Gpa
5	Poisson's Ratio	-
6	Density	g/cc
7	Thermal Conductivity	w/mk

Step I: Find out f_i^+ and f_i^-

Find the best f_i^+ and the worst f_i^-values of all criterion functions, i¼ 1, 2, n. If the ith function addressesa benefit, then f_i^+ =max f_{ij} and f_i^-=min f_{ij}, while If the ith function addresses a loss then f_i^+ =min f_{ij} and f_i^-=mix f_{ij}.of the attributes considered Tensile Strength, Yield Strength, Modulus of Elasticity, Poisson's Ratio, Density, and Thermal Conductivityare beneficial attributes thus higher values are desirable. Brinell Hardness is a non-beneficial attribute thus lower values are desirable.

TABLE II. ALTERNATIVES AND ATTRIBUTES FORMATERIAL SELECTION.

Alternatives	Attributes						
	Brinell Hardness	**Tensile Strength**	**Yield Strength**	**Modulus of Elasticity**	**Poissons Ratio**	**Density**	**Thermal Conductivity**
AISI 1018	126	440	370	205	0.29	7.87	51.9
AISI 1020	121	420	350	205	0.29	7.87	51.9
AISI 1040	201	620	415	205	0.29	7.885	50.7
AISI 4130	217	560	460	200	0.28	7.87	42.7
ST35	187	607	571	210	0.29	7.89	25
ASTM A572	135	400	350	200	0.26	7.8334	51
S 550 MC	121	760	550	200	0.29	7.84	42.7
S 700 MC	161	950	700	200	0.30	7.8	42.7
AA6063 T6	75	250	210	69.5	0.33	2.7	201
AA6061 T6	95	310	276	68.9	0.33	2.7	167
	Min	**Max**	**Max**	**Max**	**Max**	**Max**	**Max**
fi+	75	950	700	210	0.33	7.89	201
fi-	217	250	210	68.9	0.26	2.7	25

Step II: Calculate the values S_j

$S_j= \sum_{i=1}^{n} w_i (f^+_i - f_{ij}) / (f^+_i - f^-_i)$

Where W_i are the weights of criteria, communicating the decisionmaker's inclination as the significance of the criteria.

we give more importance to the Tensile Strength, Yield Strength,and Brinell Hardness so we gave extra weightage to these attributes, Here the Weightage is 0.2. For remaining attributes like Modulus of Elasticity, Poisson's Ratio, Density, and Thermal Conductivity we gave less weightage of 0.1. The addition of total weightage is 1.

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TABLE III. CONVERSATION OF EVERY VALUE TO S_J

0.071830986	0.145714286	0.134693878	0.003543586	0.057142857	0.000385356	0.084715909
0.064788732	0.151428571	0.142857143	0.003543586	0.057142857	0.000385356	0.084715909
0.177464789	0.094285714	0.116326531	0.003543586	0.057142857	9.63391E-05	0.085397727
0.2	0.111428571	0.097959184	0.007087172	0.071428571	0.000385356	0.089943182
0.157746479	0.098	0.052653061	0	0.057142857	0	0.1
0.084507042	0.157142857	0.142857143	0.007087172	0.1	0.001090559	0.085227273
0.064788732	0.054285714	0.06122449	0.007087172	0.057142857	0.000963391	0.089943182
0.121126761	0	0	0.007087172	0.042857143	0.001734104	0.089943182
0	0.2	0.2	0.09957477	0	0.1	0
0.028169014	0.182857143	0.173061224	0.1	0	0.1	0.019318182

Step III. Find Sj and Rj

Here, we find the total Sj of material by adding attributes Sj. Now, for Rj which is the maximum value of attributes Sj

TABLE IV: VALUES OS Sj AND Rj

	Sj	**Rj**
	0.498026858	0.145714286
	0.504862155	0.151428571
	0.534257543	0.177464789
	0.578232037	0.2
	0.465542397	0.157746479
	0.577912046	0.157142857
	0.335435539	**0.089943182**
	0.262748362	0.121126761
	0.59957477	0.2
	0.603405563	0.182857143
S+, R+	0.262748362	0.089943182
S-, R-	0.603405563	0.2

Step IV: Find Qj and Rank

$Qj= v (Sj– S^+) / (S^- - S^+) + (1 - v) (Rj– R^+) / (R^- - S^+)$

where $S^* = \min_j S_j$; $S^+= \max_j S_j$; $R^* = \min_j R_j$; $R^- = \max_j R_j$ and v is presented as a weight for the system of greatest group utility, whereas (1-v) is the weight of the individual regret. The solution obtained by $\min_j S_j$ is with a maximum group utility ("majority" rule), and the solution obtained by $\min_j R_j$ is with a minimum individual regret of the "opponent". Regularly, the worth of v is taken as 0.5. In any case, v will have any value from 0 to 1. Here we take v = 0.5.

By using the formula to find Qj, we calculated the values for 10 materials and by comparing all values we ranked all the materials by lowest to highest Qj values.

TABLE V: RANKING FROM Qj VALUES

Qj	**Rank**	**Material**
0.598704427	**3**	AISI 1018
0.634697559	**5**	AISI 1020
0.796128018	**7**	AISI 1040
0.963051528	**9**	AISI 4130
0.605688874	**4**	ST35

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0.767877236	**6**	ASTM A572
0.106686688	**1**	**S550 MC**
0.141670363	**2**	S700 MC
0.994377348	**10**	AA6063 T6
0.92211815	**8**	AA6061 T6

Step V: conditions satisfaction

The best-positioned material by the action Q (least), if the following two conditions are fulfilled:

a. Acceptable advantage. $Q(A^2)-Q(A^1) \geq DQ$, where DQ=1/ (J-1) and A^2 is the option with the second position on the positioning rundown by Q.

J means number of alternatives

Here, j =10 so

DQ= 1/ (10-1) = 0.11111

$Q(A^2)- Q(A^1)$ =0.141670363 - 0.106686688

= 0.034983675

This condition is not satisfied.

b. Acceptable stability in decision-making. Option $A^{(1)}$ (Best positioned material) should likewise be the best positioned by S or/and R. This compromise solution is steady inside a decision-making process, which could be the strategy of greatest group utility[8].Here, rank 1 material has a minimum Rj so this condition is satisfied.

As per comparing Qj values (Qj minimum=top ranked material) and conditions satisfactions, we found S550 MCis the best material and to be used for the wishbone.

IV. ANALYSIS ON ANSYS

By using S500 MC material properties, we performed the analysis in the Ansys software and determined that this material can sustain the design load.

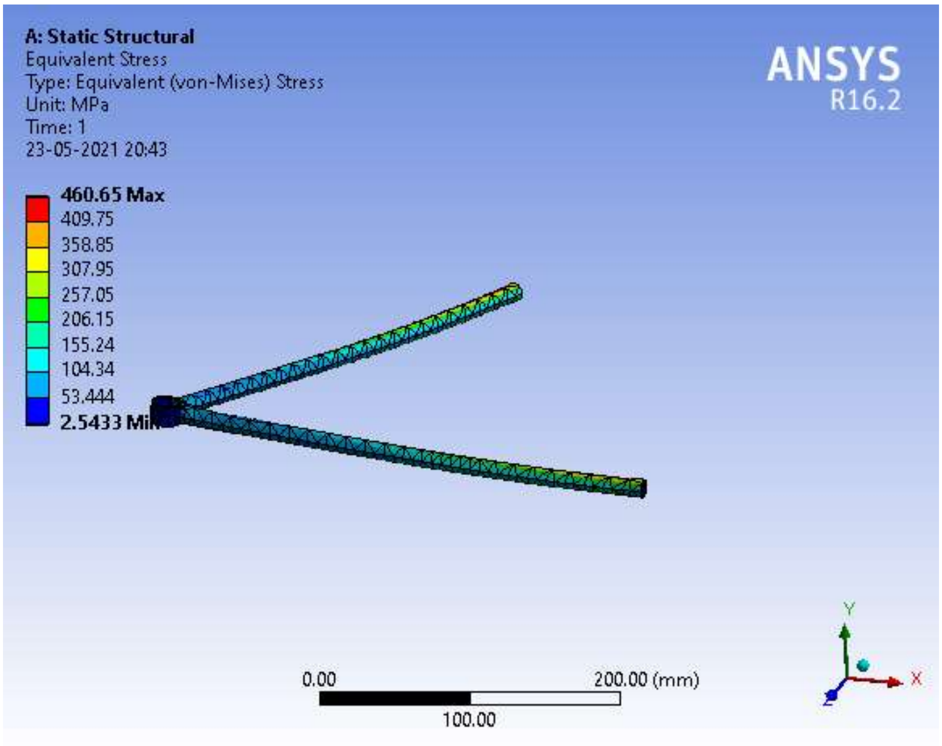

Fig1.Equivalent (Von-Mises) Stress(Front Wishbone)

As considered from the above result the maximum stress in the arm is 460.65 MPa which is less than the allowable stress of 550 MPa. For this reason, the design structure is safe on tested loads.

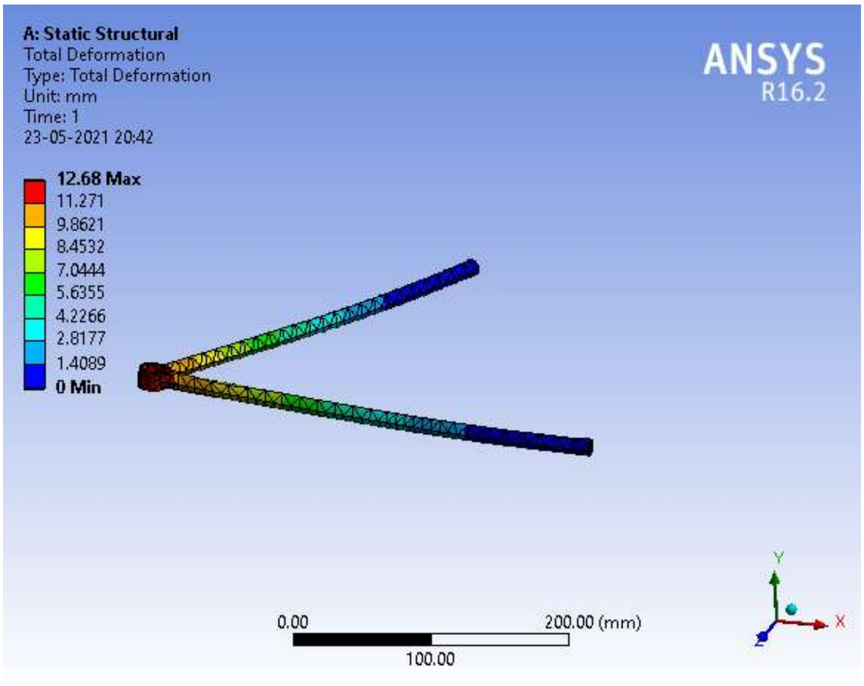

Fig 2. Total Deformation (Front Wishbone)

V. CONCLUSION

After assessing the materials, the yield for S550 MC was 550 Mpa and the yield/ultimate tensile strength ratio was 0.7237.Referring to the previous paper according to which the wishbone Ansys software gives a factor of safety as 1.1939 so we decided to use this material. By using the VIKOR method we conclude that S550 MC material is having more strength, but S550 MC material is available only in steel metal form that's why we are making some changes in it to make it a round bar so that we can check whether we can manufacture it or not in our future task.

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