

Analyzing and Optimization of Material Selection Decision for Hydroforming Processes by using AHP and TOPSIS

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Abstract: -- The hydroforming process is advanced and chipless Manufacturing process used in metal forming Industries. Nowadays the application of the hydroforming is increasing day by day in manufacturing because the method gives the product strength is more and uniform in thinning percentage. In metal forming process the Hydroforming process is the hottest area in Manufacturing. This Hydroforming method is used in Aerospace, Automobile and Agriculture Industry for Manufacturing of the Products and the types of equipment. The material selection is a major task for any product or process development. The SAW, AHP and TOPSIS methods are successfully used and the results are compared with each other. The SAW and AHP method give us the same result or sequence. These optimization methods are multiple attribute decision making (MADM). From these methods, we can achieve the selected objectives without any investment. In industries, they are using for whichever they are having some conflicts or inconsistency in their area.

Keyword: AHP, Hydroforming, MADM, Metal Forming, Optimization, TOPSIS.

I. INTRODUCTION

The objective of this study is that too difficult to select the better choices of the material out of similarity of the attributes for the Tube as well as sheet metal hydroforming processes. The Analytical Hierarchy Process (AHP) developed by Saaty and it is used successively by the many researchers, Students and Industries for optimum selection of best options [4]. The applications of SAW, AHP and TOPSIS method is used in manufacturing environment for decision making [3]. Fuzzy AHP used for vendor development especially for Pharmaceutical Industry as per their selected criteria's [2]. The facility location selection problem has been optimized by comparing Fuzzy AHP and TOPSIS methods to optimize the relocation, operation or functional expansion cost. It is minimize manufacturing cost as well as transportation cost and maximizing optimum utilization of their resources [6-7]. The multi criteria decision making problem has been analyze. The Emergency Management Australia (EMA) Disasters Database criteria's are analyze [8]. The TOPSIS theory is used for the Crusher selection for the mine planning and from this case study gives the gyratory primary crusher is the best selection of primary crusher [9]. The Fault tree analysis (FTA) model is

developed based on TOPSIS method. The accuracy and predictions of results has analyzed [10]. It is the process of finding the best choices among the alternatives for the decision making from the varieties of similar criteria's [11]. The AHP method is used for the selection of best supplier for their corporate social responsibility (CSR) and it is having seven important criteria's [12]. The following are the material grade has selected for this particular case study. The P1, P2, P3 and P4 are the attribute codes are shown in table below.

Table 1 Material Grade Selection

Grade Code	Material Grade	P1-Yield Strength (YS)	P2-Tensile Strength (TS)	P3-Elongation %	P4-Hardness
M1	SS304	341	637	56	84
M2	SS409 L	264	438	35	69
M3	AL & Alloys	34.5	39.6	35	25
M4	Inconel	241.3	586	45	150
M5	Nickel	58.6	317.1	40	65
M6	Silver	55.7	158.6	35	90
M7	SS (Austenite)	275.8	620.5	20	160
M8	Copper & Nickel	137.9	379.2	45	35
M9	H900	184	197	15	43
M10	H1150	126	141	21	31

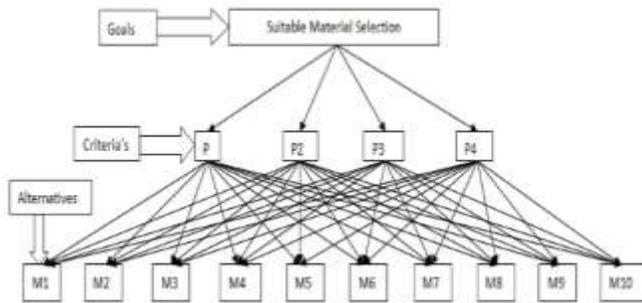


Figure 1 Decision Making Hierarchy for Material Selection

Analyzing and Optimization

Analytic Hierarchy Process (AHP) Method

This method is more popular for decision making and taking problems in Industry, Education system, Govt. Recruitment Department, Researcher, etc as per their requirements or attributes because it is going to save time, Cost. The Geometric Mean (GM) method is useful to calculate the weights of the attributes because it is very simple and easy to determine the Eigen vales and also used to reduce inconsistency in weights. The following are the Eigen values and consistency check for the calculated weights.

$$A_2 = \begin{bmatrix} 0.5269 \\ 0.1844 \\ 0.1125 \\ 0.1760 \end{bmatrix}$$

$$A_3 = [A_1] * [A_2]$$

The pair wise comparisons Scale Measurement has been taken as:

1-Equal Importance, 2-Moderate Importance, 3-Strong Importance, 4-Very Strong Importance, 5-Absolute Importance

$$A_3 = \begin{bmatrix} 1 & 5 & 4 & 2 \\ 1/5 & 1 & 3 & 1 \\ 1/4 & 1/3 & 1 & 1 \\ 1/2 & 1 & 1 & 1 \end{bmatrix} * \begin{bmatrix} 0.5269 \\ 0.1844 \\ 0.1125 \\ 0.1760 \end{bmatrix}$$

$$A_4 = A_3 / A_2$$

$$A_4 = \begin{bmatrix} 4.2720 \\ 4.3563 \\ 4.2818 \\ 4.1841 \end{bmatrix}$$

$$\lambda_{Max} = 4.2736$$

Geometric Mean (GM): 2.514, 0.880, 0.537, 0.840 and Sum of Geometric Mean= 4.771

Weights, Wj: 0.5269, 0.1844, 0.1125, 0.1760

Check for Consistency (C.I.)

$$C.I. = \frac{(\lambda_{Max} - M)}{(M - 1)} = \frac{(4.2736 - 4)}{(4 - 1)} = 0.0912$$

$$Consistency Ratio (C.R.) = \frac{C.I.}{R.I.}$$

$$Random Index (R.I.) = 0.89 [3]$$

$$Hence, C.R. = 0.061 < 0.1$$

Step-I Normalized Matrix

The abnormal data is converted into Normalized data and in each column we have selected one value which is required to achieve the selected objectives. In first three columns required Maximum and in last column minimum values are better.

Table 2 Normalized Matrix

Sr. No.	P1	P2	P3	P4
M1	1	1	1	0.2976
M2	0.7742	0.6876	0.625	0.3623
M3	0.1012	0.0622	0.625	1
M4	0.7076	0.9199	0.8036	0.1667
M5	0.1718	0.4978	0.7043	0.3846
M6	0.1633	0.2490	0.625	0.2778
M7	0.8088	0.9741	0.3571	0.1562
M8	0.4044	0.5953	0.8036	0.7143
M9	0.5396	0.3093	0.2679	0.5814
M10	0.3695	0.2214	0.375	0.8065

Step-II Relative Importance Metrics for Selected Criteria's (A1)

Criteria's	P1	P2	P3	P4
P1	1	5	4	2
P2	1/5	1	3	1
P3	1/4	1/3	1	1
P4	1/2	1	1	1

Step- III [Normalized Matrix]* [A2]

M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
0.8762	0.6688	0.3111	0.6622	0.3304	0.2512	0.6734	0.5390	0.4738	0.4196
Best					Worst				

Technique for Order Preference by Similarity to ideal Solutions (TOPSIS) Method

Step-I: To Construct Normalized Matrix

Sr.No.	P1	P2	P3	P4
M1	0.541	0.495	0.481	0.303
M2	0.419	0.340	0.301	0.249
M3	0.055	0.031	0.301	0.090
M4	0.383	0.045	0.387	0.541
M5	0.930	0.246	0.344	0.234
M6	0.884	0.123	0.301	0.324
M7	0.438	0.482	0.172	0.577
M8	0.219	0.295	0.387	0.126
M9	0.292	0.153	0.129	0.155
M10	0.200	0.109	0.181	0.112

Step-II: Weighted Matrix

Sr.No.	P1	P2	P3	P4
M1	0.285	0.091	0.054	0.053
M2	0.221	0.063	0.034	0.044
M3	0.029	0.006	0.034	0.016
M4	0.202	0.008	0.044	0.095
M5	0.490	0.045	0.039	0.041
M6	0.466	0.023	0.034	0.057
M7	0.231	0.089	0.019	0.102
M8	0.115	0.054	0.044	0.022
M9	0.154	0.028	0.015	0.027
M10	0.105	0.200	0.020	0.020

Step-III:

Sr. No.	$(V_j - V_{ij})^2$	$S_i^+ = \frac{1}{n} \sum (V_j - V_{ij})^2$	$(V_j - V_{ij})^2$	$S_i^- = \frac{1}{n} \sum (V_j - V_{ij})^2$	$S_i^+ + S_i^-$	$P_i = \frac{S_i^-}{S_i^+ + S_i^-}$	Ranking
M1	0.0552	0.235	0.0767	0.277	0.512	0.54	
M2	0.0923	0.304	0.0438	0.209	0.513	0.41	
M3	0.2505	0.500	0.0077	0.088	0.588	0.15	Worst
M4	0.1261	0.355	0.0308	0.175	0.53	0.33	
M5	0.0249	0.158	0.2183	0.467	0.625	0.75	Best
M6	0.0340	0.184	0.1936	0.44	0.624	0.71	
M7	0.0880	0.297	0.0477	0.218	0.515	0.42	
M8	0.1621	0.403	0.0169	0.13	0.533	0.24	
M9	0.1441	0.380	0.0217	0.147	0.527	0.28	
M10	0.1494	0.387	0.0502	0.224	0.611	0.37	

Simple Additive Weightings (SAW) Method

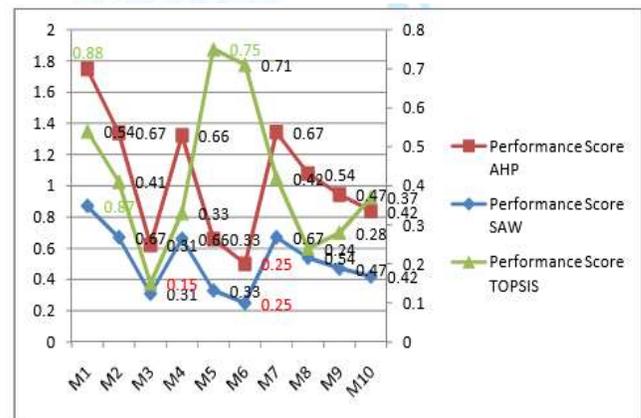
The total performance score of each attribute as an alternative is as follows.

$$P_i = \sum_{j=1}^N W_j * M_{ij}$$

Alternatives/Criteria's	P1	P2	P3	P4	Performance Score	Ranking	Choice
M1	1	1	1	0.2976	0.87	I	Best
M2	0.7742	0.6876	0.625	0.3623	0.67	III	
M3	0.1012	0.0622	0.625	1	0.31	IX	
M4	0.7076	0.9199	0.8936	0.1667	0.66	IV	
M5	0.1718	0.4973	0.7143	0.3846	0.33	VIII	
M6	0.1633	0.2490	0.625	0.2778	0.25	X	Worst
M7	0.8088	0.9741	0.3571	0.1562	0.67	II	
M8	0.4044	0.3953	0.8936	0.7143	0.54	V	
M9	0.5396	0.3093	0.2679	0.5814	0.47	VI	
M10	0.3895	0.2214	0.375	0.8065	0.42	VII	
Weights (Wj)	0.5269	0.1844	0.1125	0.1760			

The comparative discussion of the selected methods and the green color and red color indicates best and worst choices respectively are as follows.

Alternatives	Performance Score		
	SAW	AHP	TOPSIS
M1	0.87	0.88	0.54
M2	0.67	0.67	0.41
M3	0.31	0.31	0.15
M4	0.66	0.66	0.33
M5	0.33	0.33	0.75
M6	0.25	0.25	0.71
M7	0.67	0.67	0.42
M8	0.54	0.54	0.24
M9	0.47	0.47	0.28
M10	0.42	0.42	0.37


II. CONCLUSION

The Multiple Attribute Decision Making (MADM) methods are successfully used for the selection of suitable material

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for Hydroforming Operations. The SAW and AHP methods gives best choice of material is M1 and worst choice is M6. The TOPSIS method gives us best and worst choices are M5 and M3 respectively. The choices we are confirmed by calculation the overall performance score of each alternative then we have decided the choices. From this optimization method we understand the elongation %, Yield Strength and Tensile Strength are major or effective parameters for the hydroforming process. Out of these selected grades material shows that the SS304 and Nickel are the best choices for the Hydroforming operations for getting the better quality in final product, so that the life and strength of the product can be improved.

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