Selecting of best forging press lines considering postures based on production process and maintenance by using VIKOR method

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ABSTRACT

Hot or cold forging is one of the most important processes that shape the materials in the industry. This process can be done very quickly with forging presses.
Competition also has a big precaution in forging companies. Almost all commercial and passenger vehicles use forged parts. Crankshafts, connecting rods and front and rear axles are the main parts of these parts. Forging companies compete over time to produce these pieces. Because manufacturing these parts in less time means less cost. That's the forging company that has achieved this one step ahead of the others. One of the most important ways to reduce this forging time is to use new technologies and minimize downtime.

After the forging process, defects that occur in the forging press or forging process that form this process are affecting both the quality of the product as well as the quality of the forged material. These failures can be caused by both production proses and maintenance failure. In the forging line, defects, postures or failures in production proses often occur in inadequate line organization planning or lack of education.

Many areas of work on multi criteria decision making (MCDM) have been conducted. Some of the best known of these methods are TOPSIS, AHP and VIKOR. In this study, it was aimed to find out which forging line worked more efficiently with the VIKOR method, taking into consideration both the production and maintenance-oriented postures that occurred during the manufacture of a forging manufacturing method.

Keywords *– Crank-Shaft, connection rods, hot forging, maintenance, VIKOR*

1. INTRODUCTİON

In this century, there is a tough competition situation that we have experienced with the developing technology and the globalization. The aim of this competition is to give the customer the best and most ideal product. As a result of this competition, the factories both develop themselves to become a top of level and also provide the customer with the ideal product.

Metal forging factories are available in many parts of the world. Each forging factory is shaped according to the requirements of the customer. According to the type, weight and the name of the part to be produced, the forging factories have supplied the most suitable forging presses.

The decision making process consists of many elements interacting with each other. It is difficult to make a decision between these units that interact with each other. The system is totally affected when the wrong choice is made for any of these units. For this reason decision making processes are both sensitive and very important problems. It is of most importance that each decision is taken in the process of decision making. Some forging factories have turned to small but mass-produced forging machines for forging large pieces. Some of them turned to bigger forging press for forging parts which are weight and volume.

Metal forging factories are always in competition with each other. The factory that gives the right product at the time of the customer is that will win this competition. Producing a product on time and in the right way in a metal forging factory is directly related to the factory unplanned posture. Unplanned stops occur both in production processes and in the lack of maintenance of forged machines.

It is quite difficult to find out which forging press is most efficient in a factory where many forging press are located. It is quite difficult to find which forging machine is more efficient if all the machine data are gathered together. As a result, a complex problem arises. MCDM methods have been developed to solve these problems more easily. Among these methods, the most known are VIKOR, TOPSIS, AHP, PROMETHEE and ELECTRE.

Multi-criteria decision-making methods are the most appropriate method of selecting and making decisions in a system where alternatives and criteria exist. There are some components that make up the decision-making process in multi-criteria decision making problems.

2. TYPE OF FORGING PRESSES AND POSTURES

2.1 Type of Forging Press

There are a numerous types of forging process and machines. These are differ from each other which are sizes and weight of hammer, hammer or ram velocity etc. Fig. 1. shows the types of the forging presses.

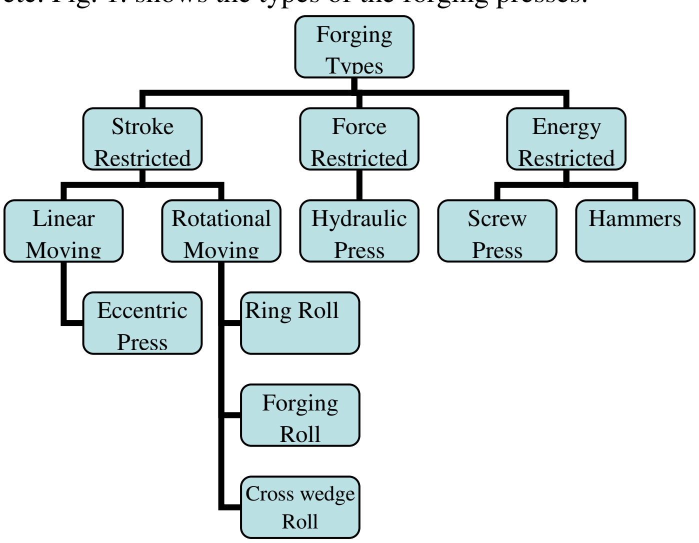

Fig. 1. Forging types [1]

The most known of these are drop hammers, hydraulic presses and mechanic presses. In this project, these presses and hammers will be mentioned, but unlike hammers and hydraulic presses, eccentric or mechanic presses will be focused.

Mechanical or linear moving presses differ from drop hammers and hydraulic presses. They operated two working surface together by offset cams, cranks, and other rigidly connected mechanical systems. The strokes of mechanical presses are shorter than those of either drop hammers or hydraulic presses. Mechanical presses are often favored for low-profile forging because of that.

2.2 Type of Forging Postures and failures

Postures in the forging press are divided into two as postures of based on forging process and forging machines. Postures or failures based on the production process and forging press can be listed as follows.

1. Die failures and postures

3. Material failures and postures

4. Main forging press failures and postures

5. Burr press failures and postures

6. Conveyor failures and postures

7. Loader and separator failures and postures

8. Robot failures and postures

9-Induction furnace failures and postures

3. GENERAL INFORMATION MULTI CRITERIA DECISION MAKING (MCDM) MODELS

The practice of decision making is ancient. The earliest known reference relating to Multiple Criteria Decision Making (although not using that name) can be traced to Benjamin Franklin (1706–1790), the American statesman, who allegedly had a simple paper system for deciding his position on an important issue. More recently, the economist Vilfredo Pareto (1848–1923), born in Paris to Italian expatriates, was the first to mathematically study the aggregation of conflicting criteria into a single composite index. [2]

MCDA techniques have found wide application in public-sector as well as in private-sector decisions on agriculture resource management, immigration, education [3], transport [4], investment, health care environment 5], defense, etc. [6]

Multi-criteria decision making models are the most important decision-making models known as based on objective. These methods are not determined by the feelings and thoughts of the person and are completely based on calculations and concrete proofs. Multiple criteria decision making (MCDM) is a branch of operational research dealing with finding optimal results in complex scenarios including various indicators, conflicting objectives and criteria.[7]

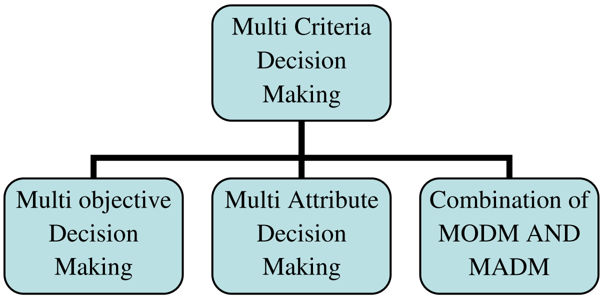

Fig. 2. Classification of MCDM [8]

The MCDM can be classified as given in Fig. 2 depending on the number of alternatives considered, differences can be catered between Multi-Purpose Decision Making (MADM) and Multi-Target Decision Making (MODM); otherwise they share similar features. The MODM is suitable for evaluating constraints in the form of decision variables vectors.

Most known MCDM models are given below:
1-AHP by Saaty, 1970's
2-TOPSIS by Hwang and Yoon 1981
3-ELECTRE by Benayoun et al. 1966
4- PROMETHEE by Brans and Vincke 1985
5-Simple Additive Weighting (SAW)
6- VIKOR by Opricovic 1998

4- VIKOR METHOD

Vlsekriterijumska Optimizacija I Kompromisno Resenje i.e. VIKOR) method was developed by Opricovic in 1998 for multi-criteria optimization of complex systems [9]

New researches entail new MCDM approaches such as VIKOR. Recently, due to its characteristics and capabilities, the VIKOR method has been considerably undertaken by researchers to provide decision making problems, especially in the field of supplier selection, with more accurate solutions. This includes deploying VIKOR either solely [10] or along with other mathematical or MCDM approaches such as AHP , ANP rough sets , and artificial neural networks. [11]

5. APPLICATION AND METHODOLOGIES

5.1 Definition of the Problem

In large and small-scale factories, the productivity and efficiency of in-plant machines is a very important criterion for operation. This efficiency is not measured only by the amount of product produced by the process end. It is very important for productivity to know the criteria such as machine working hours, the amount of product produced, the faults in the production process, mechanical and electrical failures. It is of great importance for a factory to know which machine is more efficient considering all such criteria. In this study, we will first find out which forging machine is more efficient by using the VIKOR method by considering the production problems and the product items from the production in a factory where forging machines are located. Then, the impact of mechanical and electrical posture on forging machines efficiency will be calculated by adding the mechanical and electrical posture criteria to the production criteria using the VIKOR method.

5.2 Selecting of best forging presses lines

A total of 9 forging press (FP) production lines will be selected as the best line. A total of 14 criteria were used to rank these forging lines. A matrix was created from these criteria and the data of the forging presses. These values are given in table 1.

The weight value of each criterion is given to the importance of production. These values are shown in table 2.

In order not to choose the most efficient forging press, the data and postures in the production process are given below in 14 criteria.

1-Number of forged parts (C1)

2-Working time of forging presses (C2)

3-Number of correction parts (C3)

4-Other die failures. (C4)

5-Die pusher failures. (C5)

6-Broken die failures. (C6)

7-Failures Parts (C7)

8- Failures that do not affect production. (C8)

9- Forging Press Failures. (C9)

10-Loader failure. (C10)

11-Burr press failures. (C11)

12-Induction furnace failures. (C12)

13-Conveyor failures (C13)

14-Robot failures (C14)

Table 1. Criterias of forging press line

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
FP1	200.138	87.382	0	10.176	995	75.950	951	75.955	3.425	0	1.215	2.620	835	1.430
FP2	291.348	97.920	0	11.255	945	54.155	648	54.155	5.590	95	2.085	4.960	50	2.775
FP3	329.314	128.710	0	11.373	2.470	40.258	264	40.258	8.100	1.155	1.320	1.505	250	1.640
FP4	593.015	149.987	0	25.420	1.230	9.060	1.688	9.060	4.490	4.455	1.455	2.630	685	1.925
FP5	472.630	164.038	0	13.750	3.920	7.395	625	7.395	3.845	4.420	900	3.145	325	0
FP6	461.028	119.414	0	21.466	1.315	37.415	487	37.415	3.870	1.485	2.365	3.825	1.180	1.585
FP7	168.173	57.425	8.077	6.260	915	33.750	404	33.750	1.185	230	775	3.645	750	725
FP8	692.261	167.060	37.194	10.055	1.870	11.160	448	11.160	3.375	5.890	975	2.280	345	0
FP9	497.189	152.070	12.749	9.880	1.845	6.195	187	6.195	3.905	465	1.575	4.490	1.175	0

Table 2. Weight value of criteria

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
w	0,14	0,12	0,03	0,08	0,05	0,04	0,03	0,12	0,13	0,03	0,05	0,09	0,04	0,05

Table 3. Best f_i^* and worst f_i^- values

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
f_i^*	692.261	167.060	37.194	25.420	3.920	75.950	1.688	75.955	8.100	5.890	2.365	4.960	1.180	2.775
f_i^-	168.173	57.425	0	6.260	915	6.195	187	6.195	1.185	0	900	1.505	50	0

Among the criteria, a matrix was created by choosing the best and worst criteria for each forging press. The matrix is given table 3.

Table 4. Matrix Values of S_J and R_J

	P1	P2	P3	P4	P5	P6	P7	P8	P9
Sj	0,63	0,51	0,56	0,47	0,58	0,46	0,83	0,55	0,57
Rj	0,13	0,10	0,09	0,11	0,11	0,06	0,14	0,11	0,12

Table 5. S*, S^{-}, R*, and R^{-} values

S*	S^{-}	R*	R^{-}
0,469	0,835	0,066	0,132

The values of Q_1, Q_2 and Q_3 are calculated by giving the values v, respectively. The values are given in table 6.

Table 6. Matrix of Q_1, Q_2 and Q_3 values

	v	FP1	FP2	FP3	FP4	FP5	FP6	FP7	FP8	P9
Q_1	0	1,00	0,62	0,37	0,74	0,79	0,00	1,13	0,69	0,82
Q_2	0,5	0,72	0,38	0,31	0,38	0,55	0,00	1,06	0,46	0,55
Q_3	1	0,44	0,13	0,26	0,01	0,31	0,00	1,00	0,24	0,28

Rank the alternatives, sorting by the values S, R and Q. The below table 7, shows ranked values.

Table 7. The Evaluation Matrix Value of Each Forging Press

S_J	R_J	Q_1	Q_2	Q_3
0,469	0,066	0	0	0
0,473	0,091	0,374	0,318	0,011
0,518	0,107	0,626	0,38	0,135
0,557	0,112	0,693	0,38	0,241
0,565	0,115	0,748	0,467	0,262
0,574	0,118	0,791	0,553	0,285
0,584	0,120	0,824	0,554	0,314
0,630	0,132	1	0,72	0,44
0,835	0,140	1,31	1,065	1

Table 8. Determination Matrix of Each Value

S_J	R_J	Q_1	Q_2	Q_3
FP6	FP6	FP6	FP6	FP6
FP4	FP3	FP3	FP3	FP4
FP2	FP2	FP2	FP2	FP2
FP8	FP8	FP8	FP4	FP8
FP3	FP4	FP4	FP8	FP3
FP9	FP5	FP5	FP5	FP9
FP5	FP9	FP9	FP9	FP5
FP1	FP1	FP1	FP1	FP1
FP7	FP7	FP7	FP7	FP7

Table 9. The result of VIKOR method

1	2	3	4	5	6	7	8	9
FP6	FP3	FP2	FP4	FP8	FP5	FP9	FP1	FP7
2503	3150	4002	2501	1601	2502	1602	4001	2504

C_1 is the acceptable advantage,

$Q(F^{(m)}) - Q(F^{(1)}) < DQ$ for maximum M (the positions of these alternatives are "in closeness"). [12]

According to $\left(F^{(2)} - F^{(1)}\right) \geq DQ$; same time $DQ = 1/(m-1)$

$$DQ = \frac{1}{(9-1)} = 0{,}125$$

DQ=0,318-0 ≥0,125

C_1 is provided according to these conditions.

C_2 Acceptable stability in decision making means that the FP alternative with the best Q value should have achieved the best score in at least one of the S and R values. FP6 provides this condition.

C_2 is provided according to these condition.

6. CONCLUSION

In this study, both the production data and the maintenance data were considered and the most efficient forging press selection was attempted with VIKOR method. From the result of VIKOR, FP6 should be the best alternative since it has the lowest S, R, and Q values with respect to other alternatives. According to the production criteria, (FP6), (FP3) and (FP2) forging machines were the most efficient machines in the results using VIKOR method, respectively. On the other hand, the forging presses (FP9) and (FP1) are also calculated as the most inefficient machines. For the determination of the validity of the results, the conditions for the fulfillment of Condition 1 (C_1) and Condition 2 (C_2) have been examined. As a result of the review made, Condition 1 and Condition 2 are provided.

The machine that produces the largest number of parts in metal forging factories is not the most efficient machine in this work. Defects occurring in the production process or in the forging press during the production process are all a loss and greatly affect the efficiency of the forging machine. These losses are invisible but are huge losses. In this century, if factories are seriously pursuing their efforts to reduce the above-mentioned defects, it will not be difficult for between competitors to exit without getting harm.

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