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CessationsAppraisal Model Realization by Fuzzy Logic Goal Programming

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ABSTRACT

In the competitive setting, search for a compromise decision to meet the objectives and constraints are on and such decisions usually not reach the optimality. Study under taken at three industrial set up to ascertain the expenses incurred by the cessationsof particular equipment. The compound goals pertaining to a factual life problem might be incommensurable, inconsistent and irreconcilable in character. Undeniably, such tribulations may be handled with the help of goal programming approach. However, in most of the authentic cases, the aspiration levels in the objective function and the other pertinent parameters involved in defining the goals may not be accurate. Therefore, a fuzzy goal programming model is formulated involving multiple criteria for decision making when the objectives or constraints or both are expressed as fuzzy goals. The approach applied by incorporating flexible bounds, constraints and fuzzy aspiration levels assigned in objective function having objectives of varying importance.

Key words*: Model, Cessations Appraisal, Fuzzy logic*

1. Introduction

The assessment of aspiration levels is subjective in scenery in goal programming approach and would be possible to solve the problems having well defined goals over a set of feasible actions. Th***e*** study is to test the aspects persuading the maintenance structure and the appraisal of optimal manpower cost for cessations. The outcome of the mentioned features for a variety of maintenance work with respect to related complexity has to be scrutinized. The constraints in such logical work out have been devised based on several prioritised key jobs. The model development and the capacity for relevance of the fuzzy logic goal programming approach for maintenance system cessations appraisal have been presented here.

Many researchers have offered copious approaches to covenant with the practical harms. Fuzziness is apprehended as the unfocused environment should be deemed throughout the progress of system model. To appraise the manpower cost in the maintenance of Boilers, it has befallen obligatory to disembark at the desired wage rate for the person/ persons deployed for an assortment of maintenance work. Such wage rate can be determined by relative study of the comparative variations for diverse maintenance work and then maintenance cost of the specified jobs would be reckoned.

Fuzzy Goal

The fuzzy logic models are extensively used for resolving the harms apprehensive with multiobjective decision making. In countless realistic circumstances, it is hard to assign precise aspiration levels to objectives. However, the decision maker is able to enumerate the existence of this in terms of an imprecise interval around it. An objective with imprecise aspiration level is referred to as Fuzzy goal and it can be represented as:

$$g\ (J) \gtrsim p \text{ or } g\ (J) \lesssim p$$

Where, the symbol '~' signifies fuzzyfication.

Fuzzy Subset

When E is a set and J be an element of E, a fuzzy subset A of E is a set of prearranged pairs $\{J, \mu_A(J)\}$ for all $J \in E$, when $\mu_A(J)$ is a membership function to takes its values in an entirely planned membership set, M to signifying the level of membership.

The fuzzy subset A be implicit as an usual subset if $M = \{0, 1\}$ considering that the membership function $\mu_A(J)$ may take any value at all in the interval $\{0, 1\}$. Thus, an element J of E may not be a member of $A(\mu_A = 0)$, somewhat might be a member of $A(\mu_A$ near to zero), may be more or less a member of $A(\mu_A$ neither too near to zero nor too near to one) or may be a member of $A(\mu_A$ near to one) or finally a member of $A(\mu_A = 1)$.

Fuzzy Linear Goal Programming

The method of fuzzy linear goal programming transforms the multiobjective linear programming to a single objective for the deterministic problem to be solvable by simplex method. In its simplest form the membership function has a value 'one' if a given goal is not violated a value 'zero' if it is severely violated and a value between zero and one for any weaker violation.

In the majority of the pragmatic pronouncement creation circumstances, the aspiration levels p_i to the criteria g_i (j) and an assortment of supplementary strictures used in defining them possibly will not be precise. Occasionally, the criterion themselves are defined qualitatively rather than quantitatively. During such circumstances, while the objectives and the constraints are expressed as fuzzy goals, subsequently fuzzy goal model may be avowed as:

Find, $J \in S$ (Set of actions), subject to

$g_i(J) \gtrsim p_i$ for $i = 1, 2, ..., k$

$f_j(J) \lesssim b_j$ for $j = 1, 2, ..., m$

$J \geq 0$ ... (A)

On the other hand, in a few circumstances the unyielding constraints may possibly subsist. Accordingly, the fuzzy goal model is able to state as:

Find, $J \in S$ (Set of actions), subject to

$g_i(J) \gtrsim p_i$ for $i = 1, 2, ..., k$

$f_j(J) \leq b_j$ for $j = 1, 2, ..., m$

$J \geq 0$ ... (B)

The fuzzy model (A) engrosses the fuzzy goals escorted by the fuzzy constraints and the fuzzy model (B) is having the fuzzy goals together with the firm constraints. The models (A) or (B) cannot be resolved in their present structure. The fuzzy goals all along with the fuzzy constraints, if any, are acknowledged by the fuzzy sets A_i with appropriate membership functions $\mu_{Ai}(J)$ distinct over the set of feasible conclusion creation procedures. These membership functions are used as proxy characteristics for the allied fuzzy goals in devising the model. Based upon the temperament of the quandary, the fuzzy sets analogous to fuzzy goals are amassed with a apposite operative, to attain a fuzzy set of choices D and its association function $\mu_D(J)$ treated as a significance function $V(\mu)$.

2. Literature Review

Choi (2009) [2] described a new mathematical model of line balancing for processing time and physical workload at the same time by goal programming approach and designed an appropriate algorithm process for the operation managers to make decisions on their job scheduling efforts, whereas various computational test runs are performed on the processing time only model, the physical workload only model, and the integrated model. Kharrat et al. [9] proposed an interactive optimization method for imprecise multiple-objective decision-making situations. The aim of the proposed approach is to integrate explicitly the decision-maker's (DMs) preferences within the interactive imprecise goal programming model. The DMs preferences will be expressed through the satisfaction functions concept.

Kharrat et al. [10] adapted a record-to-record travel (RRT) algorithm with an adaptive memory named taboo central memory (TCM) to solve the lexicographic goal programming problem. The proposed method can be applied to non-linear, linear, integer and combinatorial goal programming.Mavrotas et al. [12] applied an integrated approach in order to find the mixture of Best Available Techniques (BAT) for the entire industrial sector that satisfies as much as possible the economic and the environmental criteria. Mezghani et al. [13] addressed an effective method to elaborate an aggregate plan which takes into account the manager's preferences by a Goal Programming (GP) approach, with satisfaction functions. Applied to a real case problem, weighted GP has initially been used; the results were not satisfactory for the manager. The proposed GP with satisfaction function given very satisfactory results for the manager.

Patia et al. [17 have formulated a mixed integer goal programming (MIGP) model to assist in proper management of the paper recycling logistics system. The model studies the inter-relationship between multiple objectives (with changing priorities) of a recycled paper distribution network. The objectives considered are reduction in reverse logistics cost; product quality improvement through increased segregation at the source; and environmental through increased wastepaper recovery. Romero and Carlo [18] elucidated an optimization structure called Extended Lexicographic Goal Programming (ELGP) which is then demonstrated that there are a significant number of Multiple Criteria Decision Making (MCDM) approaches that, from a logical point of view, can be reduced to the ELGP structure by assessing the theoretical and practical advantages of the proposed unified approach.

Ghosh and Roy [5] have presented a Multiple-Criteria Decision Making (MCDM) methodology for selecting the optimal mix of maintenance approaches – Corrective Maintenance (CM), Time-Based Preventive Maintenance (TBPM) and Condition-Based Predictive Maintenance (CBPM) – for different equipment in a typical process plant. Giannikos and Polychroniou [6] introduced a fuzzy goal programming model for allocating tasks to employees in teamwork. The model also considers the possibility of improving employees' abilities through training and of using subcontracting or overtime, if necessary.

Wang and Chin [22] have proposed a sound yet simple priority method for fuzzy AHP which utilizes a linear goal programming (LGP) model to derive normalized fuzzy weights for fuzzy pair wise comparison matrices. The proposed LGP priority method is tested with three numerical examples including an application of fuzzy AHP to new product development (NDP) project screening decision making.

Yuniarto and Labib[24]proposed a framework of integrating preventive maintenance (PM) and Manufacturing control system using Fuzzy-logic control. The aim of the research was to control a failure-prone manufacturing system and at the same time it proposed which PM method was applicable to a specific failure-prone manufacturing system.

3. Problem Formulation

CessationRepairs of boilers installedare selected for study in three different process industries and perceived varieties of problems.This study is to ascertain the expenses over anycessation under different prevailing conditions.

Objective of the Study

To realise the cessation ascertain model by Fuzzy Logic Goal Programming approach

4. Realization of the Model

The existing maintenance system for Boilers has been premeditated scrupulously. The development for appropriate manpower utilization in maintenance depends on some decisive factors. An approach has been made to expand a generalized model of maintenance system that would help in optimal planning of manpower resources in terms of the wages to be incurred in maintenance. The major factors (J_i) influencing the maintenance time possibly will be symbolized as beneath:

a) Job Quality (J_1)
b) Skill of the Workers (J_2)
c) Resource Items (J_3)
d) Supervision Quality (J_4)
e) Environment (J_5)
f) Teamwork (J_6)

For a more significant psychiatry, each such factor $\mathbf{J_i}$ (i = 1, 2... 6) can be categorized under five different levels (j = 1, 2... 5) with gaze at to the complexity of maintenance job as shown in Table 1. The ascending order of the level would signify the increasing complexity in maintenance jobs. Based on the study, benchmark jobs can be estimated with due consideration to the different levels of job complexity. The most complex benchmark job should consist of factors having the highest level of complexity may be presented as:

Table 1: Influencing factors

Factor J_i	Job Complexity Level 'j'				
	1	2	3	4	5
Job Quality	J_{11}	J_{12}	J_{13}	J_{14}	J_{15}
Skill of Workers	J_{21}	J_{22}	J_{23}	J_{24}	J_{25}
Resource Items	J_{31}	J_{32}	J_{33}	J_{34}	J_{35}
Supervision Quality	J_{41}	J_{42}	J_{43}	J_{44}	J_{45}
Environment	J_{51}	J_{52}	J_{53}	J_{54}	J_{55}
Teamwork	J_{61}	J_{62}	J_{63}	J_{64}	J_{65}

$J_{15} + J_{25} + J_{35} + J_{45} + J_{55} + J_{65} \leq 100$ ... (1)

Similarly, other benchmark jobs are identified and given as:

$J_{14} + J_{25} + J_{35} + J_{44} + J_{54} + J_{65} \leq 90$ ... (2)

$J_{15} + J_{25} + J_{32} + J_{42} + J_{54} + J_{64} \leq 75$ ... (3)

$J_{14} + J_{23} + J_{31} + J_{41} + J_{54} + J_{62} \leq 55$ ... (4)

$J_{14} + J_{21} + J_{31} + J_{42} + J_{51} + J_{61} \leq 40$ ... (5)

Despite the setting of goals for each of the key jobs, some deviations would always exist in real life. However, any deviation from the goal should be allowed only within the permissible limit for a better functioning of the maintenance system. The other constraints to restrict the lower limit, higher limit and the difference in scores of the consecutive job complexity levels related to each influencing factor would be as below:

$J_{i1} \geq (9 - i)$ ... (6)

$J_{i5} \leq 20$ ... (7)

$J_{i(j+1)} - J_{ij} \geq 3$ ... (8)

It is desired to obtain the optimum scores of the influencing factors corresponding to the different job complexity levels with the use of a fuzzy model as has been presented below:

Find J ∈ S (Set of actions) … (9)

subject to

$J_{15} + J_{25} + J_{35} + J_{45} + J_{55} + J_{65} \lesssim 100$ ... (10)

$J_{14} + J_{25} + J_{35} + J_{44} + J_{54} + J_{65} \lesssim 90$ … (11)

$J_{15} + J_{25} + J_{32} + J_{42} + J_{54} + J_{64} \lesssim 75$ ... (12)

$J_{14} + J_{23} + J_{31} + J_{41} + J_{54} + J_{62} \lesssim 55$ ... (13)

$J_{14} + J_{21} + J_{31} + J_{42} + J_{51} + J_{61} \lesssim 40$ ... (14)

$J_{i1} \gtrsim (9 - i)$ ... (15)

$J_{i5} \lesssim 20$ ... (16)

$J_{ij} - J_{I(j-1)} \gtrsim 3$ ... (17)

where, i = 1, 2, ..., 6; j = 2, 3, ..., 5; $J_{ij} \geq 0$ and the symbol ~ represent fuzzyfication.

The constraint equations (10-14) showthe constraints for the bench mark jobs. The equation (15) represents the fuzzyfication of the lower limit for the first level of job complexity for each factor influencing the maintenance operation and score for the higher limit increases by 5 as the job level increases by equation (16). Equation (17) represents the difference in score as 3 with regard to consecutive complexity sublevels corresponding to each influencing factor.

Now, tolerance limit of 1 is provided for both the lower limit of score and the difference in scores of the consecutive sublevels for each factor level. A tolerance limit of 5 is provided for the higher limit of score for each factor level. The membership functions for the fuzzy constraints (15-17) are as under:

$$\mu_l(J) = \begin{cases} 0 & if Z_l \leq (9-i) \\ [Z_l - (9-i)]/1, & if (9-i) < Z_l < (10-i) \\ 1 & if Z_l \geq (10-i) \end{cases} \quad l = 1,2,\ldots,6 \quad \ldots (18)$$

$$\mu_l(J) = \begin{cases} 0 & if Z_l \geq 25 \\ (25 - Z_l)/5, & if\ 20 < Z_l < 25 \\ 1 & if Z_l \leq 20 \end{cases} \quad l = 7,8,\ldots,12 \quad \ldots (19)$$

$$\mu_l(J) = \begin{cases} 0 & if Z_l \geq 2 \\ (Z_l - 2)/1, & if\ 2 < Z_l < 3 \\ 1 & if Z_l \geq 3 \end{cases} \quad l = 13,14,\ldots,36 \quad \ldots (20)$$

Where,

$Z_l = J_{i1}$	**for $_l$ = 1, 2... 6**
$Z_l = J_{i5}$	**for $_l$ = 7, 8... 12**
$Z_l = J_{ij} - J_{i(j-1)}$	**for $_l$ = 13, 14 ... 36**

and i = 1, 2, ..., 6; j = 2, 3, ..., 5.

Thus, the membership functions take the forms as:

μ_l (J) = J_{i1} - (9- i)	**for $_l$ = 1, 2 ... 6**
μ_l (J) = 5 + 0.2 J_{i5}	**for $_l$ = 7, 8 ... 12**
μ_l (J) = (J_{1j} - $J_{1(j-1)}$ - 2)	**for $_l$ = 13, 14, 15, 16**
μ_l (J) = (J_{2j} - $J_{2(j-1)}$ - 2)	**for $_l$ = 17, 18, 19, 20**
μ_l (J) = (J_{3j} - $J_{3(j-1)}$ - 2)	**for $_l$ = 21, 22, 23, 24**
μ_l (J) = (J_{4j} - $J_{4(j-1)}$ - 2)	**for $_l$ = 25, 26, 27, 28**
μ_l (J) = (J_{5j} - $J_{5(j-1)}$ - 2)	**for $_l$ = 29, 30, 31, 32**
μ_l (J) = (J_{6j} - $J_{6(j-1)}$ - 2)	**for $_l$ = 33, 34, 35, 36**

Where, i = 1, 2... 6 and j = 2, 3, 4, 5.

Model Development

A model is developed aimed to evaluateby fuzzy approach for solving the goal programming model having linear objective and constraints assigning equal importance.

The fuzzy set of decision D, using intersection operator (λ) is given as

$$\mu_D(J) = \text{Min}\,[\mu_1(J), \mu_2(J) \ldots \mu_{36}(J)] = \bigwedge_{i=1}^{36} \mu_l(J) = \lambda \text{ (say)} \quad \ldots (21)$$

Where, the infix notation '∧' stands for the phrase 'infimum of'. Now, equations (9-17) are converted to model as below:

Maximize λ

Subject to

$J_{15} + J_{25} + J_{35} + J_{45} + J_{55} + J_{65} \leq 100$ ... (22)

$J_{14} + J_{25} + J_{35} + J_{44} + J_{54} + J_{65} \leq 90$ ... (23)

$J_{15} + J_{25} + J_{32} + J_{42} + J_{54} + J_{64} \leq 75$ ... (24)

$J_{14} + J_{23} + J_{31} + J_{41} + J_{54} + J_{62} \leq 55$ ... (25)

$J_{14} + J_{21} + J_{31} + J_{42} + J_{51} + J_{61} \leq 40$ ... (26)

$\lambda \leq \{Z_l - (9 - i)\}/1$ for $_l$ = 1, 2... 6... (27)

$\lambda \leq (25 - Z_l)/5$ for $_l$ = 7, 8... 12 ... (28)

$\lambda \leq (Z_l - 2)/1$ for $_l$ = 13, 14... 36 ... (29)

$J_{ij} \geq 0; \lambda \geq 0$ ... (30)

Where, i = 1, 2...6 and j = 2... 5.

Now, replacing Z $_l$ in equations (27) to (29), the model takes the form as:

Maximize λ

subject to

$J_{15} + J_{25} + J_{35} + J_{45} + J_{55} + J_{65} \leq 100$ ... (31)

$J_{14} + J_{25} + J_{35} + J_{44} + J_{54} + J_{65} \leq 90$ ... (32)

$J_{15} + J_{25} + J_{32} + J_{42} + J_{54} + J_{64} \leq 75$ ... (33)

$J_{14} + J_{23} + J_{31} + J_{41} + J_{54} + J_{62} \leq 55$ ... (34)

$J_{14} + J_{21} + J_{31} + J_{42} + J_{51} + J_{61} \leq 40$ ... (35)

$J_{i1} - \lambda \geq (9 - i)$ ... (36)

$0.2\, J_{i5} + \lambda \leq 5$ ... (37)

$J_{ij} - J_{i(j-1)} - \lambda \geq 2$ ... (38)

Where, i = 1,2 ... 6 and j = 2, 3 ... 5

$J_{ij} \geq 0; \lambda \geq 0$

Table 2: Scores for influencing factors

Factor, J_i	Complexity Levels ($_j$)				
	1	2	3	4	5
Job Quality	7.86	10.74	13.62	16.54	19.46

Skill of Workers	**2.86**	**5.74**	**8.62**	**11.54**	**14.46**
Resource Item	**6.86**	**9.74**	**12.62**	**15.54**	**18.46**
Supervision Quality	**1.86**	**4.74**	**7.62**	**10.54**	**13.46**
Environment	**5.86**	**8.74**	**11.62**	**14.54**	**17.46**
Teamwork	**0.86**	**3.74**	**6.62**	**9.54**	**12.46**

5. Result, Discussion and Conclusion

The model provides the optimal scores for each influencing factor in the maintenance system corresponding to the job complexity sublevels. Table 2 presents the optimal scores that satisfy the scores of benchmark jobs without any deviation. These optimal scores can be used for the appraisal of manpower wage rate in maintenance. However, if the optimal scores are rounded to the nearest integer values in the usual manner, it would also provide the same wage rate for the manpower group engaged in maintenance. Based on the scores of the various influencing factors of different complexity sublevels, the scores for the benchmark jobs are deliberated and presented in Table 3. The appraised results are very close to the assigned score to the benchmark jobs andIt is uncalled to cite that the Fuzzy goal programming model in general make available the enhanced outcome with regard to the most advantageous human resources expenditure in maintenance as judge against to those achieved by using the pre-emptive goal programming model in relevant cases.

It is unneeded to cite that the Fuzzy goal programming model in general endow with superior results as compared to the pre-emptive goal programming model.

Table 3: Scores for Benchmark jobs

Factor, J_i	**1**	**2**	**3**	**4**	**5**
Job Quality	**19.46**	**16.54**	**19.46**	**16.54**	**16.54**
Skill of Workers	**14.46**	**14.46**	**14.46**	**8.62**	**2.86**
Resource Item	**18.46**	**18.46**	**9.74**	**6.86**	**6.86**
Supervision Quality	**13.46**	**10.54**	**4.74**	**1.86**	**4.74**
Environment	**17.46**	**14.54**	**14.54**	**14.54**	**5.86**
Teamwork	**12.46**	**12.46**	**9.54**	**3.74**	**0.86**
Total	**95.76**	**87.00**	**72.48**	**52.16**	**37.72**

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