A GOAL PROGRAMMING TECHNIQUE FOR DECISION MAKING IN THE ETHANOL PRODUCTION PLANNING

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ABSTRACT

There have been significant advances in the theory of goal programming (GP) in recent years, particularly in the area of intelligent production planning and solution analysis.
In this paper a supply chain problem involving the production of ethanol and various by-products. The intention of this paper is to minimize the total production costs within a maximum allowable budget without violating the demand constraints. The secondary objectives are adhering to: given pollution norms and waste minimization constraints. A preemptive goal programming model is developed to solve the ethanol production planning problem.

Keywords: Goal programming, decision making, Ethanol

I. INTRODUCTION

The goal programming (GP) technique has become a widely used approach in Operations Research (OR). GP model and its variants have been applied to solve large-scale multi-criteria decision-making problems. The GP technique was first used by Charnes and Cooper in 1960s. This solution approach has been extended by Ijiri (1965), Lee (1972), and others. The Goal Programming Method is an improved method for solving multi-objective problems. Goal programming is one of the model which have been developed to deal with the multiple objectives decision-making problems. This model allows taking into account simultaneously many objectives while the decision-making is seeking the best solution from among a set of feasible solutions. The goal programming technique is an analytical framework that a decision maker can use to provide optimal solutions to multiple and conflicting objectives. Goal programming is a special type of technique. This technique uses the simplex method for finding optimum solution of a single dimensional or multi-dimensional objective function with a given set of constraints which are expressed in linear form. Multiple objectives arise in production companies because of several departments with different functions, In fact the basic concept of goal programming is whether goals are attainable or not.Next,
Rising fuel prices and policy initiatives have continued to stimulate renewable fuels including ethanol. Since, the mid-1990s the number of ethanol facilities and the plant size has increased gradually. By mid-2006, nearly 100 ethanol facilities in the United States were producing more than four billion gallons of ethanol annually, with 50 to 100 million gallon per year plants as standard size [3]. This paper deals with a supply chain problem involving the production of ethanol and various by-products. The process includes material sources, the processing mills and the customers. The primary objectives are to minimize the cost of: source materials, production (wet or dry milling), and transportation of final products. Additionally, the minimization of pollution at milling sites is another important management objective.

The goal programming (GP) technique provides an analytical framework that a decision-maker can use to provide optimal solutions to multicriteria and conflicting objectives. The GP and its variants have been applied to wide variety of problems [4] [6]. The use of GP in process industry problems is not new. Krajnc [4] investigates possibilities of attaining zero-waste emissions in case of sugar production. Arthur and Lawrence [1] designed a GP model to develop production and shipping patterns for chemical and pharmaceutical industries.

The model presented in this paper is designed to illustrate how preemptive GP can be used as an aid to solving multicriteria production related problems. Our ultimate goal is to develop a max-min model as well as a fuzzy goal programming model. Zimmermann [7] proposed the first

method for solving fuzzy linear programming problems. Fuzzy optimization has been focusing, first in solving models which reflect real life uncertainty, and second on transforming them into equivalent crisp problems to benefit from efficient existing solving algorithms. Fuzzy decision is a combination of goals and constraints, denoting a max-min model because it considers that the best fuzzy decision is the union of the aggregated intersections of goal and constraints [2].

II.FORMULATION

In order to formulate the model, we define the following:

(i) Notations

Indices:

i : the index of the sources of corn

j : the index of the production process

k : the index of the product (ethanol, corn oil, dry meal, corn gluten, live stock feeding, waste)

l : the index of the customer groups

Sets:

I : the set of the sources of corn

J : the set of the production process

K : the set of the products

L : the set of the customer groups

(ii) Parameters

d_{kl} = Monthly demand for product type k for customer group l .

C_{ijkl} = Total cost of producing and shipping the k^{th} product type (including raw materials) from the i^{th} corn source through the j^{th} milling location to the l^{th} customer group.

t_{ijk} = Unit time to produce a unit of the k^{th} output type at the j^{th} mill.

l_j = Production capacity at the j^{th} mill.

l_{jk} = Pollution level at the j^{th} mill for the production of a unit of the k^{th} output type (Gallons of water)

H_j = Number of hours available on a yearly basis for the j^{th} mill

TC = Total cost

PG_j = Pollution limit for the j^{th} mill

TW = Total waste generated

P_q = Priority labels, where, q 1,2,3

(iii)Variable

X_{ijkl} = the amount of product type k produced from corn from source i in mill type j for customer group l .

d_1+= the deviation variable of overachievement of the goal 1

d_1^-= the deviation variable of underachievement of the goal 1

d_2^+= the deviation variable of overachievement of the goal 2

d_2^-= the deviation variable of underachievement of the goal 2

d_3^+= the deviation variable of overachievement of the goal 3

d_3^- = the deviation variable of underachievement of the goal 3

(iv)Goal constraints and objective functions

Goal 1: Minimize total cost

………..(1)

$$Z_1 = \sum_{l=1}^{L}\sum_{k=1}^{K}\sum_{j=1}^{J}\sum_{i=1}^{I} C_{ijkl}X_{ijkl} - d_1^{+} + d_1^{-} \leq TC, X_{ijkl} \geq 0$$

$Goal2 : \text{Re}\,ductioninlevelofpollutionforthejmill$

$$Z_2 = \sum_{k=1}^{K}\sum_{j=1}^{J} P_{jk}Xijkl - d_2^{+} + d_2^{-} \leq PG_J \forall i = 1toIand\forall j = itoJ$$

……..(2)

$Goal3 : \text{Re}\,ductioninlevelofwaste$

$$Z_3 = \sum_{i=1}^{I}\sum_{J=1}^{J}\sum_{K=1}^{K} X_{IJKL} - d_3^{+} + d_3^{-} \leq TWforK = 6$$

…….(3)

The objective function of the model is to minimize the deviation variables corresponding to various goals. Highest priority is assigned to the total cost goal, to minimize the total cost. Therefore, the undesirable deviational variable in the first priority is overachievement of goal 1,i.e d_1^+ should be minimized. Then , the first priority function in the objective function is $P_1d_1^+$.

In the second priority of pollution level, we wish to minimize the pollution level from each mill to a predetermined safe limit. Therefore, the undesirable deviational variable in the second0

priority goal is overachievement of the goal 2 i.e. d_2^+ should be minimized. Then, the second priority function in the objective function is $P_2\, d_2^+$. Finally, in the third priority of waste level, we wish to restrict the waste produced within a predetermined limit. Therefore, the undesirable deviational variable in the third priority goal is overachievement of the goal 3 i.e. d_3^+ should be minimized. Then, the third priority function in the objective function is $P_3\, d_3^+$.

Hence the objective function for the goal programming model is:

Minimize: $Z = P_1d_1^{+} + P_2d^{\ +} + P_3d_3^{+}$ (4)

(v) Constraints

The objective functions formulated in the previous section are restricted by two sets of constraints. They are the demand constraints, and the time constraints.

……….(5)

$$\sum_{k=1}^{K}\sum_{l=1}^{L} X_{ijkl} \geq d_{kl}, \forall i = 1........I, \forall j = 1..............J$$

$$\sum_{l=1}^{L}\sum_{k=1}^{K}\sum_{i=1}^{I} t_{ijk} X_{ijkl} \leq H_{J}, \forall j = 1..................J \qquad ....(6)$$

$$X_{ijkl,} d_1^{+}, d_1, d_2^{+}, d_2^{-}, d_3^{+}, d_3^{-} \geq 0, i \in I, j \in J, k \in K, l \in L \qquad ....(7)$$

Constraint (5) ensures that the customer demands are met, whereas, the constraint (6) limits the hours available for processing on each type of milling. Constraint (7) ensures that all the decision variables are non-negative.

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