UNIVERSITI TEKNIKAL MALAYSIA MELAKA

GOAL PROGRAMMING APPROACH FOR PRODUCTION PLANNING

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Management)

by

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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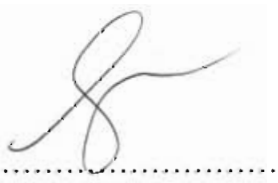

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APPROVAL

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ABSTRAK

Goal programming adalah kaedah untuk menyelesaikan masalah keputusan yang melibatkan beberapa tujuan. Goal programming berupaya menentukan titik yang paling memenuhi set gol dalam persoalan keputusan. Secara tradisional, tujuan perancangan pengeluaran dan kawalan adalah baik untuk memaksimumkan keuntungan atau meminimumkan kos dan diformulasikan untuk menjadi fungsi objektif-tunggal dalam pengaturcaraan linear. Nanum begitu, pengaturcaraan linear bukanlah tanpa masalah. Pada kenyataannya, pendekatan pengatucaraan linear yang umum adalah tidak berkeupayaan untul mewakili keadaan yang kompleksitas. Oleh sebab itu, kesedaran haruslah meningkat semasa melibatkan beberapa tujuan yang bertentangan antara satu sama lain. Jadi, penulis bercadang menggunakan konsep goal programming untuk menyelesaikan masalah dalam perancangan pengeluaran dan kawalan. Dengan demikian, kajian ini adalah untuk menyiasat and mengetahui bagaimana preemptive goal programming dan weighted goal programming boleh digunakan untuk meningkatkan keputusan pengurusan berkaitan dengan beberapa tujuan yang harus dicapai dengan menggunakan pelbagai sumber daya yang disediakan dengan sepenuhnya sementara memenuhi sekatan yang dihadkan dalam lingkungan persekitaran.

ABSTRACT

Goal Programming is a class of methods for solving problems that involves multiple objective decisions making. Goal programming enables determines the point that best satisfies the set of goals in the decision problem. Traditionally, the objective of production planning and control is either to maximize profit or minimize cost and is formulated to a single-objective function in linear programming. However, linear programming is not without problem. The difficulty with the general linear programming approach is in its inability to represent the complexities of reality. Hence, increasingly aware of presence of multiple objectives that are conflict to each other must have, so the author intends to propose concept of goal programming to solve the problem in production planning and control. Thus, this research is to investigate how preemptive goal programming and weighted goal programming can be used to enhance management decisions associated with multiple goals that need to be achieved in order to efficiency utilize variable resources while meeting the restrictions imposed by environment surroundings.

DEDICATION

I dedicate this research to my parents. Without their patience, understanding, support, and most of all love, the completion of this work would not have been possible.

ACKNOWLEDGEMENT

First of all, I would like to express my sincere gratitude and appreciation to my principal supervisor Associate Professor Dr. Mohamed Khaled bin Omar and Mr. Nor Akramin bin Mohamad for their grateful guidance during the course of final year's project. Theirs advice and encouragement played an essential and major role for the success of this entire project.

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LIST OF ABBREVIATIONS

DM	-	Decision Making
ETPP	-	Earliness Tardiness Production Planning
GP	-	Goal Programming
IPOPT	-	Interior Point Optimizer
JIT	-	Just In Time
KSE	-	Kuwait Stock Exchange
LP	-	Linear Programming
MODM	-	Multiple Objective Decision Making
MOO	-	Multiobjective Optimization
MRP	-	Material Requirements Planning
MS	-	Management Science
NIMBUS	-	Nondifferentiable Interactive Multiobjective Bundle Based Optimization System
OR	-	Operational Research
SMB	-	Simulated Moving Bed

CHAPTER 1

INTRODUCTION

The theme of this project addresses the goal programming (GP) approach for production planning with resource utilization constraint. The research problem, objectives, and scope of this project will be developed based on the theme stated above.

1.1 Background of Goal Programming

Management science (MS) and operations research (OR) can both be defined as field of study for the application of mathematical analysis to solve managerial problems. These fields of study consist of a collection of mathematical algorithms and logic structures that are used to solve problems. OR/MS can trade their origin of industrial application of methodology to the development of goal programming. Goal programming (GP) extended itself by reengineering many of the prior single objective linear programming (LP) models with multiple objectives. This is a direct relationship between the topics in MS/OR and GP.

GP is one of a set of MS/OR mathematical techniques that can be used to solve managerial problems when multiple objectives are present. For this reason, GP is included as a unique problem solving methodology in virtually every MS/OR book on the market today.

Goal programming which is an extension of linear programming is appearing as the most promising methodologies for multiple objective decision making (MODM). In addition, it has been utilized in many real-world decision making problems. MODM is a term used to describe a subfield in operations research and management science. Generally, MODM is defined as a means to solving decision problems that involve multiple (sometimes conflicting) objectives. The goal programming model is one in which all objectives are converted into goals. This conversion is accomplished by assigning an „aspiration level" to the right-hand side of each objective. The purpose of goal programming is to minimize the deviations between the achievement of goals and their aspiration levels, in the other word; those unwanted deviations are minimized hierarchically, according to the priority levels of individual goals. As such, the approach is appropriate for linear, non-linear or integer models.

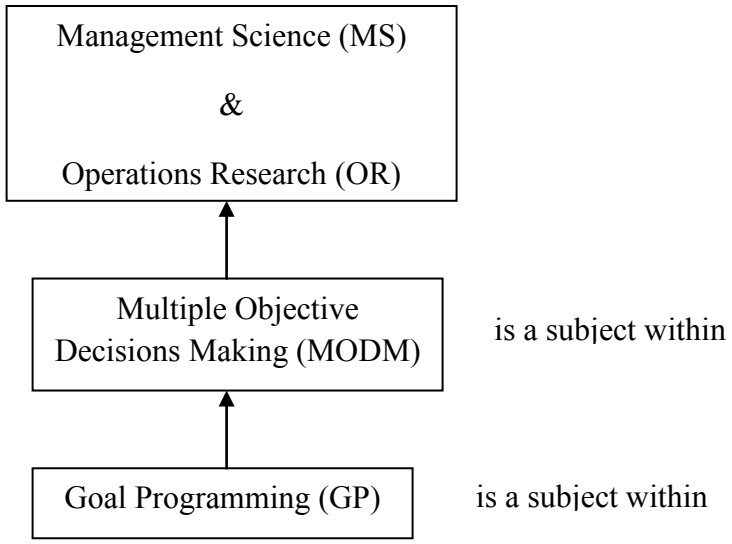

Figure 1.1: Relationship of GP with MS/OR and MODM. *Source* Marc J. Schiederjans, *Goal Programming: methodology and application*, United States of America, 1995.

1.2 Research Problem

This project involved one company that produces twenty types of products. The production of these products is done in two separate machine centres within the plant. Moreover, the production process involves some in-process inventory. The company has normal monthly operation hours of 630 for machine centre 1 and 600 for machine centre 2. In addition, each product has it is own estimated profit. For coming month, the company estimates the sales volume based on the forecasted from the marketing department for the Product A and Product B are 50 and 80 respectively. The production manager has established several goals that need to be achieved if possible for production run in the next month as below:

1. Limit the amount in-process inventory for the month to $18400.
2. Attain a monthly target sale of 50 units of Product A for the month.
3. Avoid underutilization of regular operation hours of both machine centres.
4. Limit the overtime operation of machine centre 1 to 20 hours.
5. Attain a monthly target sale of 80 units of Product B for the month.
6. Avoid overutilization of regular operation hours of machine centres.

The production manager desire to know whether the goals stated above can be fully achieved or partially achieved. This complex and conflict problem is reported by S. M. Lee (1972). Thus, the author intends to use goal programming approach to solve the production planning problem faced by the described situation. In other words, the author attempts to investigate the possibility of achieving all goals set by the production manager through the use of goal programming approach.

1.3 Objectives

This research intend to use the concept of goal programming as a multiobjective approach to develop production planning, and therefore, the objectives of this project are as follows:

1. To understand the concept of goal programming and its application in production planning and control.
2. Consider a case of production planning and control and formulate a goal programming model that can accurately represent the production planning problem stated in section 1.2.
3. Develop the goal programming model in MS Excel and use the MS Excel solver to provide a solution to the problem.
4. Conduct a study to compare between two approaches of goal programming to solve production planning and control namely preemptive and weighted goal programming.
5. Report the results and findings.

1.4 Scope

The focus of this project is to understand and apply the concept of goal programming in production planning and control. In this project, there are two approaches of goal programming which will be used, including the preemptive and weighted goal programming. Both of the models are developed and solved using MS Excel. The parameters used in the both goal programming models are deterministic. Therefore, this project will not be considering stochastic goal programming approach as a modeling for production planning and control.

1.5 Organization of Report

The author report is divided into six sections, namely (i) Introduction, (ii) Literature Review, (iii) Methodology, (iv) Concept of Goal Programming, (v) Result and Discussion, and (vi) Conclusion and Suggestion. The content of each chapter is as follow:

(i) Chapter 1: Introduction

This chapter contains the element of background, research problem, objectives, and scope to be covered in the project. The purpose is to give a brief overview about the topic of research.

(ii) Chapter 2: Literature Review

In this chapter, collection of information which is related to the project is excerpted. This information including the definition of GP, general mathematical modeling of GP, application and advantage of goal programming approach for production planning.

(iii) Chapter 3: Methodology

This section explains the research methodology undertaken by the author. It includes the research method and tool used by the author. Moreover, a solution methodology of problem flow chart is depicted as well.

(iv) Chapter 4: Concept of Goal Programming

This chapter consists of introduction of goal programming, its structure model, and the step taken in the goal programming formulation. Besides that, an example of goal programming problem is solved by using graphical and simplex method is provided.

(v) Chapter 5: Result and Discussion

This chapter illustrates the results obtained using tables and figures. Any important findings will be presented in a comprehensive manner. Besides, comparison between the result of preemptive goal programming and the weighted goal programming will be carried out in order to find any discrepancy exists.

(vi) Chapter 6: Conclusion and Suggestion

This last chapter will be a concluding section for the whole project undertaken by the author. Suitable suggestions for further improvement to the research will be included.

CHAPTER 2

LITERATURE REVIEW

There are a lot of published research papers that consider the goal programming (GP) approach for production planning. Since, this project is focusing on multiple objectives optimization analysis in order to efficiency utilizes the variable resources. Thus, in here, a brief literature review on definition of GP, concept of GP, general mathematical modelling of GP, application of GP, and advantages of GP approach for production planning are provided.

2.1 Introduction to Goal programming (GP)

Traditionally, the objective of aggregate production planning is either to maximize profit or minimize cost and is formulated to a single-objective function in linear programming (LP). Recently, many researches and practitioners are increasingly aware of presence of multiple objectives in real-life problems (Vincke, 1992). For any individual firm, it is extremely important to achieve the most efficient utilization of available resources while meeting the restrictions imposed by the environment as well as by organizational

policies concerning employment, inventories, production, and the use of outside capacity. However, all of these aspects are not always possible to share one common characteristic such as the objective might be to maximize total profit. In this kind of situation, management might instead set of numeric goals for the various objectives and then seek a solution that makes as much progress as possible toward all these goals. This is the kind of problem that goal programming addresses.

Goal programming was first introduced by Charnes and Cooper (1961) and further developed by Lee (1972). GP is the most promising methodologies for multiple objective decision making (MODM), has been utilized in real-world decision making problems. The purpose of goal programming is to minimize the deviations between the achievement of goals and their aspiration levels. There are many researcher applied GP in their research, such as, Biswas and Pal (2005) involved a priority-based Fuzzy Goal Programming (FGP) for optimal production of seasonal crops by utilizing the cultivable land and available production resources. Bal *et al*. (2006) suggested to used the goal programming approach based on the minimization of deviation from the median (GPMED) to solve two-group classification problems because it is almost superior to all other method. Leung and Ng (2007) used preemptive goal programming model to solve aggregate production planning for perishable product by applying the postponement concept. More recently, Leung and Chan (2009) proposed a goal programming model to deal with aggregate production planning problem in a surface and materials science company.

2.2 Concept of GP

Goal programming (GP), which is an extension of linear programming (LP), is commonly applied to deal with multi-objective problems (Rifai, 1994). Charnes and

Cooper (1961) described that GP is used to derive a set of conflict objectives as close as possible. Tamiz *et al.* (1998) revived the state-of-the-art current developments in goal programming. With fast growth in computational facilities, both linear and non-linear production planning can be solved by using exact and heuristic methods. (Jones, Mirrazavi, & Tamiz, 2002).

Basically, structures of GP and LP are the same that is the objective function is stated, after that followed by the system constraints. However, the special concept of GP is to introduce extra auxiliary variables called deviations; these deviations represent the distance between aspiration levels of goals (target values) and the realized results. Two kinds of deviations are considered, under-achievement of the goal as represented by negative deviation (d^-) and over-achievement of the goal as represented by positive deviation (d^+). Each goal is expressed as linear equation with deviations. Since there are multiple goals, the management can assign a priority factor P_j to each goal according to its level of importance. In other words, the goals can be ranking according to the degree of importance relative to each other; the highest ranking number of goal is considered first and then followed by the second higher ranking number of goal, and so forth.

In developing GP model, it is consists of two sets of constraints; system constraints and goal constraints. System constraints represent the relationship among the decision variables and the system parameter, whereas goal constraints are auxiliary constraints, which determine the best possible solution with respect to a set of desired goals.

GP programming provides two alternative ways of formulating problems with multiple-objectives. First is called weighted goal programming and second approach is called preemptive goal programming. In this project, both of the approaches will be used by the author to solve the problem in production planning and control.

Weighted goal programming is assign weights to the goals that measure their relative importance and then seeks a solution that minimizes the weighted sum of the deviation from the goals. Whereas, preemptive goal programming requires deciding on the order of important of the goals; in which unwanted deviations are minimized hierarchically, according to the priority levels of individual goals, so that goals of primary importance can receive first-priority attention, those of second importance can receive second-priority attention, and so on. Then, the goals of first-priority are minimized in the first phase. Using the obtained feasible solution result in the phase, the goals of second priority are minimized, and so forth. The preemptive GP model accepts implicitly infinite trade-offs among goals having different priority levels (Romero 2004).

2.3 General mathematical Modelling of GP

According to Romero (2004), the framework of GP model can be formulated as follows:

Achievement function:

$$\text{Min. } Z = [\sum_{k\in h_i}(\alpha_k d_k^+ + \beta_k d_k^-), \dots, \sum_{k\in h_j}(\alpha_k d_k^+ + \beta_k d_k^-), \dots, \sum_{k\in h_Q}(\alpha_k d_k^+ + \beta_k d_k^-)] \quad (1)$$

s.t

Goal and system constraints:

$$f_i(x) \sim 0, i = 1,2, \dots, q \quad (2)$$

$$g_k(x) - d_k^+ + d_k^- = b_k, k \in h_j, j \in \{1, 2, \dots, Q\} \quad (3)$$

$$d_k^+, d_k^- \geq 0, k \in h_j, j \in \{1, 2, \dots, Q\} \quad (4)$$

Where the relational symbol ~ denotes =, ≥ or ≤

h_j = index set of goals placed in the j[th] priority level

α_k = weighting factor for positive deviation

β_k = weighting factor for negative deviation

$f_i(x)$ = system constraint

$g_k(x)$ = goal constraint

b_k = aspiration level of goal k

$d_k^+ = \begin{Bmatrix} g_k(x) - b_k, & if\ g_k(x) > b_k \\ 0, & otherwise \end{Bmatrix}$ is positive deviation; and

$d_k^- = \begin{Bmatrix} b_k - g_k(x), & if\ g_k(x) < b_k \\ 0, & otherwise \end{Bmatrix}$ is negative deviation.

It is noted that, in optimization formulation, $d_k^+ \cdot d_k^- = 0$ for all k. Moreover, in the achievement function, $\alpha_k = 0\ if\ d_k^+$ is not an unwanted deviation and $\beta_k = 0\ if\ d_k^-$ is not an unwanted deviation. It implies that only unwanted deviations are included on the achievement function. For instance, if over-achievement is to be minimized, then the negative deviationd_k^-, is not an unwanted deviation and $\beta_k = 0$.

2.4 Some Recent Approaches for GP

2. 4.1 Fuzzy GP

Fuzzy programming in based on the theory of fuzzy sets, introduced by Zadeh (1965), was appeared as a prominent tool for solving problems with imprecise data where, the