SYSTEM DYNAMICS MODELLING FOR CORPORATE PLANNING: A MODULAR APPROACH FOR PRODUCTION SYSTEMS

By

RAKESH KUMAR

DEPARTMENT OF MECHANICAL ENGINEERING

Thesis submitted in fulfilment
of the requirements for the degree of
DOCTOR OF PHILOSOPHY

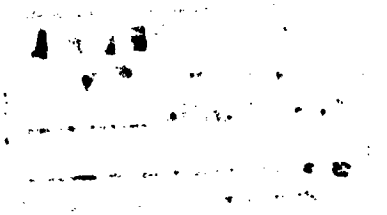
To the

INDIAN INSTITUTE OF TECHNOLOGY,DELHI

SEPTEMBER 1984

DEDICATED TO

PARENTS



CERTIFICATE

The thesis entitled "System Dynamics Modelling for Corporate Planning: A Modular Approach for Production Systems" submitted by Mr. Rakesh Kumar to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy, is a record of bonafide research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which has attained the standard required for a Ph.D. degree of this institute. The results presented in this thesis have not been submitted elsewhere for the award of any degree or diploma.

3rd Sept. 1984

PREM VRAT

Professor of Industrial Engineering
Department of Mechanical Engineering
New Delhi-110016.

ACKNOWLEDGEMENTS

I wish to express my deepest sense of gratitude to Dr. Prem Vrat, Professor of Industrial Engineering, Department of Mechanical Engineering, I.I.T., Delhi for providing valuable guidance, supervision, inspiration and courage to take-up the present study.

My sincere thanks are due to Dr. A.N. Saxena, Director General, Sh. R.S. Gupta, Deputy Director General, Sh. J.S. Saraon, Regional Director, and Shri B.K. Ghosh, Director (Administration) at the National Productivity Council for their encouragement and advice.

I am deeply indebted to Mr. Olaf Kleine, adviser, National Productivity Council (1974-1981), for valuable advice and inspiration during the conduct of the study.

I am specially grateful to Dr. Sushil K. Agrawal, for his constructive suggestions. But for his interest and encouragement the work could not have been accomplished in time.

I am also thankful to Sh. R.M. Narchal, Sh. A. Ramachandran, Dr. D.K. Banwet, Dr. N. Singh, Sh. Rajesh Chadha and all my colleagues and friends for their valuable cooperation.

I extend my sincere thanks to the managements of the National Productivity Council and the Steel Plant for providing me necessary facilities and opportunities to apply the various concepts discussed here in a real life situation.

Last but not the least, thanks are to the family members for their patience, understanding, co-operation and constant inspiration. without which this study could not have been completed.

(RAKESH KUMAR)

ABSTRACT

This thesis aims at developing a modular approach for modelling the dynamic behaviour of production system for the purpose of corporate planning using System Dynamics methodology. The proposed approach has been employed for designing computerised corporate simulation model of a typical steel plant. The modular construction facilitates the development of similar model of any manufacturing system.

The literature on corporate planning models has been classified and reviewed. Design of generalised models, based on an understanding of system structure, controllable and non-controllable parameters is considered to be a crucial area for further research. The two surveys carried out to study the corporate planning practices in Indian context have revealed the need for strengthening the knowledge and experience in the area of corporate planning through development and application of dynamic, mathematically simple, flexible and user oriented corporate planning models.

Modular approach based on system dynamics methodology is suggested for the development of corporate planning models. Out of the three major modules of a corporate planning model, viz., marketing, production and finance, the production system module has been taken up for detailed investigation, design and application.

Basic feed-back modules of a production system in general have been investigated and separately studied. These have been integrated to evolve a generic feedback structure of a production sub-system. The capacity centre module so evolved has been applied to model the various production sub-systems of an integrated steel plant. One such application in case of a rolling mill is presented. The validation runs of this model have established that capacity centre module signifies to a large extent the dynamic behaviour of production.

The capacity centre module designed, based on the generic feed-back structure, has been taken as a basis to develop an integrated feed-

back model of any production system. This has been demonstrated for the case of a steel plant. The model of the production system of steel plant has been developed through stagewise integration of twelve inter-dependent capacity centre modules. The scope of the model has been enlarged to simulate the generation of scrap, and to identify the intensity of bottleneck at each capacity centre. The validation results have established that the modular approach using system dynamics methodology can be applied to simulate the production behaviour of any complex integrated system comprising of a set of interdependent capacity centres.

The model of the production system has been extended in a limited manner, by developing an aggregated accounting module, to simulate some of the financial consequencies of physical flows and financial indicators of interest.

Simulation experiments have been conducted with the model and the scope for its application in the area of corporate planning is established. The model has been applied in a real life situation to identify debottlenecking priorities, generation of optimistic and pessimistic scenarios, and evaluation of expansion, modernisation and debottlenecking projects. The results of some of these experiments are discussed. The model extends over 1000 statements representing 12 capacity centres, 3 major raw materials and 17 finished products of the steel plant.

The major findings of the research have been summarized, and the significant research contributions made are highlighted. Some of the limitations of the study have been outlined, and scope for future research is indicated.

An extensive bibliography on corporate planning models is given at the end of the text, followed by appendices.

CONTENTS