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Simulating manufacturing dynamics

Energy recovery from exhaust gases

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FEATURES

Noise control — the good and the bad news **Page 26**
by Martin Smith, Acoustic Division, Trox Brothers Ltd
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Simulating Manufacturing Dynamics using a Microcomputer **Page 30**
by B H Claybourn and R Reed, Newcastle upon Tyne Polytechnic
The role of case studies and business games has long been recognised as an essential feature of business education and it is to this collection of educational methods that the simulation game described in this article is offered.

Increasing employment **Page 37**
by Dr Parker, Senior Research Fellow, Ashridge Management College
In this article, the author suggests that employment could be increased through the creation of ideas for new products within smaller businesses.

Product Liability Law in the United States **Page 43**
by Professor Douglas Muster and John O'Quinn
In recent years there has been increasing concern in many countries that the public must be protected from injury by the products and by-products of technology. In this article, (which will be concluded in the next issue of CME), the authors look at the law in the USA and the lessons which may be learned from it.

Hydraulics and electronics **Page 49**
by Philip Belsham, Managing Director, Bofors Electronics Ltd
One of the most exciting aspects of modern technology is the increasing fruitful marriage between electronics and electrohydraulics. The rapid proliferation of automated processes, production lines and entire factories, is the result of this marriage. One of the more vital requirements for automation is closed loop control of the movement of objects — workpieces and tools — and this is one of the two fields in which electronics makes a vital contribution.

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COVER

This high precision 70mm tungsten carbide ball from Spheric Engineering is made to a diameter and sphericity tolerance of ±0·00064mm (0·000025 in) for use in a special valve application in the Australian petroleum industry.

In addition to tungsten carbide, Spheric manufacture high precision balls in carbon chrome, silicon carbide, ceramic, phosphor bronze, stainless steel and rubber in standard Imperial or metric sizes from 0·5mm to 75mm and 0·2 in to 3 in in four grades of sphericity and diameter tolerances. **Circle 1**

SIMULATING MANUFACTURING DYNAMICS USING A MICROCOMPUTER

A student awareness package

by B H Claybourn* & R Reed*

The student of production management unlike his counterpart in say engineering or science, often commences his studies with no previous experience and very little conception of the discipline he has chosen. In addition, it is found that he does not fully appreciate the significance of the system dynamics, decision making, or the uncertain environment within which the production system is located. Thus the education of the potential manager is composed of a mixture of exposure and formal tuition, which if properly orchestrated in a complimentary manner, provides the necessary background for the development of the efficient and effective executive.

The role of case studies and business games has long been recognised as an essential feature of all such education, and it is to this collection of educational methods that this simulation game is offered. Its distinguishing feature is the use made of the micro-computer, which permits the organisation of the game to be extensive, whilst at the same time allowing the benefits of computer aided learning to obtain. Each group is permitted to progress at its own rate, the computer acting as a patient tutor, free of any covert criticism or comment on the groups actions.

The idea for the game was proposed by R J Sury, to whom the authors' are indebted; however the use of the computer has permitted extensive development and many new additions far in excess of anything originally conceived. The game in its final form has been developed for students pursuing business studies degrees, as well as engineering degrees, and has also found favour with management studies students at diploma level. The educational feature of the game does not lie in its successful completion or overall performance, but rather with what is learned during the playing. Students familiar with such techniques as stock control or forecasting etc are likely to benefit less than their inexperienced colleagues encountering this once only game, because it is their mistakes which promotes discussion with the human controller in what is a teaching by exception situation.

The addition of a hard copy printout facility to the normal VDU display is used to full advantage, since such permanent listing is restricted to the publication of errors during play. It is the operation of the printer, which draws the controller's attention to the groups erroneous activities; these may be one of two principal forms:–

(a) the inability to calculate correctly in some aspect of the game, eg holding costs.
(b) tactical errors in decision making resulting in say shortages or similar deficiencies.

The game may be played in a competitive manner using several terminals with the advantage that the difficulties encountered are not personalised to the group controller relationship, as is bound to occur in the manual version when each period's requirements are announced, following completion of planning. Finally the use of the microcomputer permits operation of the game at residential schools, which often occur away from educational or institutional establishments where large facilities reside.

Basis of the game

The basis of the game is one of an ongoing production system for which the student teams are responsible during the simulation period and which it is assumed will continue after they have relinquished their responsibility. The situation they inherit is one of a single product factory, having a normal weekly capacity of 400 units, based on a single shift five day working week. The teams are responsible for material ordering, production scheduling and calculating the direct and indirect costs involved. The game concerns the manufacture of a product having a lead time of less than one week, where the production scheduled for a particular week is available for sale at the end of that week.

The sales price of the product remains fixed throughout the game of which some 50 per cent represents direct costs, the remainder forming a contribution to indirect costs and profit. The indirect cost is made up of fixed overheads and selling costs. The former is held constant throughout the game with the latter, representing the variable portion of indirect costs, being proportional to the units sold. The direct cost is solely concerned with the raw material purchased and those costs associated with production. Using normal capacity production together with these costs a maximum unit profit results and this is used as a basis of assessment both during and at the end of the game.

The student teams commence participation in the game at the end of week 12 of a calendar year. There is a supply of finished products and raw materials which may or may not be adequate, and they are informed that the sales demand for week 12 has been satisfied and that a raw material order is expected to arrive in week 13. However, they are only permitted to schedule production with raw materials already in stock and may not use a raw material delivery until the week following arrival.

The production plans and performance for the previous two weeks are available, together with the actual sales demand pattern from week 1. Furthermore, a weekly sales forecast for more than 30 weeks made just prior to week 1 is also to hand. The team are given details of the raw material ordering procedures, costs, nominal delivery times, the costs of holding stocks, excess charges for below normal capacity production and a method of assessing in monetary terms any failures to supply customer requirements. It should be noted here that no back ordering is allowed. Finally, details are given of the means of increasing production capacity above that of the normal single shift working by various forms of overtime and sub-contracting. For such short planning horizons, ie one week, additional shift working is not permitted and limits are fixed on the amount of evening overtime and weekend working that can be achieved in unit production terms. The students are told that a holiday period is scheduled for weeks 25 and 26, when no factory production can be expected but where materials can be ordered, received and products sold.

The game requires the teams to produce quantity plans in terms of raw materials ordered and production scheduled, and produce weekly accounts for their activities. They are at liberty to order materials as necessary and schedule production as they see fit. When the weekly plan is submitted to the computer, a validation procedure checks that it is viable and it is then regarded as committed. The computer responds by giving details of actual production performances and customer demand. The students must assess these results and complete the weekly cost, profit and sales analysis sheet. As stated there is no facility for back ordering when failure to meet customer demand occurs.

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These shortfalls are simply translated into a number of lost customers, which is a non-linear relationship and the magnitude increases disproportionately with the size of the shortfall. The results are quantified in money terms by multiplying the number of lost customers by the products maximum unit profit.

To simulate the highly uncertain and dynamic situations found in production management, the game is interspersed with various disturbances which result in less than the planned production performance being achieved. These disturbances include productivity and quality levels which fall short of 100%. In addition the quality short falls also waste materials. Further, raw materials orders are either lost or are only partially fulfilled, with the usual promise of the rest next week. The above, together with a strike and the failure of subcontracting increases the students' awareness of the potential problems in operating a production system. However, the behavioural aspects which influence labour attitudes and performance etc are not catered for.

Each team is subjected to the same actual demand pattern and thus the performance of several teams may be compared in a manner similar to several firms equally sharing a given market. At the end of the game an analysis is taken on the teams' overall performance. Here, the actual profit achieved as a ratio of the ideal is used as a measure of short term activity. The ideal profit being defined as the total demand multiplied by maximum unit profit. Further, where applicable the less realistic costs of lost customers when failing to meet customer demand is used as an indicator of the longer term performance by using the ideal profit to produce a company survival factor.

The computer package

The computer package is designed as an interactive program through which information can be presented to the student, and in which verification of student calculations can take place. The computer which ran the program had to satisfy two basic criteria. The first was to allow visual access to computer output for up to four students, and the second, was a criterion based on the probability aspect. The use of teletypes to mainframes was discounted, since it is extremely difficult to give visual access to the required number of students; visual display units were discounted since their access on residential courses could not be guaranteed. The unit chosen on which to implement the package was a 16K PET with integral VDU, cassette unit and a printer. The program is written in BASIC but uses no special PET BASIC functions and hence is a transferable program to other computers.

On start-up the program sets up the initial conditions for week 12 of the game and has the demand quantities for the finished product stored in memory. The computer is designed to be run for groups of weekly periods, up to a maximum of four such groups which allows flexibility in the length of game to be played.

The student team are expected to specify their weekly production and ordering programmes before submitting them to the computer, using the function keys. (See Fig. 1). Each part of the programme is validated before being accepted. Here comparisons are made with the constraints imposed on production and the teams raw material availability. The total plan is then subjected to a set of carefully monitored and controlled factors

*** HELP ***

The following list of command keys have these given meanings. No other keys work.

H Displays the command key meanings.
R Signals a raw material order.
D Signals day shift production.
E Signals evening shift production.
G Signals Saturday shift production.
U Signals Sunday shift production.
S Signals subcontracting.
C Signals a production plan submission.

Fig. 1. Command keys for entry end submission of a plan.

which are designed to randomly disturb the students' production planning. It is unlikely that there will be 100% production in any one week, but the levels of production achieved have a probability inversely proportional to the loss in production. The probabilities of strikes, loss of subcontracting and failure of raw material supply have similarly been fixed. The actual production levels achieved are specified by the computer but the students are then expected to submit a cost analysis of the week's inventories, production costs, shortage costs and indirect costs to be verified against computed values.

TEAM (NAME) WEEK 21

RAW MATERIAL HOLDING COSTS

YOUR ANSWER = 23·9
CORRECT ANSWER = 52·1

Fig. 2. Printout after incorrect student response.

This tutorial approach enables a close monitoring of student performance since a printout is obtained if there is a discrepancy between student and computer values. (See Fig. 2). At the end of a game a final printout is given of the cumulative sales, shortages, costs and profits together with a calculated profit factor and survival factor. The structure of the program is such that it is easy to change the figures for sales demand, or the probabilities for perturbations in the production cycle, and it is expected that users of the game will need to do this over time.

User experiences

To ensure that the educational objectives of the game would be fully realised, students were involved early in the production of computer package. The basic game together with some of its additions were tested for pertinence and understanding by playing the exercise manually under classroom conditions, with supervision being provided by the authors. As the package was developed, further student tests were implemented to obtain opinions on the significance of the various visual displays and hard copy outputs etc. In one of the later tests the students were asked to record their experience of the game, adding suggestions where appropriate. Ultimately the finalised package was tested under full terminal conditions with several groups playing together. It was during this simulation that the competitive aspects of the package, and the full implication of the games' dynamics were revealed and favourably received by students. □

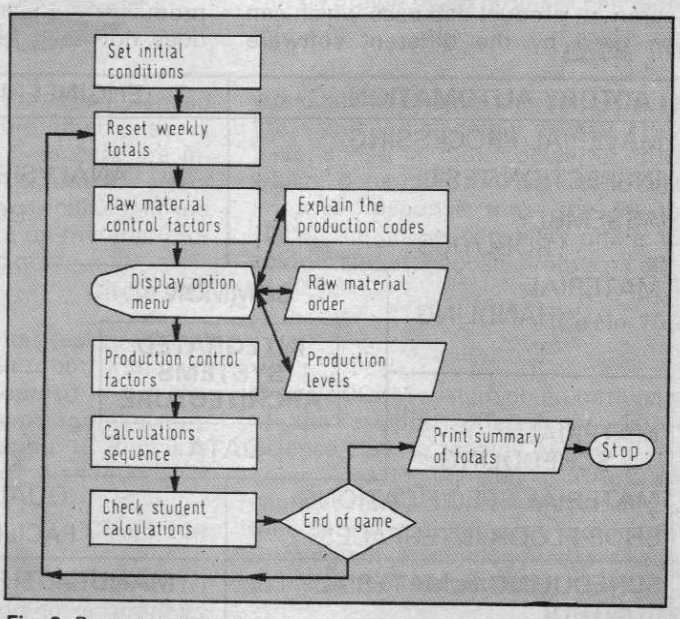

Fig. 3. Program sturcture.