INNOVATIONS IN SIMULATION FOR SMALLER DESIGNERS AND MANUFACTURERS IN THE UK

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ABSTRACT

Simulation tools and technology are now commonplace in the high technology environments of many large-scale companies. However, this is not yet the case in many smaller firms. Furthermore, the smaller firm may have a highly individual approach to its design and manufacture. The paper focuses upon the specific example of small and medium sized enterprises engaged in the design and manufacture of bicycles from the United Kingdom. Conversely, the smaller firms are synonymous with high technical standards in terms of the traditional engineering qualities of strength, durability and manufacturing tolerances. The smaller firms compete against much larger firms with greater technical and manufacturing resources. Interestingly, the smaller firms can introduce innovative designs faster and sometimes carry out design work for larger firms. The paper explores how issues of scale may be addressed in order to speed up the use of appropriate simulation tools and technology for smaller designers and manufacturers.

INTRODUCTION

On-going research into simulation at the University of Manchester revealed that smaller designers and manufacturers in the UK largely overlooked the benefits of simulation. This was in stark contrast to the adoption of simulation by their competitors from much larger firms. It is suggested that at least some of the reluctance of smaller designers and manufacturers to adopt simulation is due to a lack of suitable tools. That is, simulation tools that reflect the scale of the task and are appropriate to the industrial environment of the smaller firms.

THE IMPORTANT CONTRIBUTION OF LEADING SIMULATION RESEARCHERS

Wiedemann [6] represented a notable step forward in the integration of teaching material and assessment exercises. Moreover, Wiedemann [6] represents a very significant development in modelling and simulation resources because the working database system allows the user to compare different tools and techniques. A particularly useful point is its range of use. This system with its extensive resources is suitable for engineers working in industry and academia as well as a range of ability levels. For example, the tutorials reveal a wealth of experience and insight. All of this is available on-line within the database system as well as a variety of modelling and simulation tools. This diversity is distinctive because personal direct observation suggests that researchers and developers tend to favour their own particular tools and techniques rather than offering a selection.

Table 1: A Summary of the Advantages of the Toolset [2]

The advantages of the toolset proposed by Krug, Liebelt and Baumbach [2].
Less stress
Fewer tasks for the operator
Greater accuracy-times derived from the workplace
Greater acceptance of modelling as a relevant technique

Another recent article by Krug, Liebelt and Baumbach [4] allows more accurate planning and reduces the tasks of the production operator. They show how an intelligent toolset for modelling, simulation and optimisation of supply chain management assists efficient use of Just-In-Time manufacture as well as distribution. Moreover, they achieve greater accuracy by using real transition times instead of the more generally used average times or values. Their models more accurately reflect reality yet smooth production by removing from the machine operator the burden of unrealistic constraints.

An article by Hignett and Zobel [3] illustrated the advantages as well as disadvantages of the ASEASY planning tool for use within an integrated approach to modelling and simulation for SME designers and manufacturers. The idiosyncratic nature of SME manufacturers noted in Hignett and Zobel [4] parallels similar findings in other industries and different European industries [1,6] mean that is problematic to suggest an overall approach that addresses the specific problems of the smaller firm.

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The owner or Managing Director tends to think that their firm is special and so believes that it faces a particular set of problems. This is generally not the case! Smaller firms tend to share certain characteristics. These characteristics may be summarised as a dearth of key resources. These are shortages of time, machines and skilled labour.

Moreover, control in terms of decision-making is frequently concentrated in one individual. This may also be aggravated by a dependence upon a small number of key skilled workers. The main key skills are welding, painting or finishing and assembly. These workers are crucial to the successful operation of the smaller firm because they generally perform their tasks to a much higher standard than is found in the larger mass-production manufacturers In short, they enable the smaller firm to compete against the larger firms with much more extensive resources by offering a better bicycle. This means a bicycle superior in terms of quantifiable characteristics such as strength, lightness with a more durable and finer-detailed finish.

THE ADVANTAGES OF MODELLING AND SIMULATION FOR SMALLER MANUFACTURERS

Smaller manufacturers generally operate in an environment characterised by shortages of materials, specialist manpower and production capacity. The use of Simulation tools helps deal with changes both unplanned and planned. At a bare minimum the ability to predict with some degree of accuracy "What if" scenarios in terms of lack or substitution of parts and materials provides a very useful and comforting facility. This is because the smaller manufacturers face difficulties in ordering small quantities of specialist parts and materials from much larger firms.

THE ADVANTAGES OF MODELLING AND SIMULATION FOR DESIGNERS AND MANUFACTURERS

In the specific case of the bicycle manufacturers of the UK, the use of computer-based technology allows the engineer to take a step back from the actual processes of design and manufacture. This allows a freedom to experiment with variants and pose "what if?" questions.
It also permits a greater insight into the manufacturing process by enabling engineers to deal with problems and different production scenarios at a high conceptual level.

The selection of modelling and simulation software

The Simplex3 System was selected from a range of modelling and simulation software. An innovative research team from the University of Passau in Germany developed Simplex3. However, Simplex3 is largely unknown in the United Kingdom and this novel aspect added interest to the challenge of modelling and simulating the fast changing bicycle industry.

The advantages of Simplex 3

The Simplex 3 system is a powerful modelling and simulation system permits both continuous and discrete event simulation. At the core of Simplex3 is a public library of models that may be transferred to the private library of the user. The model in the private library may then be modified and used for experimentation. Moreover, the results of the experiments can be displayed in a variety of ways. The Simplex 3 software tool is well documented and respected in German-speaking countries. It is used for both academic and industrial applications. However, this is not yet the case in the UK, largely due to the original documentation being available in German.

Table 2: The Main Advantages of Simplex3

The Main Advantages
C language
Stable
Support available from a team of experienced developers
Comprehensive documentation in German and English
A library of useful models serves as a foundation for modification and experimentation
Inputs are possible by command line or modification of the existing models
An informative GUI
Choice of various graphs charts and diagrams to illustrate results. Supports reverse engineering by modelling structures and processes
Low cost or free for academic users

This table summarises the main advantages of the software selected.

For instance; simulation experiments with Simplex3 can produce results from different production runs. Another useful example of the use of Simplex3 for designers and manufacturers is the simulation of different kinds of frame coatings.

This is not a trivial point for manufacturers because it involves changing the layout of the factory and may encompass acquiring new facilities such as acid baths, plating tanks and drying ovens, all with the necessary additional ventilation and cooling equipment. In the case of the selection of different kinds of paint or electro-plating of the original metal, the choice is not straightforward. The design and manufacturing considerations involve cost, time, weight as well as manufacturing complexity.

SCALEABILITY ISSUES

Scale is generally viewed in terms of scaling up. However, in the case of the small and medium-sized designer and manufacturer the difficulty relates to the diversity and power of the various simulation tools. The smaller firms require simulation tools that are intuitive, easy to use and less powerful. This is because the fast-moving pace of many tasks being dealt by a small number of key workers allows little time to train in new skills and techniques. Moreover, directors and decision-makers from the senior management may be from non-technical backgrounds, such as accountancy or finance. Key decision makers may lack an engineering paradigm.

An example of a simulation and modelling system

The appearance and durability of the surface coatings of the bicycle are important considerations for engineers in the design and planning of the production line. However, the choice between painting or electro-plating of the bicycle frame and other parts shares common features and similar steps that may be used to re-engineer the final part of the production using modelling and simulation technology.

Table 3: The Simulation of Painting and Plating Processes

Electro-plating processes	**Painting processes**
Cleaning	Cleaning
Sanding (abrasion)	Sanding (abrasion)
Copper plating	Priming (undercoat)
Nickel plating	No. of coats of paint
Chromium plating (optional)	Varnishing/ Lacquering
Applying decals or badges	Applying decals or badges

Note that the first and final parts of the processes are the same. Therefore, it would be feasible to use the same manpower and equipment to perform these tasks.

THE RE-ENGINEERING OF INDUSTRIAL PROCESSES

A factory production line is in effect a series of discrete events. The different steps of production resemble a series of building blocks of a model. Modelling and simulation tools like Simplex3 can assist smaller firms in coming to market faster with new designs of bicycles. This is undertaken by using simulation tools to plan for the entire virtual design and manufacture before making even a single physical item. Ideally, there would be no requirement for physical samples of new parts. This is an important advantage in an industry where leading manufacturers are wary of releasing samples in case of unauthorised copying.

THE PLANNING OF THE MANUFACTURING PROCESSES

This starts not with the intended new or modified design but rather with earlier designs and production. The aim is to plan and manage the transfer of production capacity in a structured manner. The traditional alternative is to allow chance and the vagaries of the market as well as other manufacturers and suppliers to force a decision to be made. For example, it is suggested that earlier designs be subjected to renewed scrutiny in view of changes in: improvements in materials and manufacturing technologies. These improvements encompass changes in the availability, quality and cost of materials as well as purely technical considerations such as practical improvements in welding or bonding techniques.

The aim is to incorporate strategic thinking into operational reality by reducing bottlenecks and waste. For example, it is suggested that aluminium-alloy competition frames could be simply protected with layer(s) of clear varnish or lacquer to save time in preparation and drying. This would free up additional production capacity. For example, the baking ovens and the repeated priming of the surfaces for painting would not be necessary. It would also make the highly stressed bicycle frames safer by allowing crack-detection to be much easier.

THE PARALLELS WITH OTHER INDUSTRIES

Here the intention was to make modelling and simulation easier, faster as well as to provide some examples to assist engineers. The most immediate concern was to identify a compound model that may be tailored to meet individual requirements. Fortunately, there are a number of parallels that are immediately obvious. The drying of paint as well as the heat-treatment of metals parallels a model named Biotope available in the public library of Simplex3. The model Biotope simulates the silting of a lake in which the sun changes the speed of the layers of silt over time.

Here the most obvious parameter is temperature: the input of heat upon chemical and physical changes. Moreover, both the drying of paint and the heat-treatment of metals are in effect discrete-event processes. This is because the different stages of preparation, coating and finishing are distinct parts of the production process and can occur in separate parts of the factory with the tasks being done by workers with very diverse job titles. In fact, environmental considerations such as the handling of noxious chemicals like paint solvents, acid-based cleaning solutions and electro-plating solutions mean that some physical separation as well as control by technically competent operators is highly desirable, if not mandatory.

The important determinant is when has the desired change taken place. This can be in terms of physical handling: dry paint and cooled metal or include changes in hardness and resistance to wear or abrasion.

Here the key point is these examples are qualitative changes. Moreover, they can be measured in quantative terms such as time, physical appearance and dimensions as well as resistance to abrasion or deformation.

HCI ISSUES

Here the most salient point is that the most powerful or innovative tool is of little value if users find it problematic to use. Furthermore, some non-technical staff such as secretaries, personal assistants to directors or non-technical directors can influence the selection, use or even abandonment of tools if they find them difficult to use. Experienced engineers of high technical skills frequently overlook this point.

The GUI

The user requirements for an intuitive Graphical User Interface may depend on the levels of skills and background of the user. For example, a non-technical user may prefer a simple GUI that resembles the commercial packages that are synonymous with spreadsheets and word processing. A more technical user may focus more on the functional aspects. It may be the case that the more technically proficient user prefers to input on the command line and gain in speed and simplicity.

FINDINGS

The use of Simplex3 in the UK represents a step forward in simulation for smaller firms. It may encourage both researchers and engineers in industry to introduce this innovative simulation system. Certainly, the use of Simplex3 in the United Kingdom is less advanced than in Germany, the country of its origin. However, the work at present being done at the University of Manchester is attempting to introduce the use of Simplex3 to a wide range of users.
This may be seen as a step forward in both UK simulation as well as European and global simulation. This is because the use of Simplex3 in an English-speaking environment clearly opens up wider opportunities for dissemination to both researchers and industry.

Each of these features in isolation represents benefit but taken together Simplex 3 represents a considerable improvement for smaller designers and manufacturers seeking to update their engineering capabilities.

Perhaps, the benefit that would most appeal to the production manager is that the present production is unaffected. Production can continue as normal, yet potentially useful experience is gained to the benefit of future stability.

ON-GOING RESEARCH

A more extensive public library of models would be a most useful feature for both academics and engineers in industry. It would serve as a teaching tool as well as a quick starting point for engineers. Other research could focus upon human-computer interface issues such as the design for a graphical User Interface (GUI) as well as the requirements of different users from experienced engineers to senior managers from non-technical backgrounds. Research effort is also being directed towards software engineering to see if simpler and less powerful versions (“strip-out” or “light”) of existing powerful simulation tools confer benefits to the networks in smaller firms in terms of speed and stability.

An additional point under consideration could be the use of simulation and modelling software as tools for teaching in new courses. This would further disseminate findings to a wider audience because innovative ideas for courses are subject to scrutiny by engineers engaged in teaching, research and industry. Moreover, the students may apply their recently acquired knowledge and skills in an industrial environment.

CONCLUSIONS

The often highly idiosyncratic approach observed and documented in smaller firms may act as a barrier to the introduction of simulation tools and technology. Conversely, the small number of key workers and decision makers may aid the process of technology transfer because there are fewer people to win over. Furthermore, the smaller firms can respond faster to technical innovations because they lack the formalised hierarchies and defined procedures of larger firms. Indeed it is for these very reasons the larger firms employ them to carry out important design work, particularly for racing and special editions.

Perhaps the key to introducing simulation tools and techniques in smaller firms lies in the need for simplicity. This is to ensure a rapid adoption of the simulation tool and technology without the need for extensive specialist training. In effect, this implies a less powerful yet simpler to operate simulation tool. However, this could ultimately result in a fast and very stable tool that requires very little in terms of maintenance and support.

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BIOGRAPHIES

WAYNE HIGNETT is at present researching into Modelling and Simulation within a Concurrent Engineering context at the University of Manchester, Department of Computer Science. He has a Master of Research degree in Informatics from the University of Manchester as well as a Master of Science in Business Administration (Information Technology) and postgraduate qualifications in Education and Management from other UK universities. He has taught at a senior level in the United Kingdom and overseas for many years.

RICHARD ZOBEL graduated in Electrical Engineering from London University in 1963. His first experience of simulation was obtained during 1962-66 at Sperry Gyroscope whilst working on naval surface to air missiles, using mainly valve analog computers. His Ph.D., obtained in 1970 at Manchester University, concerned hybrid analog-digital computing. As Lecturer and Senior Lecturer he became involved in digital signal processing, instrumentation and design environments with special emphasis on the simulation aspects of real-time embedded systems. He is a former Chairman of the United Kingdom Simulation Society (UKSim), Former Secretary of the European Federation of Simulation Societies (EUROSIM), and is a European Director of SCSI, the Society for Computer Simulation International. His current research work concerns distributed simulation for non-military applications, model re-use, distributed simulation model databases, issues of verification and validation of re-useable simulation models and security for distributed simulation under commercial network protocols. He is now semi-retired but remains very active.