Fulmer Newsletter
contract research and engineering in materials technology
No. 42 June 1980

INDUSTRIAL TRAINING AND TECHNOLOGY TRANSFER

As an independent contract research and engineering organisation specialising in materials technology, Fulmer's facilities and expertise are increasingly in demand for industrial training purposes. Fulmer's specialism is in the provision of programmes tailor-made for the individual requirements of specific clients, rather than formal training courses. Of particular importance is Fulmer's flexibility in being able to accept trainees into laboratory-based development, testing and consultancy programmes, whilst at the same time providing in-situ technical assistance on the client's premises. Training programmes can be provided for the staff of manufacturing companies, and national and international Agencies, in the following areas of materials technology and engineering, particularly involving metals and plastics:

- Materials processing
- Laboratory management
- Project management
- Product development
- Materials testing
- Quality control procedures
- Technical services & consultancy
- Information services

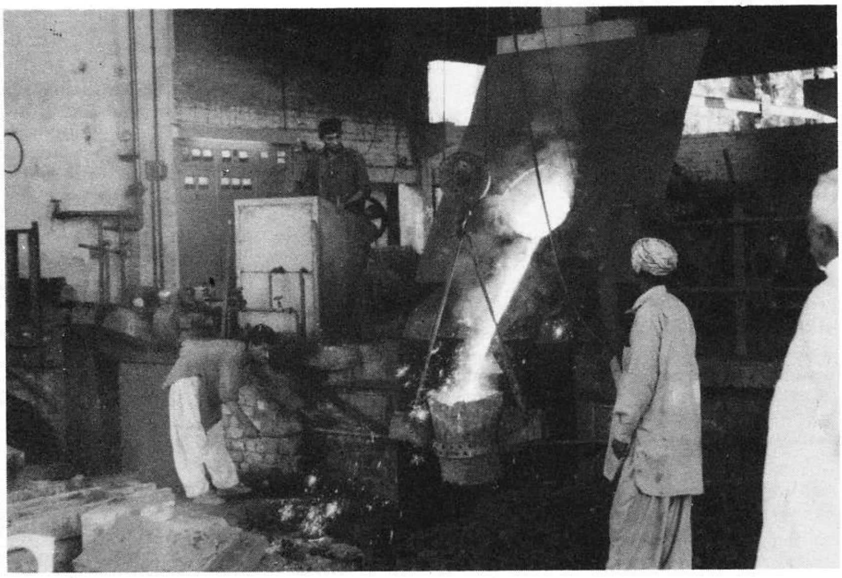
In addition to specific education programmes, many other projects undertaken by Fulmer and its Yarsley subsidiaries involve a substantial training element. For example, Turnkey Projects managed by Yarsley Technical Centre often require the client's injection moulding engineers to be trained at YTEC's Redhill laboratories. Following plant commissioning, YTEC's engineers also remain on-site for a further period of training.

PAKISTAN METALS ADVISORY SERVICE

With a population of around 72M in an area of 310,400 sq. miles, Pakistan is still essentially an agricultural country. Before partition in 1947 the limited amount of engineering which was practised on the sub-continent was located in what is now India. For centuries there has been a widespread cottage industry producing brass and bronze utensils but the absence of any substantial iron or coal deposits precluded any large scale metallurgical industries. After partition the need to develop Pakistan's own engineering industries arose. This occurred on a fragmented basis resulting in a large number of small steel mills, cast iron and bronze foundries, etc., all working in isolation. Without any strong links with an established metallurgical industry or of formal training routes these companies flourish mainly on the sometimes amazing ingenuity of their owners.

The growth of the Pakistan engineering sector, which is vital to the economy of Pakistan as a whole, depends on the metallurgical industries being in a position to provide the right type of products of sufficiently high quality. It is with this background that in 1975 the United Nations Industrial Development Organisation (UNIDO) appointed Fulmer Research Institute to set up a Metals Advisory Service (MAS) in Lahore. The aims and objectives of the project were defined as:

- Provide technical assistance to the metals industry in Pakistan with respect to improving productivity, profitability and quality of product.
- Provide information on new techniques where these are suitable for application in Pakistan.
- Examine and assess indigenous sands and clays for use in foundries.
- Establish chemical and metallurgical analysis facilities at the MAS laboratories to assist Pakistani companies lacking these facilities.



Monitoring cast iron melts at Rastgar Industries, Islamabad.

The project is administered by the Pakistan Ministry of Industries, which is responsible for the provision of buildings, and the local counterpart staff who will eventually manage MAS on their own. UNIDO provides aid in the form of specialised capital equipment (analytical and test apparatus, furnaces, etc.), the provision of external consultants (Fulmer) and the overseas training of local staff (mainly at Fulmer's laboratories).

During Phase 1 of the project, which ran from Autumn 1975 to the end of 1977, laboratory facilities including chemical analysis, metallography, a library and reprographic facilities were established next to the foundry in the Pakistan Industrial Technical Assistance Centre (PITAC), whose General Manager, Brigadier M.A. Faruqui is also the Director of MAS. Six members of Fulmer's staff visited Pakistan during this period to help establish the facilities, give on-site training, seminars, and advice to metallurgical companies on trouble-shooting, quality control, new processes, etc. Over 100 enquiries were dealt with for more than 30 firms. Five members of MAS staff received training at Fulmer on ferrous and non-ferrous foundry work, heat treatment, thermal analysis and documentation. These staff returned to apply their training to assist the Pakistan metals industries. Whilst most of the written enquiries are handled in English, MAS also produces a Newsletter and technical information in Urdu in order to disseminate the information right to the shop floor. The first edition of this Newsletter was published in August 1977.

By the end of Phase I the activities of MAS had grown to such an extent that UNIDO divided the project into four areas:

- Pilot plant iron ore benificiation, steel rolling, etc.
- Foundries, S.G. iron, sands and bentonites, analysis and testing.
- Cokeless cupolas.
- Direct reduction of iron ore.

Fulmer is continuing to give assistance on the general running of MAS, the analytical and testing facilities, and foundry processes including the exploitation of indigenous sands and binders, the introduction of S.G. iron and shell moulding and investment casting techniques. Phase II commenced in October 1978 but has been delayed whilst a most important development has had time to mature — the building of specially designed new laboratories on a new industrial estate on the outskirts of Lahore. MAS 'moved house' in February 1980 and Fulmer's team of six specialists has now re-started field service at the new laboratories. These staff will spend up to 2½ months each covering different aspects of the work and working to a completion in Autumn 1980.

The training programme also continues. The Chief Chemist of MAS spent 3 months at Fulmer last summer and two more engineers will also spend several months at Fulmer later this year. The staff of MAS has been built up to around two dozen, half of which are 'engineer' grade. The list of facilities is also now quite impressive and Fulmer wishes MAS a successful future in giving vital aid to the metals industries in Pakistan.

The new MAS foundry building nears completion

For further information, please contact:
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FULMER INDUSTRY — EDUCATION PROJECT

Through our engineering consultancy work at Fulmer we are very conscious of the need for industry to improve product design and associated with this, to encourage the employment of high quality technologists and engineers. Based on the premise that the training of engineers and technologists must start at school, a group of Fulmer staff has, over the last five years, been actively studying ways of improving the image of technologists and engineers by explaining their role to secondary schools and colleges. The reason for the work is threefold; firstly, the national concern at the present educational standards of students entering engineering subjects; secondly, the poor status of technologists and engineers in our society, and thirdly the need to attract more able children from both the arts and science streams into these subjects. Through the aid of a grant by the Industry-Education Unit of the Department of Industry, Fulmer has been able to continue the work and devise ways of forging stronger links between education and manufacturing industry.

Originally six schools reflecting different parts of the secondary education system in Buckinghamshire and Berkshire were selected to take part in the project. Local Education Authority advisers chose these schools for an in-depth study which had the following aims:

1. To demonstrate ways of encouraging children to become interested in applied sciences and engineering.
2. To encourage children to develop interests in manufacturing industry through school and company activities.
3. To influence the attitude of all teachers towards industry.
4. To help industry explain to children its needs and aims, and how it uses people.

A major ingredient in the project is to give students an opportunity to experience at first-hand the work of technologists and engineers. Parallel activities are used with teachers from a wide range of curriculum subjects.

Work in the classroom is spearheaded by three workshops or seminars which are of a highly participative and interactive nature: the first workshop entitled 'Technology is Fun' lasts approximately two hours and is aimed at boys and girls between 13 and 15 years. Using examples taken from the child's experience the group explores together the qualities and skills needed by technologists and engineers. Apart from the need to know the 'language' of the subject, which will include mathematics, physics and other natural science subjects, students consider qualities such as divergent and convergent thinking, logical and planning ability, social and communication skills and probably the most important quality of all, inquisitiveness. It is explained that no-one will have all of these attributes in full measure, but if we define technology as a 'problem solving activity aimed at providing a practical solution to human needs', then the student will understand the relevance of the qualities and skills outlined. Further it can be seen that technologists and engineers do not need to wear a boiler suit, flat hat and heavy boots, and carry a bag of spanners!

The workshop comprises experiments and project work related to everyday experiences. Familiar objects taken, for example, from food products and leisure items are deliberately considered to emphasise that such products present just as important technological problems as the design of a bridge or an oil rig.

In one experiment inquisitiveness is discussed by use of an apple suspended on a string; here is a situation many children have experienced in party games but have generally not observed closely. Experiments and observations are made on the period of swing in relation to changes in the length of string or alternatively reducing the weight of the apple by successive bites. From these simple beginnings the need for careful recording and communication of observations and results is discussed. This leads directly on to the value of mathematics in describing the observations quantitatively.

The ability to draw and to think in three dimensions is discussed. Paper chains and the associated Möbius strip are good media through which these ideas can be explored.

Exploring the Bernoulli principle in the 'Technology is Fun' Workshop

Tea making, a subject on which all British children consider themselves expert, is used to introduce the subject of planning. The group determine the fastest and most efficient way to make one cup of tea. This exercise gives an opportunity to explain the need for technologists and engineers to plan their operations in an optimum way.

Following a discussion of creative thinking, the students are invited to become 'technologists for a day' and help in the design of a consumer product. One group, for example, has designed a new product range for a chair manufacturer; the children are found to be very receptive to this exercise and can experience at first hand the excitement and challenge of industrial designers, technologists and engineers.

Finally, an 'open ended' problem is examined in groups to emphasise the importance of getting on with other people. In one case the students attempt to solve a structural problem relating to the design of an oil rig using tin cans and wooden slats, while another group consider the use of aluminium foil as the basis of a packaging material for eggs. By the time the workshop is concluded the children have seen at first-hand that technology is a problem-solving activity which usually results in the manufacture of a product.

A sequel to this first workshop is a seminar entitled, 'Why Do Things Look Like They Do?' In this session, which has been developed for 'O' and 'A' level students across the whole curriculum, the relationship between technology, market costs, human and aesthetic factors are considered in the development of a technically or commercially successful product. 'Wealth creation' as a cornerstone of our whole economy is considered. In one example students are invited to design a lady's travelling case, bearing in mind need, technology and cost considerations. The session is concluded with a critical evaluation of the different solutions offered by the design groups and the 'open ended' nature of problems is discussed.

A further seminar has been developed for Nuffield Science and Design Technology courses. This stems from the unfamiliarity of students and teachers in the methodology and approach to project work. The sessions allow students to explore, often for the first time in their academic lives, the different approach needed to solve open ended problems and the associated methodology; further direct parallels can be drawn between the approach needed with the development of an industrial product.

Participative work with teachers has also been pursued in order to introduce them to problem solving, and the project approach seen by people in industry. A course entitled, 'Science through Application and Resources' has been developed for teachers where topics relevant to the school curriculum are enriched by project work taken from industry, the world of work and other sources outside the school.

Technology courses can be one of the best routes for introducing students to the world of work. Schools are now using industrial problems for the basis of school projects at 'O' and 'A' levels. They include the development of a novel hearing aid and a device for monitoring laboratory fume cupboards. In order to carry out these projects successfully the students need to visit the company and personnel from the company require to visit the school; this leads to real and permanent links between students and professional engineers.

Students testing the design for a packaging material to be used with eggs

Another part of the Fulmer project has been to assess the value of teachers spending three weeks in industry. In one case a design teacher worked on industrial problems in two separate companies. As a result of this exercise firm links have been established between the school and the respective companies, ranging from the offer of staff and facilities for project work through to development of company products as part of school projects. Industry and education links need not be confined to the technology and science departments. The whole school can use industry and the world of work as a 'Text Book' to enrich the standard curriculum subject. For example local industry can provide material for geography, history, language and religious education subjects and in the process help industry to understand the work of education. Company visits can be of great value if they are topic based and planned beforehand in co-operation with the company. At the present time the 'Text Book' is being developed for use by students and teachers through the whole secondary education system.

The Fulmer Industry Education Project started with a small group of schools in order to check the validity of this approach to linking schools with industry. In the course of one year Fulmer is now actively using parts of the programme in over 25 schools and has given advice on the project principles to more than 50 others. In the future we expect to continue work in depth in the original project schools, who will act as a research base for industry-education links and make the work of the project available to schools in other parts of the country.

As a nation we have a duty to explain to children still at school the essential role that industry plays in providing the wealth on which the future of this country depends. Industry needs many more resourceful and talented engineers of all types to do this, and we must therefore encourage able and enthusiastic young people to look towards industry for a satisfying and rewarding career: one which will provide them with opportunity, challenge, financial reward and the status that technologists and engineers deserve.

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TRAINING R & D MANAGERS IN PROJECT PLANNING

the past eight years Fulmer has been running a successful series of seminars on Project Planning and Control for Research Managers, based on the RPD system developed at Fulmer.

This article explains the background to these seminars and discusses the lessons learned in running them. Current developments at Fulmer in this area are also described.

Origins of RPD

RPD (originally an acronym for Research Planning Diagrams) was developed about ten years ago in response to Fulmer's own project planning needs, particularly the need to present project plans clearly to potential clients.

Project Network Analysis techniques such as CPM and PERT, despite their success in planning well-defined engineering projects, were found to be inadequate in R & D. They do not make provision for uncertainty of outcome and, although they can be generalized to do so, the resulting complex notations are confusing; as an aid to communication they are self-defeating.

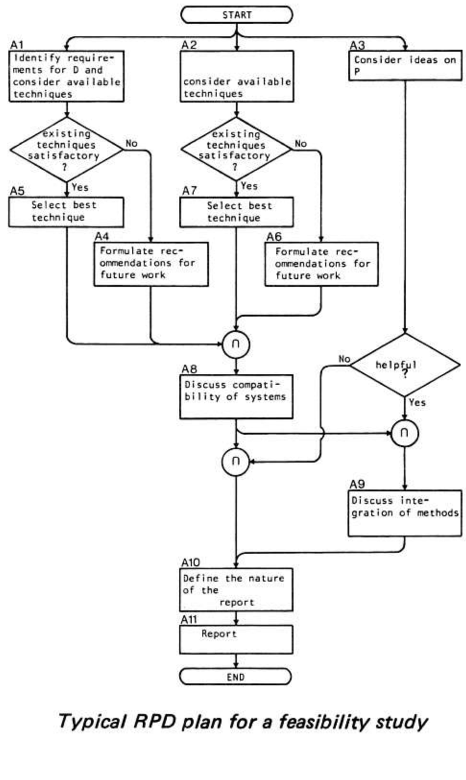
It was soon realised that a clear notation for R & D project planning must emphasize the contingencies that can arise and the alternative courses of action which may be needed. RPD notation was therefore based on computer programming flow charts, with their natural emphasis on the logic of alternatives.

Quantitative analysis of RPD plans is also different from that of conventional networks. Traditional network concepts such as that of the critical path are retained but the main feature of RPD analyses is that answers to questions of project cost, benefit and duration are all given in probabilistic terms.

The Seminars

The RPD seminars each take the form of an interactive discussion group of between 10 and 25 participants. RPD methods are explained in the context of network analysis and their applications in R & D management are discussed. About 70 seminars have been held over the last eight years. Of these, rather more than half have been two-day open seminars with participants including scientists, technologists and all levels of R & D management. Representatives from large and small companies and from Government normally attend and the specialisms of participants usually cover all disciplines from engineering to the life sciences. The remaining seminars have been organised in-house for large companies and Government establishments.

Naturally this series of seminars has exposed RPD concepts to a great deal of constructive criticism. It is instructive to see how the early ideas have evolved in response to this discussion and as a result of planning experience. We now describe this evolution of ideas, first for the descriptive uses of RPD and then for quantitative RPD analysis.



Typical RPD plan for a feasibility study

Descriptive Uses of RPD

The original objective in devising RPD was to provide a diagrammatic representation of project plans as an aid to clear thinking at the planning stage and to communication and discussion of plans. This remains the most successful and most important aspect of RPD.

Experience has shown that RPD provides the most flexible and powerful notation available for contingency planning. The exercise of drawing the plan gives a major improvement in the clarity with which problems and opportunities can be foreseen.

The notation has been found to be nearly self-explanatory so that little or no training is required to interpret RPD plans.

One aspect of qualitative planning which was not fully appreciated at first is the need to keep plans simple. In R & D no matter how much time and care is devoted to a plan, unforeseen contingencies are likely to render it obsolete before the project is complete.

If a scientist has devoted too much time and effort to planning he will be reluctant to abandon an obsolete plan and, when forced by events to do so, will be disillusioned with the planning process. The simpler a plan is, the less pain is caused by scrapping it. Simplicity also enhances the use of RPD for communication. It requires that plans be constructed in an hierarchy. A simple master plan invokes sub-plans, each of which is also simple, and these in turn can also invoke other sub-plans if necessary.

Another advantage of planning in an hierarchy of simple plans is that the construction of each sub-plan can be made the responsibility of the man who will implement it. This has been found to be important. It is not realistic to expect scientists and technologists to carry through plans which are not their own.

The quest for simplicity always involves some over simplification and there is always a compromise to be found between realism and economy in drawing plans.

Once again rapid obsolescence of plans in R & D projects argues in favour of simplicity and approximation in representation.

Quantitative Uses of RPD

Critical path method is essentially a scheduling tool. That is to say, it is concerned with the provision of resources, at the optimum time for each individual task in the project. In the presence of uncertainty any schedule must be probabilistic and RPD provides a powerful analytical tool for the generation of probabilistic schedules.

In practice, however, probabilistic scheduling has hardly ever been used in full. Looking forward from the start of an R & D project, the schedule becomes increasingly fuzzy. Some tasks are downstream of loops in the plan and their start times are therefore very vague. Other tasks may not be needed at all. RPD can provide full probabilistic data on such activities but no-one yet knows how to use it effectively! The main virtues of RPD in scheduling seem to be in the identification of tasks likely to result in resource clashes and in summarizing overall resource levels in a project or multiproject situation.

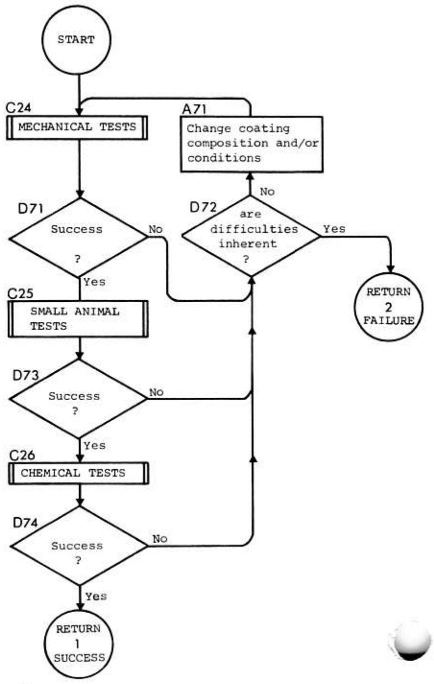
Much more successful is the application of RPD to project appraisal. Most R & D managers appreciate that single estimates of project duration and cost are less useful than answers to questions such as 'What is the chance of finishing the project within 18 months?' RPD analysis provides answers to these questions.

In fact RPD provides the most convenient representation for full probabilistic cost benefit studies. RPD analysis gives the expected utility of a project: its true figure of merit for comparison with other potential investments.

The third quantitative use of RPD is decision analysis. Rival options can be represented and analysed in a more powerful and flexible manner than in conventional decision trees.

More than half of each seminar is devoted to quantitative methods. This is essential since the underlying concepts of probability, utility and risk are new to many managers and scientists, and are controversial to others.

Once again much can be achieved by the analysis of very simple plans, using RPD at a tactical level to decide which experiment to do next.



Typical RPD subplan in an experimental investigation

The seminars have been found helpful in elucidating participants' attitudes to R & D. Rules of thumb about priorities and about the trade-off between project cost and duration are given a precise formulation.

At any particular point in a project a researcher may need to decide between trial and error, explanation-seeking or some systematic survey approach. RPD provides a framework within which these questions can be discussed and often resolved.

Many researchers and managers who have participated in the seminars find that RPD is a valuable descriptive tool for planning. However, as yet relatively few have used its full quantitative power. They find among their colleagues some resistance to the underlying statistical ideas. Another problem is that the existing computer implementation is rather unwieldy and difficult for the layman to use. However this situation is changing. There is currently a strong trend in statistics in favour of the Bayesian methods on which RPD is based and increasing numbers of researchers have encountered these ideas. Also, now that we have identified the main success areas of RPD analysis, smaller, friendlier RPD programs will soon be available for use on today's smaller, friendlier computers. We now expect major progress in the quantitative use of RPD.

Current Developments

Fulmer is in the forefront of the development of the new approach to uncertainty of which RPD is just one aspect. New methods of data representation and analysis are being developed with emphasis being placed on dealing with very high levels of uncertainty in physical, economic and other quantities. These methods are collectively known as AUQ (Analysis with Uncertain Quantities) and are complementary to RPD. The first AUQ seminars will be held in 1981.

We are also seeking to extend the use of RPD beyond the R & D field into application areas such as: reliability analysis, strategic decision analysis, optimization of procedures, quantitative systems analysis, technological forecasting.

Alongside these development areas, RPD seminars will continue to be held for R & D managers and scientists. Dates already scheduled are:

2 E.500/89 27th, 28th October 1980
2 E.500/90 13th, 14th November 1980

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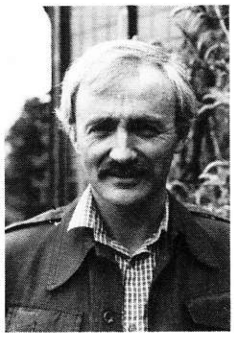
SABBATICALS AS A MEANS OF TECHNOLOGY TRANSFER

Communication is the key to successful technological transfer and a well-established procedure to encourage this is by means of sabbatical leave.

Fulmer is pleased to welcome Mr. Dan Phelan of the Caulfield Institute of Technology, Victoria, Australia, to our Stoke Poges laboratories. He will be spending much of a six months sabbatical leave working on failure investigations and helping to up-date the Forming of Metals section of the Fulmer Materials Optimizer. Mr. Phelan has a degree in physics and an honours degree in metallurgy from Melbourne University. After three years with the Victoria railways employed as a metallurgist engaged in NDT and failure investigations of rolling stock, Dan Phelan joined the Caulfield Institute in 1970. Since then he has been lecturing on engineering materials to mechanical and electrical engineering students.



FULMER MATERIALS OPTIMIZER

The Materials Optimizer is a materials information system established in 1974 by the Fulmer Research Institute for the selection and specification of engineering materials.

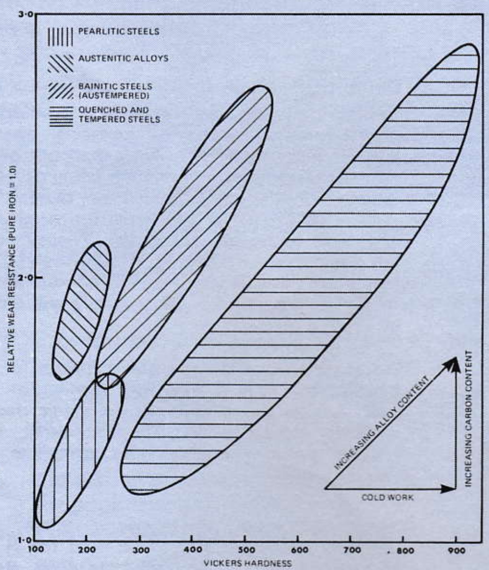
The system contains readily assimilated information on the performance, current costs and related component manufacturing processes of metals, plastics, and ceramics; plus an unbiased method of selecting the optimum material for a given application. In the current industrial economic climate of rising materials and manufacturing costs, the Optimizer is an invaluable aid to company profitability.

The system is designed to enable a rapid comparison of materials which, after appropriate processing, can compete for the same application. Presentation of data is in tabular or graphical form and is arranged in a progression of increasing detail (to enable the user to review candidate materials and proceed rapidly to the relevant information for the application).

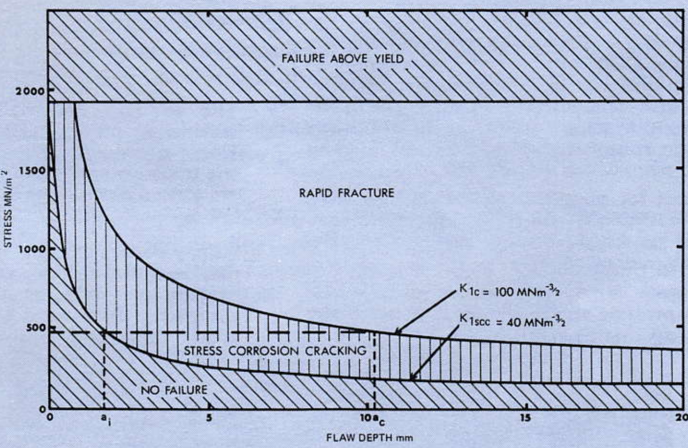
Following the success of the first edition of the Optimizer (over 400 copies were sold to companies and organisations throughout the world) Fulmer have recently revised the information contained in the system to produce the second edition, which is now available. The Optimizer system corresponds to the distillation of the equivalent of over 50 man years' experience in the use of engineering materials by Fulmer's staff and associated consultants.

The Optimizer has proved to be of great benefit to designers, production engineers, processing managers and all those whose job it is to gain maximum value from engineering materials. It has also found wide acceptance as a teaching aid at Universities and Technical Colleges, bridging the gap between theoretical knowledge and practical engineering. The new edition comprises four volumes:

Volume 1	Part 1	Product Design Analysis
	Part 2	Comparison of Materials
	Part 3	Product Manufacturing Processes and Costs.
Volume 2	Part 1	Characterization and Specification of Ferrous Metals.
	Part 2	Characterization and Specification of Non-Ferrous Metals.
Volume 3	Parts 1 & 2	Characterization and Specification of Non-Metals (Thermoplastics, Thermosets, Elastomers, Ceramics, Foams, Composites).
Volume 4		Selection of Materials for Specialist Applications.



EFFECT OF STRUCTURE, HEAT TREATMENT AND ALLOY CONTENT ON WEAR RESISTANCE OF STEELS



RELATIONSHIP BETWEEN $K_{1c}K_{1scc}$, STRESS AND FLAW SIZE

The Optimizer is printed on loose-leaf pages (as illustrated above) and is contained in plastic covered ring binders to facilitate updating which includes:

(i) Complete review of costs of materials at least once a year.
(ii) Information on new materials and processes.
(iii) Refinement and revision of data.
(iv) New sections for Volume 4.

The basic cost of the system is £500 per copy, which includes one year's updating; prices for individual sections or for multiple orders can be given on request to the Editor, Dr. M. A. Moore, Fulmer Research Institute Limited, Stoke Poges, Slough, SL2 4QD.
(Tel: Fulmer (02816) 2181 : Telex: 849374)

STOP PRESS!

A date for your diary:

Thursday, 2nd October 1980

An Open Day at Fulmer on Product Development, Liability and Testing.

Further details will be available in the September Newsletter.

Register of Consulting Scientists and Contract Research Organisations

The 5th edition of the Register is now available. For further details please contact:

Mr. E. A. G. Liddiard,
c/o Fulmer Research Institute Limited (Telex: 849374)

POLYMERS WHICH REACT WITH STEEL

Yarsley Research Laboratories at Ashtead have launched a two-year research project initially sponsored by the Department of Industry and the Ministry of Defence aimed at developing new anti-corrosive coatings which can be applied to steel under wet conditions (or even under water). The two main areas of application envisaged are for marine finishes and maintenance coatings.

In the marine environment electro-chemical corrosion (particularly if it is allied with cathodic protection) produces highly alkaline localised conditions which make most conventional paints (alkyds, drying oils, etc) unsuitable as anti-corrosion media for ships' bottoms. The conventional phenolic-based anti-corrosive coatings (e.g. Admar 173, Anti-corrosive 655, etc) have been largely replaced by new types of 'high performance' protective systems resistant to alkaline conditions such as epoxies, vinyls and chlorinated rubber. These depend on their 'barrier' properties (i.e. high thickness, low permeability) for their protective qualities, but they have to be applied to specially prepared grit-blasted dry steel substrate for adequate performance. In fact, the breakdown of any anticorrosive paints, whether on ships or steel structures exposed to corrosive environment, is usually blamed on the surface preparation.

There has always been a need, therefore, for a paint which is more tolerant to the surface condition, and although some work has been done in this area, the paint manufacturers usually specify stringent surface preparation to safeguard their own position; (it is interesting to note that the 'high performance' paints are in fact less tolerant to surface conditions than the older types, due to their 'hydrophobic' character).

The concept (Patent Pending) behind the present project is to introduce specific 'chelating' groups into the present 'high performance' resins, so that the corroding steel will react with the polymer, thus displacing water and removing ferrous/ferric ions from the surface. This initial reaction will also take part in a curing mechanism, which to some extent will rely on the presence of water to initiate the reaction sequence.

The project is planned as a two-year feasibility study in the first instance, the first year devoted to an exploration of the wide area of co-ordination chemistry as applied to polymer-metal interactions, and the second year to the evaluation of reactive polymers in coatings applications (i.e. anti-corrosive primers, underwater coatings, marine finishes, etc). The work will involve a thorough search of the patent and other literature, synthesis of new 'coating-type' polymers with specific reference to iron chelating groups, and formulation and evaluation of coatings based on these polymers.

The 'feasibility' of this idea has already been demonstrated on a model polymer coating applied to wet steel and exposed to 2,000 hours salt-spray test.

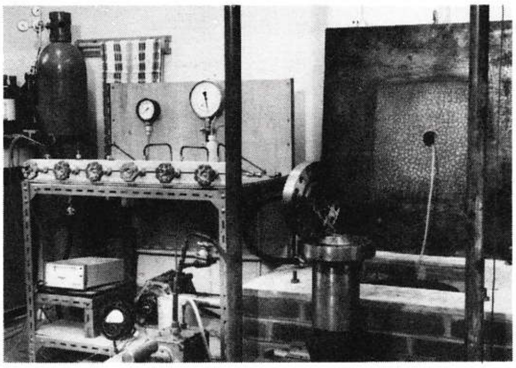
Although the primary objective of this work is to develop new anti-corrosive one coat systems for steel, other potential applications can be envisaged such as plastic/metal laminates, adhesives, re-inforced composities, etc., where specific interaction between metal and polymer should improve the bond.

Participation in this project by industrial organisations will be welcomed and enquiries are invited. For further information please contact:
Mr. W. Mikucki, Yarsley Research Laboratories, The Street, Ashtead, Surrey, KT21 2AB. (Tel: Ashtead (03722) 76391 : Telex: 8951511)

HYDROGEN STORAGE AS METAL HYDRIDES

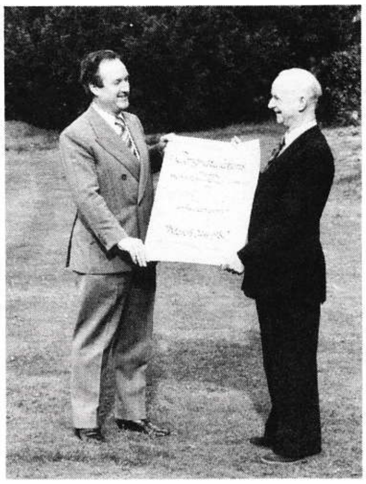
The use of metal hydrides in the storage of hydrogen is of considerable technological interest, particularly with regard to their possible application in motor vehicles fuelled by hydrogen, where the benefit of the high energy density of hydrogen is attractive. However, because many of the metal alloys, e.g. iron/titanium, considered for hydrogen storage have relatively high molecular weights, the amount of hydrogen, and hence energy, storable per unit mass of alloy is quite low – generally no more than a few per cent by weight.

Based upon ideas of Professor F.M. Page and Dr. J.D. Miller of the Chemistry Department of Aston University, and in collaboration with an industrial company, Prodia (UK) Ltd., Fulmer are currently investigating the hydrides of a number of potentially attractive, novel, light-weight hydrogen storage materials. A particular group which has shown promise is based upon boron, where it has been found that metal/boron mixtures, when hydrogenated under suitable conditions of temperature and pressure, form metal borohydrides e.g. MBH_4, which subsequently, under different conditions, decompose with the regeneration of hydrogen. The investigations are being made using an internally heated, stainless steel autoclave, capable of maintaining hydrogen pressures up to 120 atmospheres.



For further information please contact:
Mr. C. Hayman, Fulmer Research Laboratories Ltd.
(Tel: Fulmer (02816) 2181 : Telex: 849374)

"HONOURS FOR ...."



DR. W. E. DUCKWORTH

On 24th March 1980 our Managing Director, Dr. W. E. Duckworth, was received into the Fellowship of Engineering by H.R.H. the Duke of Edinburgh. The Fellowship was inaugurated three years ago under the inspiration of Prince Philip to be of equivalent status with the Royal Society. To commemorate the occasion Dr. Duckworth was presented with a congratulatory scroll from the Fulmer staff by our Chairman, Sir Ieuan Maddock, himself a Founder Fellow of Engineering.

MR. G. B. BROOK

We are also pleased to report that Mr. G. B. Brook who is Director, Metallurgy, of Fulmer Research Laboratories, has been invited to receive the award of Honorary Degree of Master of the University of Surrey. This is in recognition of his work with the University over many years as an Honorary Reader.

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