Proceedings of the

8th Annual British Robot Association Conference

Edited by: J.A. Collins, OBE

14-17 May 1985

Birmingham, UK

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ROBOTIC TRENDS

APPLICATIONS, RESEARCH, EDUCATION AND SAFETY

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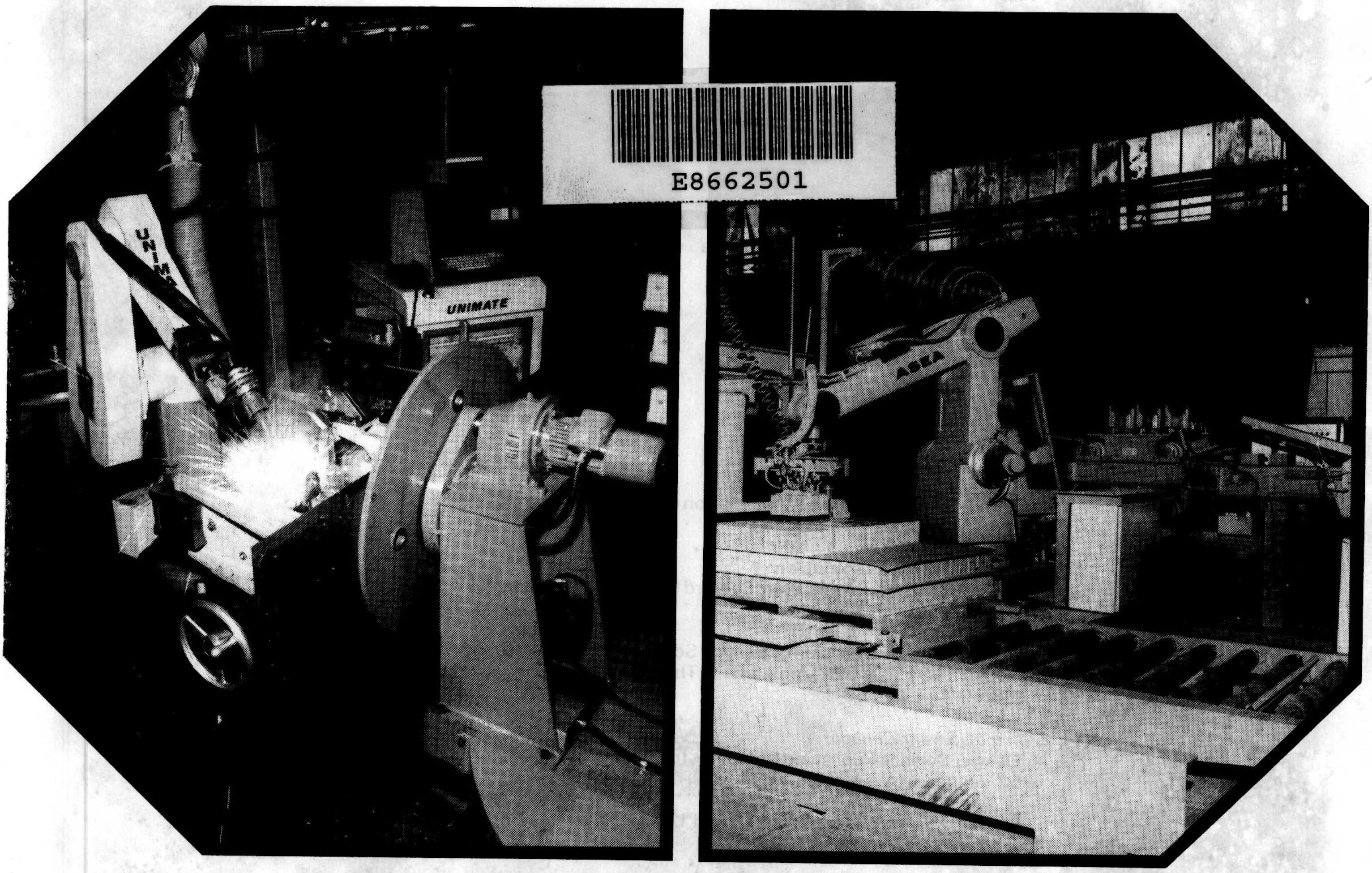

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FOREWORD

by J. A. Collins, OBE
President of the British Robot Association

IN welcoming visitors to the 3rd Automan Exhibition on behalf of the BRA Council I am particularly encouraged that the scale of the event continues to increase. Despite the continuing difficult situation for manufacturing industry the interest in seeking new and more efficient methods of production remains strong.

The number and variety of exhibitors has again exceeded the expectations of the Council and the combination of the Summit Conference and Automan '85 gives an opportunity unexcelled in Europe to date for those willing to pursue the potential of new manufacturing technology for their business.

However it must be said that the BRA statistics for 1984 revealed, as in 1983, that despite a continued UK growth in the number of robots in manufacturing Britain's major European competitor, West Germany, is still investing numerically at twice the UK rate. The same statistics also revealed that the European market for robots is the second largest in the world after Japan, which because of our current tendency to consider developments in a national context is not often visible and should be of considerable encouragement to those in the supply industry.

The exhibition and the conference places the robot in the wider context of Advanced Manufacturing Technology and it is important that their role in this regard be seen in perspective. They are an integral part of such systems and are the means by which the degree of control normally associated with the sophisticated machine tools is extended beyond their boundaries into wider operating environments. In this sense the Council views the robot as not so much a peripheral tool as a core facility in flexible automation.

There is no doubt that we shall witness consolidation in the manufacturing field and an extension of the potential for flexible automation based upon the in-house experiences gained by these major corporations.

However, such is the rate of change that there remains adequate opportunity for entrepreneurial entry and the market has never been more available to new ideas as the exhibition will bear witness.

In preparing the conference it has been one of the aims of the organisers to link, as directly as possible, the content of the individual sessions with the exhibition so that delegates may direct themselves to tangible examples of ideas which have stimulated their interest from the speakers.

The Council has every confidence that the combination of five conferences covering the whole range of advanced manufacturing, coupled with the most extensive range of eqipment on one site, will provide a unique opportunity for everyone concerned with the maintenance and growth of a viable manufacturing industry in the UK.

THE CHALLENGE

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Late papers

Keynote paper: The reward

J. A. Collins
President of the British Robot Association and TI Domestic Appliances, UK

The 3rd Automan Exhibition run in conjunction with the Summit Conference '85 represents an ideal opportunity to review the current state of the art in the industrial application of robotics, representing, as it does, tangible evidence of the continued growth of the robotics industry in the UK. Since the inception of the BRA 8 years ago when the total number of robots in use throughout British industry was less than 100 we have continually increased to a level of approximately 2,000 units representing 4,000,000 equivalent man hours per year in industrial usage. Against this background it would appear unnecessary to debate whether robots have a future. Nevertheless, there is some question as to whether, in their present form, they can continue as a separate entity in the armoury of manufacturing industry equipment. Elsewhere in this Summit Conference there are papers assessing the state of the art with regard to diverse specific applications, but here, I shall attempt to put into a wider context the robot activities and consider its role from the viewpoint of manufacturing automation overall. I shall try to address the questions 'have robots a future, and if so is it of sufficient commercial value to make the considerable effort of continued development worthwhile?' In other words what can be the possible rewards for those considering either using or making robotic devices? Does this exhibition represent the beginnings or the end of the robot era?

In the historical context, the history of the industrial robot is the classic one of most new technology developments in that it started as a "solution seeking a problem" created by entrepreneurs who were usually unconnected with the existing methods of manufacture. They achieved results initially by adapting existing technology; in this case the conjunction of mechanical actuators and simple electronic controls, in forms which were adaptable to some of the simpler tasks carried out by human beings. This initial anthropomorphic connection has importance in considering the future developments as, both from the conceptual stage to the implementation by production engineers, it has long been a stumbling block in considering what the true significance of robotics are to the manufacturing processes. The measurement of its performance technically and its economic justification have both been hampered by comparison to human operators.

From these beginnings the technical developments have moved from the simple to more sophisticated examples of control and in so doing have widened the range over which the robot is competent to operate in a production mode. Two considerations have governed this development, namely the desire to achieve flexibility between differing tasks, coupled with the achievement of a greater degree of accurate control in the movements of the system. These requirements have led to the development and adaptation from other fields, of equipment to achieve an appropriate degree of sensory capability, in vision, tactility and mobility. These advances have been greatly assisted by parallel developments in computer technology resulting in a dramatic reduction in both the cost and physical size of comparable computing power. Thus we are today capable of attaching to dynamic systems 'in situ' a computing capacity originally capable only by main frame computers. However, throughout this second generation development of robotics the problems addressed have almost invariably been those arising from the design of products for manufacture dependent on manual intervention. It is only recently that a worthwhile effort has been addressed to creating products designed for manufacture by automation the significance of which is extremely important in considering the future possibilities for industrial robotics.

Simultaneously there has taken place developments in other major areas of manufacturing processes, notably machine tool control and adaptability. These have aimed at extending the high degree of control from traditional areas e.g. machine shop to other major processes such as sheet metal formation and to make use of the techniques of machine control in peripheral activities such as component transfer between machine stations or metal forming operations. A whole breed of pallets and A.G.V's have resulted from this work giving rise to the view that such systems have outdated the conventional robot as a handling device.

But in the machine shop the robot itself has been developing from a stand alone mechanism introducing components into the control environment of the machine tool frame to that of a device capable of extending this control into the surrounding environment. An example of this can be seen in the development from the Fanuc Polar Co-ordinate 'stand alone' robot to the retrofitted robot arm which makes use of the existing Fanuc control system already driving the machine tool.

Viewed against the background I have described, it is possible to consider that a crucial factor in the future advance of robotics is that it can be seen as moving from a peripheral role to a core position in manufacturing systems development.

To date, the development of flexible automated manufacturing systems has been restricted to those areas where effective individual machine control has already been achieved but with the advent of more sophisticated robots the evidence of increasing involvement in the assembly area is a key to the role that they will ultimately play. In assembly tasks, the human attributes of dexterity of movement, flexibility of use and application of judgement have been essential features for success. It has been accepted that the accompanying shortcomings of fatigue, error and environmental limitations are the price to be paid in production and quality shortfalls. The fundamental problem currently is that the manual intervention in the manufacturing process is most evident in the assembly area and to automate it will require in part the development of a total environment conducive to the robot. Whilst it is still attempting to emulate human capabilities it can never be wholly effective. This requirement is encouraging the development of 3rd generation robots which will most likely display a different configuration in keeping with this role. Examples of this may be seen in the IBM or ASEA gantry type robotic structures in which the total volume within the confines of the frame is within the system control parameters.

This 3rd generation of robotic tools opens up possibilities in areas outside of manufacturing industry where the imprecise nature of the activities is even more pronounced. In the preparation of food, the application to medical operations the handling of textiles, mobile security, and even the personal domestic robot, opportunities are being explored and showing signs of attractive marketable possibilities.

The foregoing has indicated the growing range of existing and new application areas and it is these that are attracting to the field a new breed of robot manufacturers. The days of pioneering by entrepreneurs are long past the consolidation period of a limited range of proven machines has led to the gain of 'hands on' experience and this has now brought forward the major corporations to combine their in-house purchasing strength with the requirement of diversifying from their traditional fields of activity. Notable in this field are the GE/Hitachi, GM/Fanuc combinations in the US together with Volkswagen in West Germany each of which has seen that by exploiting the experience they gain by usage internally, they can produce newer and better robots for world markets.

Another interesting example is IBM who perceive the adaptation of their computer skills to manufacturing being achieved by the addition of articulated systems capable of acting under computer control. In addition to these new entrants some of the early major company investments are still proving to be worthwhile. Companies such as ASEA with an turnover of £85m from robots in 1984 having been achieved despite the bulk of their business being through exports.

Thus we can see that the robot, far from being submerged in the new manufacturing systems is an integral and growing part of their future development and the greater involvement of international corporate bodies will speed up the process even further.

Against this background it is unfortunate that UK Ltd, whilst increasingly involving itself in the use of robots, has so far failed to become engaged in their development and manufacture on a major scale. This would appear to be an opportune moment to broaden our vision and consider what prospects there may be for participating nationally in the changes which are taking place. Despite the advances to date it remains a fact that for the majority of small companies robots remain too expensive, too unreliable and too complex for their ready acceptance as a workable automation tool. The ability to exploit our inherent manufacturing skills by parallel product and robot redesign creating a harmonious design for manufacture is well within the capacity of our engineering capability. By such means the concept of the fully automatic flexible manufacturing unit can be achieved. Anyone who has seen the results of low budget graduate projects in robotics must be aware that the difficulty of achieving radical improvement is more apparent than real. For example the Computer Society competition in 1984 attracted 24 polytechnic institutes each attempting to create a voice controlled industrial robot for £3,000 capital expenditure. The resulting seven finalists gave impressive examples of ingenuity in conception combined with skillful implementation. There would appear to be adequate finances available as we are repeatedly told that venture capital is frustrated by the lack of suitable projects and not vice versa, and the witness of the British Telecom share issue revealed that there was an overwhelming response from the public to what they considered to be an ongoing new technology investment.

To harness these factors is the challenge that faces us to day and in order to do so we will have, initially, to overcome what appears to be the most difficult stumbling block of all, namely that co-operation of effort between groups of companies and academia on developments prior to commercial exploitation must be achieved in order to produce the results that we urgently require. This is against a background in which UK industry is increasingly moving from being an innovative manufacturing society to copying or licensing other peoples' innovations and ultimately selling under UK trade names the output of foreign companies imported into this country.

In addition to the proven record of Fanuc, Hitachi, etc. in robotic development, the acceptance by such international companies as General Motors and General Electric, that they must participate directly in this field is surely convincing evidence that the future rewards will be real.

At the same time, doubts are raised in the UK that 'robotics has peaked' or 'has been oversold'.

What we are witnessing is a crucial period of change, during which the shortfall of technical achievement, for reasons given above, is being evaluated by manufacturing engineers with increasing first-hand knowledge of application experience. The UK is not lacking in this information nor, as I have shown, by innovative skill to make radical re-assessments of both cost and technical criteria, particularly in future engineers. If we should fail to create from this an opportunity to become a substantial world force in this growing technology then we shall deserve to become mere lexicographers, reduced to inventing suitable English names for foreign made products.

Process reflections, 'A forward look'

M. P. Kelly
Chairman, BRA Management Committee and BL Technology Ltd, UK

The use of robotics as a strategic tool for the flexible automation of a range of manufacturing processes is well established. The benefits are also well established, and have been analysed and discussed in depth over the last five years.

What is perhaps less well understood are the constraints and failures that some authorities are suggesting have limited the applications of Robotics to date, and predict may well limit their further application in the future.

This paper reviews, from a user perspective, some of the better known process applications, attempting to remove the constraints, and suggests some solutions that may accelerate their future application.

INTRODUCTION

The development and application of Advanced Manufacturing Technology is often referred to as the second Industrial Revolution, and is perceived as being critical to the survival of Manufacturing Industry. At the heart of AMT is the robot, both as a technological tool, and as an obvious and potent symbol. Consequently, the successful application of Robotics is a key element of AMT, and the fortunes of Manufacturing industry within the UK. Conversely, we must not fail, and whatever limitations or constraints that are associated with robotics must be understood and removed.

However, the use of Robotics to date to automate manufacturing processes can be perceived from two apparently opposing viewpoints.

One opinion claims robotics to be a success story, achieving the advantages of productivity, quality, working environment etc, that are frequently quoted as the benefits to be achieved from Robotic Systems.

The opposing view quotes predicted growth rates that have not been achieved and suggests that the application of robotics has been constrained by such factors as cost, unacceptable cycle times, complex systems, safety problems, product design limitations, human factors, etc.

This paper will concern itself with the latter, somewhat negative view, attempt to establish the validity of these claims, and if valid, propose some solutions. The subject will be examined from a range of perspectives such as Human Factors, The Robot, The System and The Product.

It is worth noting at this early stage that Robotics is a relatively new technology, and limitations are inevitable. These will be removed ultimately by user pressure, competitive advantage, acadaemia, and by simple engineering ingenuity and inventiveness. The solution to todays problems will be taken for granted by the next generation, even though these solutions are currently perceived as the leading edge of the technology.

The advantages of today's Robotics Systems outweigh any limitations and have already made a positive contribution to manufacturing next generation technology and attitudes will make a truly dramatic effect on society.

HUMAN FACTORS

It is probably the effect of Human Factors and attitudes that have the greatest influence on Robotics, more so than technological development.

Equally, the user is the key. The user must clearly understand why he wishes to implement robotics, have clearly stated objectives, and above all else, a plan. The application of robotics must be seen as part of a structured technology plan which has senior management commitment and support. Conversely, it is the unstructured use of robotics, with no clear understanding, or worse still, being applied for the wrong reasons, with moving targets or objectives, which probably accounts for the failure of a large number of applications. It must be realised that the failure of one single project will inhibit the application of many other potentially successful applications. Stories of the failure will circulate, confidence will diminish and the degree of risk will be exaggerated.

The degree of risk can be minimised by ensuring that initial applications are kept as simple as possible. For example, in developing an arc welding cell, it is sensible to phase the system so that initially the robotic system operates on a fixed component, and a programmable manipulator added as a second phase, and the application of sensors as a third phase.

Also an analysis of what the "competition" is doing will minimise risk, and perhaps most important there must be an awareness of what the proposed system is both capable, and incapable of doing.

Skills, to develop, instal, and maintain are vital, and in the case of process applications, an intimate knowledge of the process is of equal importance. Frequently an experienced Process Engineer, or even an operative are the best people to involve in a Process project. The skills of the robot technologist are not enough, the ingenuity of the applications engineer is equally important in interfacing the manufacturing process to the robot system. There is already a shortage of qualified engineers and technologists, and a concern of the future is the present rate of technological development. Systems solutions to manufacturing and process problems are beginning to become available that may well be ahead of the user's ability to implement.

Finally, as far as the user is concerned, the system objectives should be audited against the system performance. Often the full potential of the system is not being achieved, and it is the analysis of this which will lead to other, perhaps more successful, robot applications.

The Robot Vendor has an obvious role to play in the positive application and growth of Robotics. There is evidence that some high risk process projects have been promoted, mainly on the back of the successful automotive spot welding application, and pressures by the vendor to maintain this level of sales. This is counter productive, and every effort should be made to encourage a partnership between the vendor and the user towards committed, responsible proposals.

There is an understandable lack of knowledge by the Robot Vendor of the process under review. It is unreasonable to expect the vendor to have an in-depth knowledge of a range of processes, as distinct from assembly, where a specific skill level is required. Again a partnership with the user is required, to complement the user's knowledge of his own pressures and products. Ultimately, however, the vendor must have a turnkey responsibility for the total system, from robot, to process equipment, to manipulator to the system control and hierarchy.

Acadaemia is an important contributor, and will provide the basis of the solutions associated with the robot's limitations. Developments in sensors, high level languages, artificial intelligence, intelligent grippers and process tools are all vital. However, again it must be a partnership with Industry to ensure the work is implemented, to avoid duplication, and perhaps on occasion to encourage acadaemia to allow their work to leave the laboratory and be exploited in Industry!

THE ROBOT, THE SYSTEM, AND THE APPLICATION

The critics claim that robots are too expensive, too slow, too complex, and in the same breath, too simple!

Certainly the financial equation can be difficult, particularly if the project aims to meet conventional payback criteria by simple productivity savings. Both sides of this equation require a deeper analysis.

The cost of the system can be a constraint, particularly when considering the total system cost, which will probably increase the cost of the raw robot by a factor of two or three times. Robot prices have remained fairly stable, have not increased over the last few years, and in some recent cases, shown signs of cheaper machines appearing. The user should consider his selection of robot very carefully, it is pointless selecting an expensive six axis machine to carry out a simple handling task. Positive savings can result from a simple awareness of the task needs. A move or development towards modular machines may result in price reductions. Overall, it is unlikely that machine prices will become substantially lower, particularly as the Robot Industry is a relatively low profit industry. Therefore the cost equation will be most helped by