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Quality Improvement: A View from the Chemical Industry [and Discussion]

R. N. Hodge, J. Whiston, S. Evans and J. Disney

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Quality improvement: a view from the chemical industry

By R. N. Hodge[1] and J. Whiston[2]

[1] *ICI Chemicals and Polymers Limited, The Heath, Runcorn, Cheshire WA7 4QF, U.K.*
[2] *ICI Chemicals and Polymers Limited, PO Box 90, Wilton, Middlesbrough, Cleveland TS6 8JE, U.K.*

The necessity for, the importance of and the potential benefits from a quality improvement process (QIP) will be outlined. The process will be based on simple fundamental principles and also aimed at understanding and improving the effectiveness of the relationship between the supplier and the customer, both internally and externally, within a large chemical company. The role of education for all staff as a key element of the improvement process will be described and some early successes emerging from the improvement process will be mentioned.

The need for an understanding throughout the organization of statistical methods, including statistical process control, emerging from the early implementation of the quality improvement process, as well as being a direct requirement for obtaining third party accreditation, will be highlighted and the approach adopted to staff education in these techniques will be outlined. The relevance of other quality-related methods such as 'just in time' and materials resource planning (MRP 2) within a total QIP will be discussed.

1. Introduction

Within ICI Chemicals and Polymers Limited the quality improvement process (QIP) is at a relatively early stage, but financial benefits have already been achieved, and measurement, statistical techniques and increased attention to the customer are emerging as key points. Some of the early conclusions have implications in a wider national educational context. All these aspects will be considered below.

2. ICI Chemicals and Polymers

ICI Chemicals and Polymers was formed in January 1987 from the amalgamation of four key ICI operating units: Agricultural, ICI Fibres, Mond, and Petrochemicals & Plastics Divisions. The latter itself had been the result of an amalgamation in 1981 of Petrochemicals and Plastics Divisions. It is a major company in its own right with a turnover of about £4000 M. QIP is being applied progressively across the whole of this organization.

3. The background to our quality improvement process

Each division of ICI Chemicals and Polymers had an improvement process in operation before the amalgamation. In this paper, it is the intention to use that adopted by the Petrochemicals & Plastics Division as an example of the process's development.

From its formation, the Petrochemicals & Plastics Division had to adopt a major programme of restructuring and productivity improvement. From 1981–1985 manpower was reduced from

21 000 to 14 000, older plants closed, some businesses exited and significant improvements in efficiency were achieved. This survival programme led to a movement from loss to profit. In 1984, however, it was becoming apparent that the management's energy for this survival process was diminishing and the improvement had to be maintained by other means. QIP offered such an opportunity.

4. Reasons for a quality improvement process

Among the management team there was a full understanding of the need for continual improvement and the benefits from a complete understanding of the customers' requirements. Customers were also requesting third party accreditation. These factors together with the perceived benefits eminating from QIPS outside the U.K. suggested that such a process could meet our requirements for an improvement process.

The approaches of three quality experts (Crosby, Juran and Deming) were considered. Over a period of time and it was recognized that an amalgam of their views together with some of our own could give the continual improvement we were seeking. However, Crosby's approach (1979) seemed the best starting point as his four absolutes, fully applied would meet our needs.

1. Conformance to the customers' requirements: this attention to the customer is essential to us, both in the short and the long term.

2. Prevention not appraisal: this principle was already used for the planning of major plant turn-arounds. It also allowed us to focus on the work process.

3. Zero defects: we saw this as meeting customers' requirements every time as well as having a significance for improvement.

4. Cost of quality: this would focus on the potential cost benefits meeting both external (customer) and internal (improvement) requirements.

It is interesting to note that as we have been drawn into QIP our awareness of other available material has increased. The black and white 1950s vintage film, produced by the British Productivity Centre, lists these absolutes in a very British way and there is no doubt that it helps the implementation of the process in the U.K. when it is understood that QIP is not an 'imported' product. Transformation of the four absolutes to a working model by means of an education programme for everybody, appropriate to their role, in our organization was and continues to be very significant for our thinking about QIP.

5. Education

Initially we used Philip Crosby's education programmes, but over time these have been modified and our current education includes the work of all the quality experts, emphasizes the importance and significance of measurement and puts QIP in the context of the management of change and improvement. The key principle, however, is that education in the principles of quality improvement start at the top of the organization and involves everybody down to and including the shop floor. Our Executive Board has its quality improvement team striving to improve its working processes just like any other group.

During the quality training within our Research & Technology (R&T) Department, the need for further training in statistical techniques emerged as a key need. With Professor G. B.

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Wetherill (Newcastle University), a one-week course has been developed and has been used extensively for the training of key R&T, production and technical staff. The course is so designed to enable them to design particular statistical education programmes for their more junior staff including shift operating teams. The outline of the course is as follows:

(1) Collecting and displaying data;
(2) Distribution, histograms, Pareto analysis;
(3) Problem-solving techniques;
(4) Comparative tests;
(5) Comparability analysis;
(6) Shewart charts;
(7) CUSUM charts;
(8) Statistical process control (SPC) implementation;
(9) Use of statistical techniques in our business.

Between each teaching session the students return to their locations to apply the principles they have been taught. A course manual, referred to as the SPC manual, is given to students to allow them to use the knowledge gained in the course in a practical sense in their particular field.

6. Third-party product quality accreditation

Another pressure for the introduction of statistical methods is the achievement of third party accreditation, for example, BS 5750: 1987, ISO 9000 series or the even more demanding Ford Q101. These accreditation processes call for various levels of SPC data. Over the next three years it is our intention to obtain such accreditation to ISO 9000 series for most of our products and hence it is essential that there is a sound knowledge of statistical techniques, including SPC, throughout our organization. This means having the knowledge down to our shift operating teams. Knowledge and understanding are key. A concern that we have is that in certain parts of British industry SPC data is being generated, but there is not the level of understanding that we believe is essential for true appreciation. Such lack of understanding can lead to problems and hence it is our intention to avoid this difficulty. We do believe in the prevention of defects.

The level of support for the above approach is demonstrated by the fact that a quarterly forum to share views has been established and the most recent forum was attended by over 50 staff.

7. Some examples of applied statistical approaches

Already we are seeing the application of simple statistical techniques across a number of our processes. We would like to highlight two such examples, one drawn from the 'heavy end' of our operations, the other drawn from one of our smaller businesses.

(*a*) *Pure terephthalic acid* (PTA)

PTA is produced at one of our major sites. It is a high-tonnage product produced on a world-scale plant where the specification for the final product's purity is very high, and is comparable with those for pharmaceutical products. The situation obtaining in 1984 was one of high levels of recycle. That is to say, over 5% of the final product had to be put through the purification stage again, i.e. rework in the classical sense. Because every tonne was and is saleable, this

recycling not only meant additional cost of energy, etc., but also lost sales' revenue. A number of approaches to the problem were carried out in parallel. Collectively, these led to a better understanding of the process, in particular, the linkage of product quality problems to process parameters. This in turn led to monitoring and control of two key intermediate stages of manufacture, starting with a clear specification of the *requirements* of these stages. A further action was to introduce a rigorous and documented follow-up investigation whenever a non-conformance appeared. The results, over three years since 1984, are impressive. Non-conforming product has reduced from $5\frac{1}{2}\%$ to approximately $1\frac{1}{2}\%$ and the figure is reducing still further. This has represented a business improvement of almost £3M p.a. It involved no advanced statistical techniques nor did it require a professional statistician. The disciplines involved were primarily concerned with clarifying requirements in quantitive ways identifying the 'vital few' parameters by means of a Pareto chart, then monitoring and rigorously investigating non-conformances. In other words, this was a simple application of one of the four absolutes of quality improvement, supported by simple statistics.

(*b*) *Batch chemical process*

The second example illustrates how the use of very simple SPC techniques, i.e. nothing more complex than Shewart charts, not only improved process control and reduced variability of product (the expected result of applying these techniques), but actually resulted in significant development of the process and product. This came about largely as a result of measuring the variability of incoming raw materials (from an in-house ICI supplier). By sharing the data with the supplying plant, as well as improving control of the plant processes issuing the raw materials, several benefits ensure

(i) increased throughput;
(ii) increased yield 89.5% to 92%;
(iii) increased product strength;
(iv) reduced use of expensive ingredients by 15%;
(v) improved appearance of the product.

In total, these improvements amounted to annual benefits of around £250000 in a small business. The most interesting feature, however, is that the product is being improved and the 'recipe' is being developed significantly not by the application of chemistry or chemical engineering, but by application of simple data analysis.

8. Developments from our quality improvement process

Within our R&T Department interest in more advanced statistical techniques is increasing and a design-of-experiments package has been developed to meet this need. At a later stage key production staff will also participate in this package.

With Newcastle University, a teaching company scheme has been developed and approved to apply SPC and related techniques to a number of our operating processes. This will benefit us by providing dedicated resource to apply SPC in a total quality context to our processes as well as providing academic support to our staff. The associates themselves will benefit from the experience of applying such techniques in a major manufacturing operation.

In our induction education programme for new graduates there is a module on the importance and significance of our QIP and we highlight the significance of measurement at

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that time. It is also our intention to build into the management education for new graduates, both commercial and technical modules on statistical techniques and to show how they can and should be used within the organization.

9. Comparison with Japanese industry

Last October, one of us (J.W.) had the opportunity to view at first hand during a short visit the operation of QIP within Japanese industry. It was clear that the seven simple tools of total quality control (Ishikawa 1982) are taught and are used by a full range of staff within Japan. Our belief is that if we can achieve the same objective then it will give us the opportunity to compete successfully with Japanese industry.

10. Why we need a statistical renaissance

Over the past 30 years ICI has been at the forefront of the development of statistical techniques and the introduction of statistical methods. It must therefore seem rather surprising that we are, as it were, 'reinventing the wheel'. Although in the 1950s and 1960s there was some pressure for continual improvement, the supply–demand pattern was such that the pressure was on production output with further increasing demand being met by the installation of new plants. Management of variability was not top priority. The climate in the 1980s is totally different with pressure now on achieving both output and product quality from existing assets and the recognition that continual improvement is essential. Management of variability is given high priority. The customers require that their needs are fully met; they can generally find a supplier who will meet their needs if we cannot. They also increasingly expect sales and distribution staff to be able to converse in a clearly understood manner on statistical techniques such as the capability of a particular process and the agreed requirements for SPC data. The effect of this is that all staff, both operating and commercial and through to and including shift operating teams, have to have a clear understanding of statistical techniques and methods. Appropriate education is the only way to ensure that all staff can respond to the customer's needs.

11. Statistics education in the United Kingdom

The need for quality improvement in a competitive world is clear; Japanese industry has already demonstrated the benefits which can accrue from the application of a QIP and dedication to continual improvement. In the competitive world of the 1980s and the 1990s, it is essential that British industry can not only compete with the Japanese, the Europeans and the Americans, but achieve a competitive edge. Quality improvement offers this potential competitive edge if education programmes to support quality improvement are carried through with vigour and determination. Our QIP is already demonstrating the potential benefits from the use of statistical techniques. We aim to continue our education process throughout our organization. It is essential that the level of knowledge of simple statistics needs to be a key part of the educational curriculum of the United Kingdom. The Japanese teach simple statistical techniques at High School and if quality improvement is to achieve the competitive edge which is essential to British industry, then a similar approach needs to be

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adopted within our schools. It is not only the specialists who must have the knowledge of statistics, but also the staff joining from schools and colleges. It is essential that in the office as well as at the technical level there must be appropriate knowledge.

14. Other quality-related techniques

The use and significance of statistical techniques have developed naturally from our QIP and the requirements which are essential to achieve accreditation. These techniques are gaining acceptance and understanding as they are seen to fit naturally into our QIP. 'Just in time' and 'materials resource planning' will emerge as requirements for some sectors of our business in the future. As they do, our intention will be to put them into our QIP with education as the first requirement for all staff who need to use these techniques. This we see as the key to success (meeting requirements) if the benefits to both ourselves, as the supplier, and to our customer are to be obtained.

15. Conclusions

As we have discussed a QIP and as this implies an on-going commitment, the word 'conclusions' is perhaps inappropriate. It may be better to express it as a summary of current status. In that context we see quality as necessary for the achievement of successful business. Quality to us is meeting needs, achieving beneficial change in our organization and having the attitude to seek continual improvement. Within this quality umbrella statistical techniques feature significantly and their role is a developing and increasing one.

References

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Ishikawa, K. 1982 *Guide to quality control*. Kraus International Publications: Tokyo.

Discussion

S. Evans (*The London Hospital Medical College, London, U.K.*). Assessment of quality in two areas of public life in the United Kingdom has some obvious problems. In the National Health Service (NHS), efficiency rather than quality is measured. Virtually all measures of efficiency are optimized by admitting everyone entering the hospital into a bed and then injecting cyanide! The outcome of treatment is totally ignored.

In universities, the quality of research is being assessed with, as far as is known, little attention being paid to the contribution which statisticians could make to this process. If this is so, should we as statisticians be doing something constructive to improve quality assessment?

J. Whiston. There is no doubt that the NHS would benefit from a quality improvement approach, as there is a need to understand clearly who is the customer and who is the supplier. This applies to the patient (the true external customer) and the range of medical services being provided to the patient (the medical services are the true supplier).

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With its multitude of departments there would be significant benefit from understanding that each department is either a supplier or a customer to another department. The definition of who is the customer and who is the supplier will only be gained by all the staff when they understand the improvement process.

The contribution which statisticians can make to any debate, be it university research or the performance of the NHS, is to ensure that there is an understanding of opportunity, numeracy and variation. So many decisions appear to be taken within natural variability of data. If the statistician could ensure that before action is taken there is a real problem then that would be a major contribution.

J. Disney (*Department of Mathematics, Statistics and Operational Research, Trent Polytechnic, Nottingham, U.K.*). The new 'quality wave' has produced many new acronyms, which are often not self-explanatory. One such example, quoted by Mr Hodge, is MRP2. Can he explain this term?

J. Whiston. Materials resource planning is a technique which minimizes inventory and therefore reduces working capital. It must be fully understood by all involved. In particular, it must be recognized that there are suppliers and customers both internally as well as externally, and also that the key requirements are a closer relationship between suppliers and customers and an understanding of agreed needs.

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