Quality Improvement Programme in a Just-in-time Manufacturing Environment

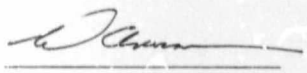
Wayne Aronson

A project report submitted to the faculty of Engineering, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

Johannesburg, 1987

DECLARATION

I declare that this project report is my own, unaided work. It is being submitted for the Degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.



19 day of JANUARY 1988

ABSTRACT

Quality improvement is one [illegible] accessible frontier for cost reduction in companies today. This report represents the results of a 4 month project investigating quality improvement techniques and ideas. The report examines some of the already existing Japanese manufacturing techniques, such as Just-in-time and Total quality control. A quality improvement programme is proposed based on analysis and comparisons of presently existing programmes. Details and recommendations for implementing this programme are given, together with relevant case-study illustrations.

ACKNOWLEDGEMENTS

I would like to thank:

- Professor John Bicheno for his dedicated help and advice throughout the duration of this project.
- Mike Karle for reading and commenting extensively on this report.
- MSN Products and specifically Pieter DuPlessis for assisting me with my case studies.
- CSIR for its financial assistance.
- My family and Debbie for their help and support.

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 BACKGROUND TO THE PROJECT 6
2.1 INTRODUCTION 6
2.2 JUST-IN-TIME PRODUCTION WITH TOTAL QUALITY CONTROL 6
2.2.1 The Just-in-time (JIT) Concept 7
2.2.2 The Total Quality Control (TQC) Concept 11
2.2.3 Relationship Between JIT and TQC 13
2.2.4 Hindrances to Implementation of JIT/TQC 15
2.3 CONCLUSION 16

3.0 QUALITY IMPROVEMENT TECHNIQUES 18
3.1 INTRODUCTION 18
3.2 PLANNING FOR QUALITY 19
3.2.1 Review of Available Quality Programmes 22
3.2.1.1 Philip B. Crosby: 'Quality is Free' 22
3.2.1.2 J.M. Juran and F.M. Gryna: 'Breakthrough Sequence' . 25
3.2.1.3 D.P. Hutchinson: 'Quality Improvement for Cost Reduction' 27
3.2.1.4 Leon B. Crosby: 'Stage One - Control of Quality' . . 29
3.2.2 Comparison of Available Quality Programmes 31
3.2.2.1 Comparison Grid 31
3.2.2.2 Results of Comparison Grid 34
3.2.3 Proposed Quality Programme 35
3.2.4 PROGRAMME APPLICABILITY TO JIT/TQC 36
3.2.4.1 ANALYSIS OF PROBLEM AREAS IN MANUFACTURING 36
3.2.4.2 Transference of Technology 39
3.3 CONCLUSION 40

4.0 MANAGEMENT COMMITMENT 42
4.1 INTRODUCTION 42
4.2 QUALITY RESPONSIBILITY 42
4.3 COST OF QUALITY 44
4.3.1 Quality Cost Categories 45
4.3.2 Zero Defects (ZD) Budget 48
4.3.3 Presentation to Management 51
4.4 MANAGEMENT ACTION 52
4.5 CONCLUSION 53

5.0 QUALITY IMPROVEMENT TEAM 54
5.1 INTRODUCTION 54
5.2 STRUCTURE OF THE TEAM 55
5.2.1 Group Leader 55
5.2.2 Group Members 56
5.3 BENEFITS OF A TEAM 57
5.4 OBJECTIVES OF THE TEAM 58
5.5 CONCLUSION 59

6.0 EMPLOYEE TRAINING AND EDUCATION 61
6.1 INTRODUCTION 61
6.2 IDENTIFYING OPERATOR ERRORS 62
6.2.1 Subspecies of Operator Errors 63
6.2.1.1 Inadvertent Errors 63

6.2.1.2 Technique Errors 64
6.2.1.3 Wilful Errors 65
6.2.2 Analysis of Performance Problems 66
6.2.2.1 Skill Deficiency 68
6.2.2.2 No Skill Deficiency 69
6.2.2.3 Selecting a Remedy 71
6.3 TRAINING 72
6.4 MOTIVATION 74
6.5 CONCLUSION 76

7.0 PROBLEM IDENTIFICATION 78
7.1 INTRODUCTION 78
7.2 PROCESS ANALYSIS TOOLS 78
7.2.1 Process Flow Charts 80
7.2.2 Pareto Analysis 82
7.2.3 Fishbone Diagram 85
7.2.4 Histogram Analysis 88
7.2.4.1 Construction of a Histogram 89
7.2.4.2 Analysis of a Histogram 90
7.2.5 Control Charts 92
7.3 CONCLUSION 94

8.0 CORRECTIVE ACTION 97
8.1 INTRODUCTION 97
8.2 VENDOR RELATIONS 99
8.2.1 Vendor Relation's Policy 100
8.2.2 Appraisal of New Vendors 101
8.2.3 Vendor Rating 103
8.3 CUSTOMER RELATIONS 104
8.3.1 Customer Satisfaction Surveys 104
8.3.2 New Customer Contracts 105
8.3.3 Response to Customer Problems 105
8.4 PROCESS REVIEW 106
8.4.1 Workplace Organisation 107
8.4.2 Visibility 108
8.4.3 Traceability 109
8.5 CONCLUSION 110

9.0 QUALITY MAINTENANCE AND IMPROVEMENT 112
9.1 INTRODUCTION 112
9.2 PRINCIPLES OF MANAGEMENT 113
9.3 FUTURE GOAL SETTING 114
9.4 CONCLUSION 116

10.0 CONCLUSION 117

11.0 APPENDIX 1 119

12.0 APPENDIX 2 124

13.0 APPENDIX 3 133

14.0 REFERENCES 135

LIST OF ILLUSTRATIONS

Figure 1. Water-level Analogy to Just-in-time 9

Figure 2. Two Stage Implementation of Just-in-time 10

Figure 3. Quality Control Evolution 12

Figure 4. Comparison Grid 32

Figure 5. Company Language 46

Figure 6. Costs Before and After Effective Quality Control . . . 48

Figure 7. Quality Cost Model 49

Figure 8. Basic or Generic (Line) Departments 57

Figure 9. Flow Chart Illustrating Performance Problem Analysis . 67

Figure 10. Cartoon Illustrating Punishing Performance 71

Figure 11. Cartoon Illustrating Rewarding Non-performance 72

Figure 12. Cartoon Illustrating an Obstacle for Desired Performance 73

Figure 13. Motivational and Maintenance Needs 77

Figure 14. Flow Chart for Printed Circuit Board Manufacture . . . 81

Figure 15. Pareto Analysis Showing Weekly Rate of Defective Boards 84

Figure 16. Fishbone Diagram for Electroless Copper Plating Process 87

Figure 17. Example of a Typical Histogram 90

Figure 18. 15 Examples of Histograms Related to Tolerances 91

Figure 19. Specimen Of Vendor Appraisal Report Sheet 128

Figure 20. Specimen Of Vendor Performance Rating Sheet 129

1.0 INTRODUCTION

Quality improvement is probably the greatest single potential source for improved company performance in South Africa, as it is for many other countries. However, most company managers are preoccupied with control and generally lack awareness of the need for improvement, the benefits or the techniques available (Hutchinson, 1985).

It is impossible to over-emphasise the importance to the company of the quality of the product that it supplies or the process that it undertakes or the services that it provides or the effectiveness with which it functions. Quality can be an asset or a liability. It can result in significant cost advantages or it can be appallingly expensive. It can build the image of a company or destroy it.

In the postwar years the quality of Western consumer products was regarded as the best in the world, whereas Japanese products were effectively unsaleable abroad. As a result, Japanese industrialists, recognising Western strengths, adopted and enhanced them for their own purposes with assistance from Western experts such as Dr. Joe Juran and Dr. Edwards Deming. They chose a revolutionary approach in contrast to the evolutionary process that occurred in the West. To achieve this, they adopted three key innovations (Hutchinson, 1985):

- Upper management leadership in quality management.
- Massive training at all levels.
- Programmes for annual quality improvement and cost reductions.

Since then the Japanese have moved from competitive quality at lower costs to superior quality, sometimes at premium prices, for many of their products. The question now remains as to whether the Japanese production system can be made to work in the Western industrialised countries. It is the view of Richard J. Schonberger (1982) that it can and he has listed five situational factors that led to Japan's success in overcoming its severe quality problems. He feels that the same five factors are present in Western industry and are as follows:

1. Awareness that there is a gap. Japan was actually aware, in the post-World War II recovery period, that the world considered 'Made in Japan' to mean 'made poorly'. Clearly Western industry today is aware of quality and productivity advantage enjoyed by Japanese export industries.
2. Determination to improve. Japan was a strong, proud industrialised nation prior to its defeat in World War II, and, like Europe, was determined to recover and rebuild following the War. Western countries have suffered enough plant shutdowns and losses of whole industries because of inability to compete; the resulting social and economic upheavals and stinging losses of prestige have fostered a nation resolved to make changes.
3. Belief that change is possible. An aggressive, literate, achievement-orientated society is unlikely to remain negative about itself for long. Some of the best western companies, on their own, have developed certain broad management practices observable in many Japanese companies. This gives the message that 'obviously we can do it, because we already have'.
4. Timing. When things are going well, it is hard to find the time or the will to change. Japan's quality campaign began when things were

not going well following the War. Although the economic recessive periods experiences by the West hardly compares, they still bring on self examination and frequent changes.

5. Know-how. The Japanese got started on their quality crusade by acquiring quality improvement know-how from such American experts as Deming and Juran. The West, in turn, have based their quality improvement know-how on Japanese techniques. This has resulted in a large number of different quality improvement programmes being developed.

Although, very often, the first four points discussed above can be found in most companies intent on improved product quality, the problem lies in acquiring the right programme. As was stated in point 5, many different quality improvement programmes exist, making it difficult to select a programme most suited for a specific company. Furthermore, these programmes do not explain implementation but give only a description of the steps required.

It is for these reasons that this study has been performed. The purpose of this report is to compare several of the available quality improvement programmes so as to develop a new programme based on the important steps found in these existing programmes. Having established this quality programme, the remainder of this report includes a detailed description of how to implement it.

Although the proposed quality programme is intended for any industry, the report has been directed more towards that of manufacture. This can be seen as a limitation of the study and should be remembered when consid-

ering the service industries. In this instance the report can serve as a general guideline.

The organisation of this report has been set out so as to make it easy for the reader to see at a glance the relationship between the various parts of the study. Chapter 2 offers the reader some background to the project, and explains the concept of the Japanese manufacturing techniques: Just-in-Time and Total Quality Control.

The essence of the report is contained in Chapter 3. It is here that several presently available quality improvement programmes are discussed and prepared, and it is from this comparison that a new programme is proposed. The remainder of the chapters, each in turn, deal with the steps of the proposed programme.

The need for management commitment is stressed in Chapter 4, together with methods for obtaining it. Chapter 5 discusses the requirements of the quality improvement team and how it can be used to assist in the implementation of the programme. The cornerstone of a quality improvement programme is employee education and training. This important aspect is covered in Chapter 6, together with details on how to deal with operator errors, training, and motivation. Chapters 7 and 8 deals specifically, although not exclusively, with process problems. The former explains how to identify the causes of problems by using such techniques as flow charts, pareto analysis, fishbone diagrams and statistical process analysis, while the latter shows the actions that should be taken to correct the problems.

Having obtained the required results from the improvement programme, it is important to ensure that these results are maintained, and new goals for improvement are set. Chapter 9 deals with the idea of maintaining newly acquired levels of quality while simultaneously setting new levels for quality for the future.

The final chapter, Chapter 10, is the concluding chapter and it presents some of the recommendations and findings of this report, together with a summary, restating the development of previous chapters.

2.0 BACKGROUND TO THE PROJECT

2.1 INTRODUCTION

Throughout this report reference is made to a number of principles and ide The purpose of this chapter is to present the reader with a background to these principles so as to ensure him a basic understanding of them. In particular the concepts of the Japanese manufacturing techniques of Just-in-Time (JIT) and Total Quality Control (TQC) are explained since these two techniques form the basis upon which this report is developed.

Throughout this report the company MSN Products has been used as a case study to illustrate different quality improvement techniques. Background material and information on MSN Products can be found in Appendix 3.

2.2 JUST-IN-TIME PRODUCTION WITH TOTAL QUALITY CONTROL

Western industry has amassed numerous prescriptions for catching up with the Japanese. Until recently, most prescription lists omitted Japanese just-in-time (JIT) production management and total quality control (TQC). Just-in-time production is simple, requires little use of computers, and in some industries can provide for tighter controls on inventory than are attainable through computer-based approaches (Schonberger, 1982). Fur-

thermore, JIT implementation results in improved process quality by uncovering hidden problems and opens the way to higher productivity. Total quality control, unlike conventional quality control, is a management system and is not restricted only to production and its related departments. Several benefits of TQC include "fewer rework labour hours", "less material waste" as well as "higher quality of finished goods" (Feigenbaum, 1983).

Many sources on the topic of just-in-time state that a JIT system will result in improved product quality, however Schonberger (1982) argues that higher quality of finished goods cannot be claimed as an effect of JIT, because equally high product quality could be attained by means of extensive final inspection plus rework lines and scrap bins. It is for this reason that the benefits derived from JIT should not be seen as improved product quality but rather improved process quality. That is, JIT will not necessarily improve product quality but it will certainly lower its costs. Total quality control, by contrast, certainly will improve product quality. Thus it can be seen that a direct relationship between JIT and TQC does exist. Let us now take a closer look first at just-in-time and then at total quality control as well as the relationship that exists between them.

2.2.1 THE JUST-IN-TIME (JIT) CONCEPT

It might well be asked: "What is just-in-time?". JIT is a philosophy that teaches that any activity that does not add value to the manufactured

product is wasteful. It teaches that inventory, stock, queues, movement, inspection and defects are wasteful (Sandras Jr., 1986). Thus the goal of JIT can be stated as: "To produce instantaneously with perfect quality and minimum waste" (Bicheno, 1986). Clearly, since this goal is, in reality, never achieved, it can be restated as: "To have all external materials required to produce a product arrive at only the proper time in the schedule when they are needed and in only the quantity required". The object is then to have product flow from one processing step to the next, with no delay, until it is in the hands of the end-user. Stated more simply, JIT means that everyone in the manufacturing loop gets just what he needs, just when he needs it (Kirkland, 1984). For JIT techniques to be effective, the inefficiencies created by inventory accumulation must be reduced to the minimum possible level. This is why the term "zero inventory" is often used interchangeably with just-in-time. Figure 1 on page 9 illustrates the well known JIT analogy.

In the illustration 'S.S. Old Timer' representing production, is allowed to float undisturbed on a sea of inventory. After the level of the inventory "sea" is lowered (following the implementation of JIT techniques), hazards to production, which were invisible because of inventory accumulation, are exposed and can be dealt with. Therefore, production (now rechristened the 'S.S. Just-in-timer') can continue sailing.

Until recently, the concept of JIT has remained beyond the reach of manufacturers, except perhaps in isolated small shops (Crosby L.B,1984). The reasons for this elusiveness are not hard to identify. For JIT to be seen to work, two things must happen. First, all parts must arrive where and when they are needed, and in the exact quantity needed. Second, all parts that arrive must be usable parts (Crosby L.B., 1984). It is for this

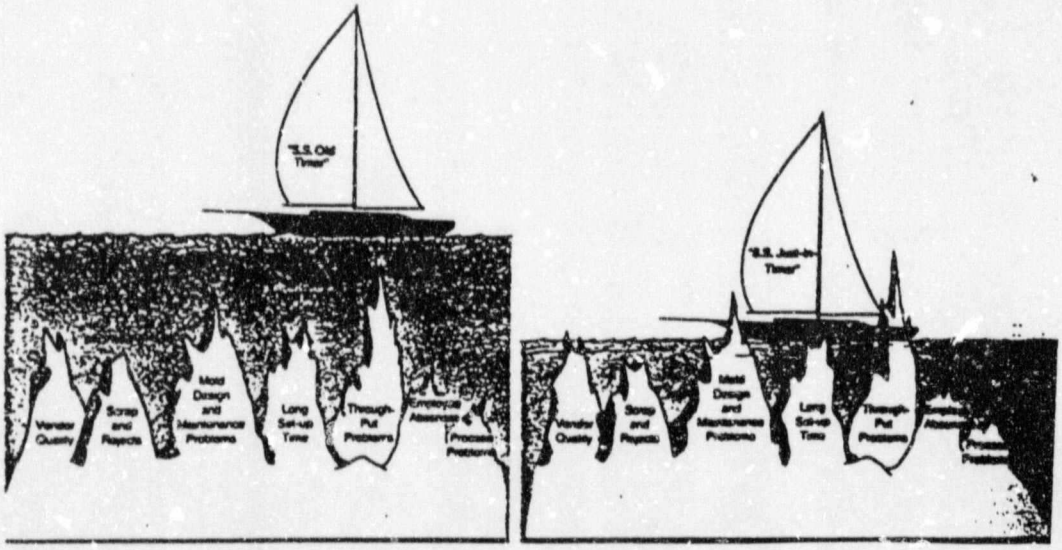


Figure 1. Water-level Analogy to Just-in-time

---

reason that any study or attempted adaptation of JIT should be done in two sequential stages.

The first stage is concerned with the control of the quality while the second stage deals with the control of quantity. Since it is difficult to control the quantity of material if the quality of the material is questionable, it becomes obvious why quality is dealt with first. Figure 2 on page 10 illustrates the two stages, together with the various activities that require attention in each of these stages.

In his review of the two stages, Bicheno (1986: 18) has indicated the differences between them to be:

1. Stage One deals with the aspects directly related to the facility and the product, with benefits of this stage being:

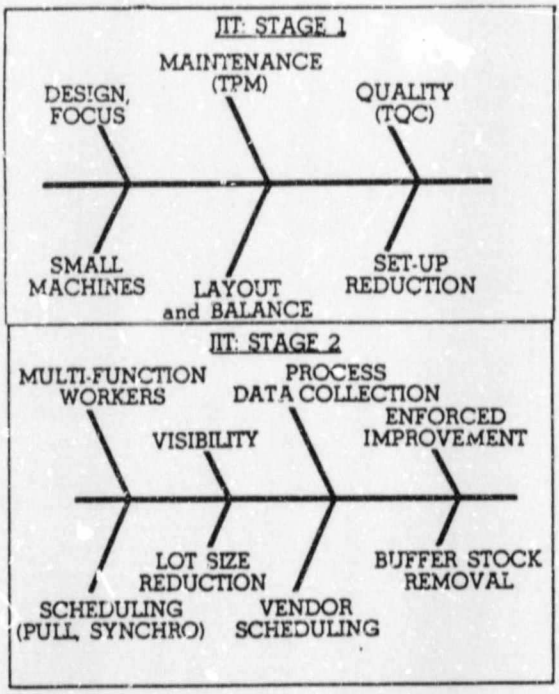


Figure 2. Two Stage Implementation of Just-in-time

- high quality
- low cost
- minimum lead-time
- high flexibility

2. Stage Two is concerned with the product being produced:

- only as needed
- with perfect quality
- at minimum cost

2.2.2 THE TOTAL QUALITY CONTROL (TQC) CONCEPT

The development of quality control, as we know it today, has spanned this entire century. From a historical viewpoint, major changes in the approach to quality-control work have occurred approximately every 20 years (Figure 3 on page 12). According to Feigenbaum (1983) this development evolved in a series of five definite steps.

The first step in the development of the quality field, **operator quality control**, was inherent in the manufacturing job up to the end of the nineteenth century. Under that system, one worker, or at least a very small number of workers, was responsible for the manufacture of the entire product, and therefore each worker could totally control the quality of personal work.

In the early 1900's we progressed to **foreman quality control**. This period saw the large-scale advent of our modern factory concept, in which many individuals performing a similar task were grouped so that they could be directed by a foreman who then assumed responsibility for the quality of their work.

The manufacturing system became more complex during World War 1, involving large numbers of workers reporting to each production foreman. This resulted in the appearance of the first full-time inspectors and **inspection quality control**.

With the outbreak of the Second World War, 100 percent inspection became impractical due to the increased mass production. Thus with the aid of a

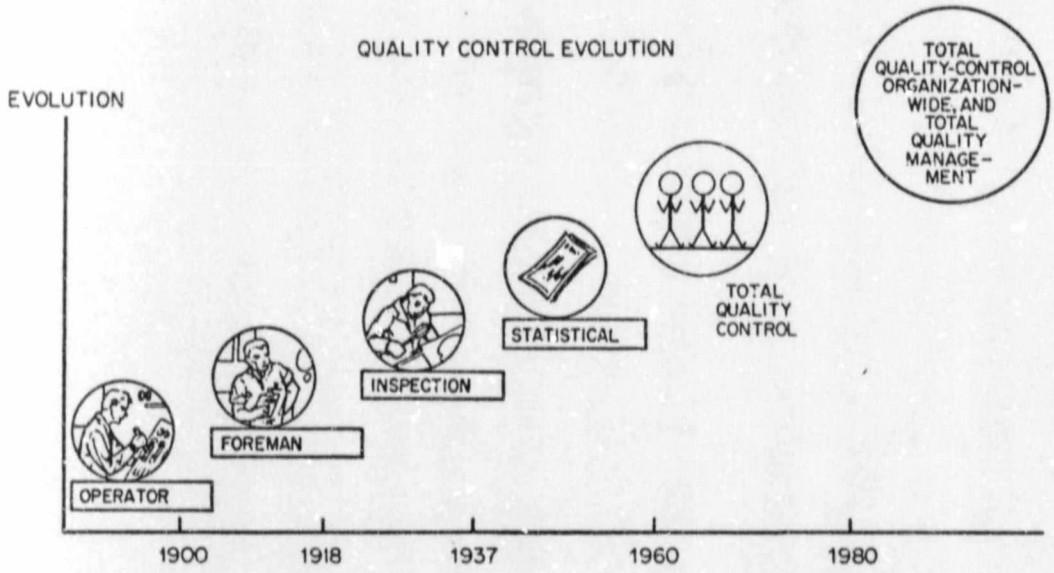


Figure 3. Quality Control Evolution

---

few statistical tools, inspectors engaged in sampling inspection, which we now identify as **statistical quality control** (SQC).

With the use of SQC methods came a better understanding about the manufacturing processes themselves as well as recommendations for improvement. These recommendations, however, often could not be handled by existing decision-making structures, which resulted in the move towards a fifth step, **total quality control**. Only when firms began to develop a specific decision-making and operating framework for product quality, which was effective enough to take suitable action on the quality-control findings, did the firms obtain genuine results in better quality and low costs.

Total quality control can thus be defined as 'an effective system for integrating the quality development, quality maintenance and quality improvement efforts of the various groups in an organisation so as to enable production and service at the most economical levels which allow for full customer satisfaction' (Ishikawa, 1985).

Although TQC advocates the total study, practice and participation of everyone in every division in the company in quality control, including the company president, directors, middle management, staff, foreman, line workers, and salesmen, in resent years this definition has been expanded to include subcontractors, distribution systems, and affiliated companies.

As TQC increases within the management and engineering practices, so to will the foundation increase for the evolution, in the decade of the 1980's and beyond, of total quality management, the JIT/TQC concept as well as quality as a major new business strategy (Ishikawa, 1985).

2.2.3 RELATIONSHIP BETWEEN JIT AND TQC

Having explained what Just-in-time and Total quality control represents, it is now necessary to identify the relationship between them. At first glance, JIT and TQC seem to be two completely separate techniques. Where as the first goal of quality improvement is satisfying the customer, JIT's first benefit is fast response to the customer (Schonberger, 1986).

Thus it can already be seen that since both strategies are related to the needs of the customer, there does exist some connection between them. The extent of this connection has been summarised by Schonberger (1986) as follows:

1) **How quality enhances JIT**

FACT	JIT/QUALITY EFFECT
Variability in quality is the major reason for buffer stock	Control variability to justify buffer stock cuts

2) **How JIT cuts cost of quality**

FACT	JIT/QUALITY EFFECT
Scrap/rework/damage costs of quality linearly relates to raw and in-process stock	Raw and in-process stock reduction cuts scrap/rework/damage costs to same extent

3) **How JIT improves quality**

FACT	JIT/QUALITY EFFECT
Time destroys evidence of causes of variability	Effective process analysis requires fresh evidence in period of limited changes - provided by vigorous JIT

Thus it can be seen that JIT techniques assist people in solving quality problems by keeping evidence fresh. Using these techniques idle inventories are taken out, so there is little to scrap or rework when a bad batch is found; this results in large cost reductions. They also help slash lead time, which does not necessarily result in flexibility, but they do demand flexibility: flexible labour and flexible equipment.

TQC fans the flames: Through awareness, it greatly accelerates quality improvement, which lowers scrap, rework, warranty, and liability costs. TQC takes out some of the rework loops as well, and that cuts lead times a bit (Schonberger, 1986).

2.2.4 HINDRANCES TO IMPLEMENTATION OF JIT/TQC

Having now been made aware of some of the benefits that Just-in-time and Total quality control have to offer, it should be surprising to find that not every manufacturing company has embarked on such programmes. The reason, however, why this is not so can be attributed to several factors which hinder this progress. Riddell (1985) has identified 10 of the most common factors:

1. Passivity among top executives and managers; their abdication of responsibility
2. People who feel that everything is fine and that there are no problems at all. There are people who are satisfied with the status quo and lack in the understanding of significant issues
3. People who think that their company is by far the best
4. People who think that the easiest and the best ways of doing things are those which are familiar to them. People who rely only on their own shallow experience
5. People who think only of themselves or their own division
6. People who do not listen to other people's advice or experience

7. People who scramble for distinction and are always thinking about themselves
8. Despair, jealousy, envy and fear
9. People who are oblivious to what is happening beyond their immediate surroundings. People who do not know anything about other divisions, other industries, the outside world, or the world as a whole - lack of self-development
10. People who continue to live in the past

Thus it can be seen that the cause of hindrance usually stems from people whose wrong attitudes are the main causes. To dispel these wrong attitudes there is a need for a successful plan of action which possess good tactics and strategies for overcoming any difficulties. The following section takes a look at several existing plans for quality improvement as well as to propose an improved plan based on a comparison of these plans.

2.3 CONCLUSION

Just-in-time and total quality control are two concepts which can no longer be ignored in manufacturing today. Both are equally important for ensuring improved productivity and product quality. This chapter has attempted to explain these two concepts, as well as to identify the hindrances that prevent their implementation.

Implementation of a JIT and TQC system will however not necessarily ensure the required results. Without a well formulated quality improvement plan,

to educate the people, and to control the problems that are uncovered by JIT, success will be limited (Schonberger, 1986).

Several such plans have been detailed in the following chapter. Both their merits and their shortcomings have been highlighted, together with a proposal for an improved plan.

3.0 QUALITY IMPROVEMENT TECHNIQUES

3.1 INTRODUCTION

The capability of providing customers with top-quality products and top-quality services appears to be an elusive devil, hard to catch, and even harder to hold on to for many quality practitioners. Somehow, things seem to have gone wrong. Dissatisfied customers, poor service, high scrap costs, excessive warranty - all of these and more are plaguing management people in the quality assurance field. In his book, Martin R. Smith (1979) has listed 'the ten deadly sins of quality assurance' that can be seen to be responsible for a large portion of these problems:

1. Too much attention to technical razzle-dazzle; not enough attention to profits, sales, and costs.
2. Too much time trying to stop defects; not enough time trying to prevent defects.
3. Too heavy a reliance on statistics; not enough reliance on good judgement.
4. Too much concentration on product specifications; not enough understanding of customer needs.
5. Too much devotion to nit-picking; not enough attention to solving major quality problems.
6. Too much concentration on manufacturing; too little attention to quality of design and service.
7. Too much time in the office; not enough time on the firing line.

8. Too much technical education for quality assurance technicians; too little practical education of operators, servicemen, draftsmen, and others responsible for getting quality.
9. Too heavy a focus on quality levels; not enough devotion to quality cost reduction.
10. Too much time spent complaining about poor attitudes toward quality; not enough focus on motivating people and convincing them of the value of quality.

Included in this chapter is a comparison of several different quality improvement programmes, as well as a proposed improved plan based on the ideas discussed in each of the quality programmes.

3.2 PLANNING FOR QUALITY

> 'In warfare, first lay plans which will ensure victory, and then lead your army to battle, if you will not begin with stratagem but rely on brute force alone, victory will no longer be assured'
>
> Sun Tzu
>
> "The Art of War" (490 B.C.)

Everyone is aware of the need for improved quality. No-one is against it, but the main problem is that the means to achieve it have not been clear. The process of quality improvement and cost reduction can only be achieved

by a disciplined, organised approach using a range of proven methods and techniques.

In the past, quality improvement has, in reality, been limited to the trouble-shooting role (Hutchinson, 1985). That is to say the **sporadic** quality problems are tackled and solved without any regard for the **chronic** problems. Before further discussion can take place, it is necessary to distinguish between what is meant by sporadic and chronic quality problems.

A sporadic problem is a sudden adverse change in the status quo, requiring remedy through restoring the status quo (eg. changing a worn cutting tool). A chronic problem is a long-standing adverse situation, requiring remedy through changing the status quo (eg. revising a set of unrealistic tolerances) (Juran and Gryna, 1980). It is the opinion of Juran and Gryna (1980) that the distinction is important for two reasons:

1. Sporadic problems are dramatic and receive immediate attention. Chronic problems are not dramatic because they have been occurring for a long time (eg. an acceptance level of 10 percent scrap), are often difficult to solve, and are accepted as inevitable. The danger is that the firefighting on sporadic problems may take continuing priority over chronic problems where larger savings are possible.

2. The approach for solving sporadic problems differs from that for solving chronic problems. Sporadic problems are attacked by commonly used control processes whereas chronic problems require a more decisive plan of action. It is this plan of action that this project is concerned with.

Although much has been written about the topic of quality improvement, very little actual information can be found of detailed quality improvement programmes. Of the several programmes that exist, the most famous of these is Philip B. Crosby's programme: 'Quality is Free' (Crosby, 1980). In his book, Crosby has set out a 14 step programme towards improved quality, with an explanation of the outcome and problems that can be expected.

Another quality programme can be found in 'Quality Planning and Analysis' (Juran and Gryna, 1980). In this book Juran and Gryna have set aside a chapter to detail their 'breakthrough sequence' for solving chronic quality problems.

David Hutchinson, in his paper presented at the 1985 S.A.S.Q.C. Quality Conference (Hutchinson, 1985), although originally based on Juran and Gryna's 'breakthrough sequence', has introduced some new ideas on quality improvement in his quality programme.

Leon Crosby has considered a quality improvement programme, in his paper to the Production and Inventory Management Journal, as the first stage to implementing a successful Just-in-time manufacturing process (Crosby L.,1984). His programme has included several steps which have merit both in a JIT manufacturing environment, as well as in conventional manufacturing.

3.2.1 REVIEW OF AVAILABLE QUALITY PROGRAMMES

As has been mentioned above, four different quality improvement programmes are investigated in this report. In order for a comparison of the programmes to be done, a description of each has been given.

3.2.1.1 Philip B. Crosby: 'Quality is Free'

The view of Philip Crosby on quality is that the cost of any improvement programme will be offset by the savings that will be obtained. In this way the programme will pay for itself and at the same time all the benefits that go together with improved quality will also be derived. His plan of action follows 14 distinct steps:

1. Management Commitment. It must be made clear to everyone involved where management stands on quality. Helping management to recognise that they must be personally committed to participate in the programme raises the level of visibility for quality and ensures everyone's cooperation so long as there is some progress.

2. Quality Improvement Team. Representatives of each department must be brought together to form the quality improvement team, so that all the tools necessary to do the job are together in one group.

3. Quality Measurement. It is necessary to determine the status of quality throughout the company. Quality measurements for each area of activity must be established where they do not exist, and reviewed where they do, so that a display of current and potential nonconformance problems are provided in a manner that permits objective evaluation and corrective action.

4. Cost of Quality. A structure for the calculation of the cost of quality must be developed, so that a measurement of quality management performance is established within the company's system. This should indicate the areas of high cost so that corrective action can be taken.

5. Quality Awareness. This step should provide a method of raising the personal concern felt by all personnel in the company towards the conformance of the product of service and the quality reputation of the company.

6. Corrective Action. As people are encouraged to talk about their problems, opportunities for correction come to light. This step should ensure that the problems that are identified through previous action steps follow a systematic method of resolving them forever.

7. Zero Defects Planning. A schedule of events must be setup so that all functions to be accomplished are clearly defined, together with the necessary materials needed and a time schedule. This step can be seen to be the planning step for the preparation for formally launching the programme.

8. Supervisor Training. Training can be seen to be the key to success in the project and this step must define the type of training that supervisors need in order to actively carry out their part of the quality improvement programme.

9. Zero Defects Day. A day of the zero defects commitment should be planned so as to create an event that will let all employees realise through a personal experience, that quality improvement is a concept to be taken seriously.

10. Goal Setting. This phase helps people learn to think in terms of meeting goals and accomplishing specific tasks as a team. Pledges and commitments must be turned into action by encouraging individuals to establish improvement goals for themselves and their groups.

11. Error-Cause Removal This step must ensure that the individual employee has a method of communicating to management the situations that make it difficult for the employee to meet the pledge to improve.

12. Recognition. Appreciation must be shown to those who participate as well as genuine recognition of performance. Thereby employees will continue to support the programme whether or not they, as individuals, participate in any awards.

13. Quality Councils. Professional quality people must be brought together for planned communication on a regular basis. This will ensure that, through communication, actions necessary to upgrade and improve the programme never ends.

14. Do-it-over-again. This step needs to emphasise that the quality improvement programme never ends.

Full details of each step has not been given as this is beyond the scope of this report. It is only necessary to identify each step of this programme so that it can be compared later with other programmes. For further details regarding this programme, the reader is advised to consult Crosby (1980).

3.2.1.2 J.M. Juran and F.M. Gryna: 'Breakthrough Sequence'

Whereas the previously mentioned programme is more directed at improving management and personnel, Juran and Gryna's 'breakthrough sequence' can be seen to be directed at the improvement of the process (Juran and Gryna, 1980). This breakthrough sequence is setout in 7 distinct steps:

1. Breakthrough in attitudes. This step proves that a breakthrough is needed and creates an attitude favourable for embarking on an improvement programme. This is done by convincing those responsible that a change in quality levels is desirable and feasible.

2. Identify the vital few projects. This step determines which quality problem areas are most important since by the pareto principle, a 'vital few' contributors to a problem account for most of the total size of the problem.

3. Organise for breakthrough in knowledge. This step requires organisation to secure the new knowledge that is needed to achieve improvements. This includes defining the organisational mechanisms for obtaining the missing knowledge such as a steering committee and a diagnostics team.

4. Conduct the problem analysis. Collection and analysis of the facts are required, to determine the cause and remedy of the problem, so that recommendations can be made.

5. Deal with resistance to change. This stage deals with the cultural resistance to the needed technical changes. This is done by determining the effects of proposed changes on the people involved and finding ways to overcome the resistance to change.

6. Institute the change. This involves gaining the approval of management for instituting the solution, and installing the solution in a way that will make it effective. Convincing the necessary departments to take action to institute the changes might also be necessary.

7. Institute control. The final step in the programme is to follow progress on the problem's solution to make sure that the solution continues to be effective, and any further unforeseen problems are resolved.

Juran and Gryna (1980) feel that any worthwhile results will not be obtained due to luck but rather to the effective execution of a well designed plan. It is their view that implementation of their 'breakthrough

sequence' will not only achieve reduced quality costs but will also provide input for quality planning on new products.

3.2.1.3 D.P. Hutchinson: 'Quality Improvement for Cost Reduction'

Hutchinson (1985) believes that a quality improvement programme must establish a strong top management linkage to quality improvement and it must reinforce positive employee attitudes towards quality. Hutchinson's 6 stage programme incorporates a formal structure that requires management and staff participation for problem solving:

1. Identification of the need. This requires that opportunities for improvement are identified and quantified in terms of money. This will provide a reasonable measure of present costs and potential savings.

2. Project selection and the team concept. A team of managers and specialists, representing a range of appropriate skills and knowledge, must be formed to tackle each project.

3. Project organisation. A project hierarchy must be created to ensure optimisation of available skills. Project organisation must be developed into two different skill groups, as the route from problem to solution is seen to be in two distinct stages:

   - the diagnostic journey from symptom to cause, and
   - the remedial journey from cause to solution.

This enables the next two stages of the quality programme to be clearly defined.

4. Diagnosis. This requires the analysis of symptoms by people with the necessary attributes. The analysis should summarise trends, patterns and groupings that will allow the formulation, testing and proving of theories as to the cause or causes of the problem.

5. Remedial action. Diagnosis of problems will lead to a wide variety of causes of the symptoms. Hutchinson shows that in general manufacturing industry the analysis of quality failure costs reveals that:

   - 40% are related to the design and the interpretation of customer needs,
   - 30% are related to manufacture or processing, and
   - 30% relate to supplier activity.

   This reinforces the requirement for company-wide quality management training. This stage must ensure that development and selection of the best remedy is based on optimisation of the user's costs and the company's costs - not departmental costs. Consideration must also be given to the human factors that may be involved in the introduction of remedial changes.

6. Control at the new level. Control requires that the necessary controls are exercised for:

   - setting new standards,
   - monitoring against the new standards, and
   - reacting to differences.

Hutchinson feels that without this disciplined approach, quality improvement will be limited to the trouble-shooting role, responsibilities will remain undefined, and efforts to achieve this improvement will be dissipated and wasted.

3.2.1.4 Leon B. Crosby: 'Stage One - Control of Quality'

Leon Crosby's (1984) programme for improved quality forms part of a two stage programme for the successful implementation of a Just-in-time system. It is for this reason that each step in his quality programme closely resembles the techniques used in present Japanese manufacture (Schonberger, 1982):

1. Train personnel on quality issues. An education programme must be developed to include everyone in the firm, to instil a team atmosphere. As a supplement to the quality control department and as a natural product of a well-trained and involved work force, quality control circles should be developed.

2. Make every defect visible. In an effort to find and eliminate every defective part, the manufacturing process must be setup to highlight the defects. Workers should be encouraged to draw attention to any part that is found to be faulty.

3. Make production people responsible for quality. By making the production people responsible for the quality of their parts or their

work on a part, costs can be reduced and quality increased. Production people must be trained on quality issues so that they are in a position to inspect the quality of the work they are performing.

4. Allow production people to stop the line. If the production work force is to take responsibility for quality seriously and to make sure there is no pressure by individual foremen or supervisors to put production quantity above product quality, every production worker must have the authority and responsibility to stop a process or shut down an assembly line, if a problem develops that cannot be solved in the time available. It is important that the people who find the problem can act immediately to save time and bring high visibility to every problem.

5. Make workers do their own rework. If workers rework all their own faulty parts, they will become more aware, quantitatively and qualitatively, of these bad parts. The need to be responsible for quality and to rework all their own errors will stimulate the production workers to resist making bad parts. It will cause workers to take a greater interest in the adjustments, maintenance, and setups of the manufacturing equipment.

6. Make maintenance the responsibility of the worker. A production worker who is using a particular piece of machinery is the person should know that piece of machinery best. Ensuring that the worker does maintenance on his machine will eliminate the temptation to misuse the equipment and will reduce the number of breakdowns during production time.

7. Install automatic measuring devices. With the electronic and pneumatic measuring devices that are now becoming available, it is feasible to test the quality of every part after every operation. While they are not strictly necessary, they can contribute to improved quality on a large scale.

Leon Crosby emphasises that his programme is a continuous process and after all or most of the steps are implemented, the work on quality is not complete. Training people and looking for improvements is an ongoing process.

3.2.2 COMPARISON OF AVAILABLE QUALITY PROGRAMMES

3.2.2.1 Comparison Grid

So as to do a comparison of the different quality programmes, all the basic steps, defined by the different authors, have been identified and setout on a grid (Figure 4 on page 32). This enables a comparison of the steps to be performed, based on the acknowledgement that each author has given to these steps. The scoring is based on the following point system:

4 points : Very strong acknowledgement of the step's importance, by the author, to the success of the quality programme.

PROGRAMME STEPS	PHIL CROSBY	J.M. JURAN	LEON CROSBY	DAVID HUTCHINSON	SCORE X	SCORE %
Management Commitment	4	4	3	3	14	87.5
Worker Responsibility	2	1	4	0	7	43.75
Quality Improvement Team	4	4	1	4	13	81.25
Organisation	3	4	1	4	12	75.0
Training	4	2	4	3	13	81.25
Education	3	2	3	2	10	62.5
Automatic Measuring Devices	0	0	4	0	4	25.0
Quality Awareness	4	2	3	1	10	62.5
Problem Identification	3	4	4	4	15	93.75
Problem Analysis	3	4	1	4	12	75.0
Quality Costings	4	3	1	3	11	68.75
Corrective Action	4	4	2	4	14	87.5
Recognition	4	3	3	1	11	68.75
Motivation	3	2	3	1	9	56.25
Quality Measurement	4	2	3	2	11	68.75
Quality Planning	4	3	2	2	11	68.75
Maintenance & Improvement	4	4	3	4	15	93.75
Quality Councils	4	2	1	3	10	62.5

Figure 4. Comparison Grid

Qualification- It is used specifically as a main step within the programme's structure.

3 points : Strong acknowledgement of the step's importance, by the author, to the smooth implementation of the quality programme.
Qualification- Together with other steps, it forms the basis of a main step in the programme's structure.

2 points : Acknowledgement of the step's importance, by the author, to definite benefits that can be derived from it.
Qualification- Mention of its importance is made within a relevant step in the programme.

1 point : Little acknowledgement of the step's importance is made, by the author, indicating that possible benefit can be derived from it.
Qualification- Vague mention of the step within the programme.

0 points : No acknowledgement of the step is made, by the author, in his programme, indicating that the step has no true value to offer the programme.
Qualification- No mention of it is made anywhere in the programme's structure.

Having assigned each author's points to the individual steps, the sum total of points are calculated for each step, together with its corresponding percentage. The maximum number of points that a step can score is 16. The corresponding percentage represents the combined view of the authors to the importance of the step in a quality improvement programme.

3.2.2.2 Results of Comparison Grid

It is understood that each step defined by the authors has some importance to play in a quality programme. Clearly, however, some steps are more important than others. Since none of the authors can agree on which steps should be used to define the basis of a programme, it is necessary to determine these using the comparison grid (Figure 4 on page 32). The results of the grid give an indication of which steps the majority of the authors agree are the most important.

Based on the results obtained, it can be seen that:

- 93.75% of all quality programmes do not end when the required results are reached, but rather carry on maintaining these results while improvements can be made.
- 93.75% of all quality programmes have defined a problem identification stage which identifies the main areas for improvement.
- 87.5% of all quality programmes identify the need to setup an individual stage for corrective action, which provides a systematic method of resolving forever the problems that have been identified.
- 81.25% of all quality programmes require a quality improvement team. The function of which is to ensure smooth implementation and operation of the programme.
- 81.25% of all quality programmes have identified the need to train all employees, about the job that they perform as well as on quality issues.

3.2.3 PROPOSED QUALITY PROGRAMME

For the purpose of proposing an improved quality programme, the 6 above mentioned steps have been chosen to form the basic structure. These steps have been selected on the basis that in each case over 80% of the authors have used them as a primary stage in their respective quality programmes.

Thus the 6 stages of the proposed quality improvement programme are:

Stage 1 : Obtain a serious **MANAGEMENT COMMITMENT** through personal participation in the programme, so as to raise the level of visibility for quality.

Stage 2 : Bring together representatives of each department to form the **QUALITY IMPROVEMENT TEAM** who can give direction and advice on the improvement programme.

Stage 3 : **TRAIN** all employees about quality so that resistance to change can be reduced and a high level of awareness and motivation can be achieved.

Stage 4 : **IDENTIFY PROBLEM AREAS** which are the most important contributors to the total cost of quality, so that improvement can be directed towards these specific areas.

Stage 5 : Setup a programme to ensure that **CORRECTIVE ACTION** is taken to eliminate the cause of a quality problem, once the error has been identified.

Stage 6 : Ensure that QUALITY MAINTENANCE AND IMPROVEMENT is an ongoing process which does not end once the initial goals are reached.

3.2.4 PROGRAMME APPLICABILITY TO JIT/TQC

The programme discussed in this report has outlined the necessary steps that must be taken to improve quality in a manufacturing environment. It is now necessary to identify how this programme is directly applicable to a JIT/TQC environment.

3.2.4.1 ANALYSIS OF PROBLEM AREAS IN MANUFACTURING

Studies of manufacturing firms show that several common problems exist (Ebrahimpour and Schonberger, 1984):

1. Underutilization of both workers and equipment.
2. Inferior quality.
3. Unreliable and long lead time.
4. High rate of scrap and defects.
5. Poor and inadequate maintenance.
6. Shortage of raw material.
7. Shortage of skilled workers.

8. Lack of appropriate supervision.
9. Informal and casual quality control.
10. Low productivity.

All these problems can be diminished by Just-in-Time and Total Quality Control, with the use of quality improvement techniques such as is described in this report. Where such techniques are seen to be applicable to JIT and TQC, the relevant chapters are indicated.

The first problem, **underutilization of resources**, is lessened chiefly by JIT which requires workers to be multifunctional: they run multiple machines and are capable of moving where the work is. This keeps workers and equipment busy and can be achieved through worker training and education (Chapter 6). In addition, under TQC, workers are kept busy on quality improvement projects which should be ongoing within the company (Chapter 9).

Next in the list is the **problem of poor quality**, which JIT deals with naturally: with small production quantities, errors are uncovered soon. All aspects of TQC apply directly to quality problems, and many plants already follow one key TQC principle: quality responsibility assigned to production people rather than to a quality control department. In many cases, however, both within JIT and TQC, the production people of western companies lack the skills (Chapter 7) for identifying errors, measuring quality, analysing defects, etc., which Japanese workers and foremen have developed.

The third problem is **unreliable and long lead times**. JIT dramatically cuts lead time by reducing setup times and lot sizes at each process. With

small lot sizes, work stations along the flow path can be close enough together to permit fast hand-to-hand transport, which cuts the transit-time. This requires the removal of everything from the work environment that is not needed for production activity in the near future, such as excess equipment, work-in-progress inventory, tooling, etc. (Chapter 8; section 8.4.1). Purchase lead times can also be improved if companies help their suppliers to adopt TQC because the suppliers' manufacturing time is similarly affected by poor quality (Chapter 8; section 8.2).

High rates of scrap, fourth in the list, is forcefully attacked by JIT and TQC. The JIT rationale is the avoidance of large lots high in defectives. All aspects of the quality improvement programme in this report serve to reduce scrap.

Fifth is **poor and inadequate maintenance**. JIT workers pitch in to clean up their own areas and also perform some preventative maintenance and repairs (Chapter 8; section 8.4.1).

Shortage of raw material, the sixth problem, cannot be coped with by JIT/TQC to any large extent. But waste of materials through scrap is avoided as seen by the fourth problem above. Furthermore, close relations with vendors helps to ensure reliable supplies of raw material (Chapter 8; section 8.2).

Problem number seven, **shortage of skilled workers**, is worsened in some respects but improved in others by JIT/TQC. JIT plants need not only skilled but multi-skilled workers, and TQC requires that workers and foremen become knowledgeable and skilled in the use of quality control techniques. However, within JIT and TQC's climate for worker involvement,