INITIATION OF JUST-IN-TIME (JIT) MANUFACTURING TECHNIQUES AT KROST PRESTIGE

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Johannesburg, 1988.

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.

(Signature of Candidate)

9 day of AUGUST 1988.

ABSTRACT

The report deals with the introduction of Just-In-Time (JIT) manufacturing to the Kitchen Units Department of a company involved in the manufacture of steel based, consumer, household products. The application of the philosophy to the department is seen as a means of improving its productivity and competitiveness.

A strategy is developed for a company wide adoption and conversion to JIT. Included in the strategy are a project by project approach to implementation as well as a JIT framework, originally developed by Bicheno [1] and later modified by Nestadt [2]. The framework is utilized as a means of conceptualizing the various JIT techniques, and as a structure for discussing those techniques such as People Involvement, Training, Layout, Setup Reduction, Small Machines, Scheduling (Kanban), and Lot-size Reduction that were initiated within the department. Various suggestions for the initiation of these techniques are presented together with the appropriate initial results from their application. The existing symbiotic relationships between the techniques are also highlighted.

Finally, although the report deals specifically with the [illegible]on of the techniques within the Kitchen Unit [illegible] of the company, the principles and ideas expr[illegible]re transferrable throughout the entire company and, in fact, throughout any manufacturing concern willing to begin the JIT journey.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

When discussing Just-In-Time (JIT) Manufacturing and its introduction to a specific environment, the topic may be dealt with on three levels.

* The JIT Philosophy : which deals with the ideals and objectives of JIT.
* The JIT Strategy : which deals with a particular plan for the implementation of JIT.
* The JIT Tactics : which deal with the actual techniques that constitute a JIT environment.

1.1 Introduction to the JIT Philosophy

Just-In-Time (JIT) manufacturing, also known as Japanese Manufacturing Techniques, JIT/TQC, Zero Inventories, Kaizen, Stockless Production as well as by a host of other names, encompasses a range of techniques that have been "distilled from worldwide experience in manufacturing" [3].

A reason for the many names probably stems from the broad range of techniques included in the system, as well as the inability of a short phrase or acronym to fully describe the total power and scope of the

system. A more appropriate name for JIT would probably be "World Class Manufacturing" [4], a name which suggests a combination of the very best practices and techniques into a broad philosophy. Once the philosophy is firmly in place, however, it no longer needs any special names [5]. For the purpose of continuity and the fact that a growing number of authors dealing with the topic refer to the above mentioned philosophy as JIT, the acronym, JIT, will be used throughout this report to describe the philosophy.

JIT has a provocative goal which may be stated as: "to produce instantaneously, with perfect quality and minimum waste". This goal will never be reached, but it gives a clear indication of the direction in which to move. A more reasonable definition is. "to have only the right materials, parts, and products, in the right place, at the right time." [6], leads to the establishment of the following JIT objectives:

* Reduction of lead times for:
  Customers,
  Materials,
  Tooling and Engineering Changes,
  Introduction of new products.
* Reduction of inventories.
* Reduction of costs.
* Improvement in quality.
* Exposure of problems.
* Development of people.

* Continuous Improvement.

These objectives are all interconnected and relate to the primary objective of FINDING AND ELIMINATING WASTE.

Taiichi Ohno, Vice President of Toyota Motors defines waste as: "... anything other than the minimum amount of materials, manpower, machines or tools necessary to production ..." [7]. Hall [8] extends this definition to *"Anything that does not add value to the product or service, whether material, equipment, space, time, energy, systems or human activity of any sort"*. The latter definition, in accordance with the intended scope of JIT, relates not only to the production environment, but also to the entire manufacturing concern.

Before eliminating waste, however, waste needs to be identified. Shingo [9] states that "unfortunately, real waste lurks in forms that do not look like waste" and "only through careful observation and goal orientation can waste be identified". Thus in order to identify waste more *easily, seven categories of* waste have been defined. A brief summary and *commentary on these seven wastes* is presented in the table below.

1. Waste of overproduction - Eliminate by reducing setup times, synchronizing quantities and timing between processes compact layout, visibility, and so forth. Make only what is needed now.

2. Waste of waiting - Eliminate through synchronizing work flow as much as possible, and balance uneven loads by flexible workers and equipment.

3. Waste of transportation - Establish layouts and locations to make transport and handling unnecessary if possible. Then rationalize transport and material handling that cannot be eliminated.

4. Waste of processing itself - First question why this part or product should be made at all, then why each process is necessary. Extend thinking beyond economy of scale or speed.

5. Waste of stocks - Reduce by shortening setup times and reducing lead times by synchronizing work flows and improving work skills, and even by smoothing fluctuations in demand for the product. Reducing all other wastes reduces the waste of stocks.

6. Waste of motion - Study motion for economy and consistency. Economy improves productivity, and consistency improves quality. First improve the motions, then mechanize or automate. Otherwise there is a danger of automating waste.

7. Waste of making defective products - Develop the production process to prevent defects from being made so as to eliminate inspection. At each process, accept no defects and make no defects. Make processes fail-safe to do this. From a quality process comes a quality product - automatically.

Table 1.1 The Seven Wastes. source: [10]

The reduction of inventory is a JIT technique that is used to expose the problems that feed waste. This process is explained by using the following "water and boat" analogy.

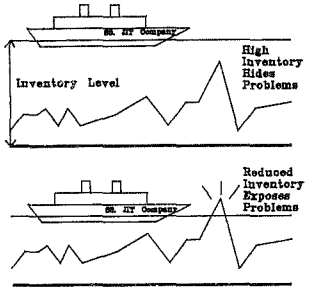


Figure 1.1 "Water and Boat" analogy of Inventory Reduction.

A company's inventory level is depicted by the water level in the diagram. The inventory is used to cover problems; ie. it serves as a buffer against unforeseen problems. Excess inventory also results in increased manufacturing costs, increased lead times, reduced feedback on quality, and less effective communication. JIT proposes a reduction in inventory so as to deliberately expose these problems. In this way the problems may be identified and then solved.

Other JIT techniques including Setup Reduction, Group Technology, Kanban, and Total Quality Control form part of the approximately thirty JIT techniques which provide "the tools for simple systems implementation", flexibility and "control by visibility" [11].

Finally, in order to emphasize the ongoing nature of JIT, the author has *specifically chosen* to use the word "initiation" and not "implementation" in the title of the report. The word *"implement" connotes* finality, a quick fix approach which begins and ends. This is definitely not the case for JIT. Thus in order to ensure the successful adoption of JIT within a company, top management should understand JIT as an infinite process, "a journey, a ceaseless pursuit of premier performance" [12].

1.2 Background to the report

Krost Prestige, formally known as Krost Bros. (Pty.) Ltd., is a company involved primarily in the manufacture of steel based, consumer, household products. The products range from post boxes and garbage cans to kitchen units and kitchen utensils.

Towards the middle of 1987, the author was interviewed and was subsequently offered an assignment to the company. The job involved working part time, for six months, investigating and initiating JIT techniques at the company. By the time the author had actually joined the company, however, it had undergone a change *in ownership, together* with a corresponding change in name (ie. to Krost *Prestige) and management*. Although this event had no significant effect on the initial investigation, it would prove to be a major factor in influencing the ultimate success of actually initiating JIT.

1.2.1 Selection of a pilot project

It was decided to begin the investigation and initiation of JIT within a pilot project. The criteria used for selecting the specific pilot project were: [13]

(a) Choose *a likely winner*.
(b) Production should be capable conceptually of assembly line type flow.
(c) Good quality.
(d) High process reliability.
(e) Good labour/management rapport.
(f) The area should possess obvious opportunities for

improvement.

After considering the above criteria, the management of Krost Prestige selected the Kitchen Units (K.U.) department as the point of departure for the JIT journey. The department manufactures steel kitchen cupboards, sink units and gas stoves which are aimed at the lower income, "black" South African market, and which are sold to furniture retailers throughout the country. The department might, therefore, be grouped under the heading of Kitchen Furniture or under the broader industrial classification of the Furniture Industry.

While conforming to most of the above criteria, the K.U. department was, however, experiencing some major problems which also face the South African Furniture Industry in general.

By examining the productivity growth rates for South African manufacturing industries, figure 1.2 indicates that the Furniture Industry is experiencing the lowest productivity growth rate. In fact, the productivity growth rate for this industry is negative, which indicates that the value of output per unit of labour input is actually decreasing.

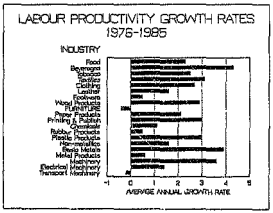


Figure 1.2 Productivity growth rates for South African manufacturing industries 1976-1985.
source:[14].

Furthermore, figure 1.3 indicates that from an inter-industry comparison, the Furniture Industry yielded the second lowest Return on Investment (ROI) for 1985 and the second largest drop in ROI from 1983 to 1985. Since the ROI is defined as the net profits expressed as a percentage of total assets, and the percent ROI is shown as being negative, companies within this sector have, on average, declared losses for that year.

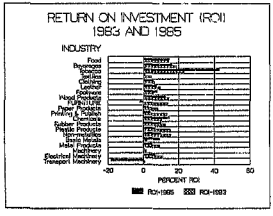


Figure 1.3 Inter-industry comparison of Return on Investment (ROI) for 1983 and 1985.
source:[15].

The consequences of these indications have expressed themselves in the form of reduced profits, reduced sales, reduced cash flows and increased manufacturing costs. More specifically, the K.U. department at Krost Prestige was also suffering from increased competition, large work in process inventories, long lead times, scheduling problems, motivational problems and poor quality. It is towards solving these problems that the JIT philosophy addresses itself. Thus "JIT is not just a way to reduce inventory, in order to get a better return on assets;

it is a means of solving problems that block the building of an excellent manufacturing organization."[16].

1.2.2 Aims of the report

The report deals with the results, insights and experiences gained from this working experience. The major objective is to develop a strategy for JIT implementation, and more specifically to present methods so as to introduce some of the JIT techniques to the K.U. department as a means of solving the above mentioned problems. Furthermore, the report intends to present the JIT strategy and the application of the techniques in such a manner so that they may be transferred throughout the entire company, and in fact, throughout any manufacturing concern willing to begin the JIT journey.

1.3 Chapter Outline

Before beginning with the implementation of the actual JIT techniques, it is necessary to prepare the company and its people for the adoption of the

philosophy.

Chapter 2 is concerned with literature survey, dealing specifically with the strategic and technical aspects of JIT.

Chapter 3 then advances with the strategic or planning stage of implementation. Here, a strategy based on four original strategies that are presented in the previous chapter, is developed and presented for a company wide approach towards adopting the JIT philosophy. Included in the strategy is a JIT framework (The Head-Vehicle-Driver Framework) which is applied as a means of conceptualizing the JIT techniques. The framework is also used as a structure for the remainder of the report, in which to discuss the technical details of implementation within a case study.

The following four chapters deal with the application of the JIT implementation strategy at Krost Prestige. Chapter 4 introduces the manufacturing environment of the Kitchen Units Department in which the organization of people and the manufacturing processes are discussed.

Chapters 5, 6 and 7 then deal with those techniques that were initiated within the K.U. department of the

company and that fall under the Head (Training), Vehicle (Layout and Setup Reduction) and Driver (Scheduling) stages of the JIT framework respectively. In each case, suggestions for and initial results from implementation are presented.

2. LITERATURE SURVEY

Since the report deals with the development of a strategy for JIT implementation and its application towards initiating JIT within Krost Prestige, this survey deals with the strategic and tactical aspects of JIT.

2.1 JIT strategies

The noun, strategy, as used in this case, is defined as: "a plan or method devised for attaining an end". In this sense, a JIT strategy deals with a specific plan or approach towards a company wide implementation of JIT. The objective of such a strategy is to direct the implementation effort so as to improve the probability of successful JIT implementation and achieve the fastest and most beneficial results from the techniques themselves. The following four approaches were considered as strategies for implementation at Krost Prestige.

2.1.1 Mayne's step-by-step guide to JIT implementation

L.B. Mayne, a consultant for Arthur Young and Company, presents a nine step strategic approach towards JIT implementation. The approach, which is "based on several hands-on experiences with conceptualizing and then realizing the power of JIT", is summarized below: [17].

A prerequisite for a successful JIT implementation is the total commitment from top management. Mayne has thus defined eight "management musts" which should precede and parallel the steps towards implementation. These "management musts" are presented in Appendix A. Once a commitment has been made and demonstrated (ie. noted by a change in management's attitude and a commitment of the necessary resources towards change) the following implementation steps can be carried out.

(1) Get Educated. This step is achieved through reading some of the extensive literature that is available on the topic, attending seminars and going on field trips to companies that have already begun the JIT journey.

(2) Make sure that the senior line manager of your facility wants to make the transition to Just-in-Time and is prepared to make the personal commitment, which will lead to the total factor commitment, which will cause the necessary

changes to occur. The top person does not have to be the JIT champion in your company, but whoever the champion is must have the respectful ear of the top person. If this condition is met, then management is, in a sense, leading the transition, and the likelihood of success dramatically increases.

(3) Hire an outsider to be your guide, catalyst, objective reviewer, alter ego, and conduit for communication.

(4) Understand who has to do what. The assignment of responsibility to the various disciplines within the company is shown in Appendix B.

(5) Train and motivate the hourly employees. There are some excellent Small Group Improvement Activity (SGIA) programmes available that encourage employee involvement and that enable the harnessing of the power of group problem solving as a means of smoothing the way to JIT manufacturing.

(6) Select a Pilot Project Line. By choosing a self contained pilot project line (not pilot project department), you will have a better chance for an early success, will learn by doing, your mistakes will not be devastating, you'll find out what works and what doesn't, you'll have a chance to train some people and learn how to do that training, and you'll radiate inquisitive

enthusiasm throughout your operation.

(7) Establish the baseline. Where are you currently in terms of manufacturing lead time, inventory, labour content, space consumption, quality cost, material procurement costs, and on time delivery performance? Establish the goals. Where do you want to be in terms of these items and others you believe important?

(8) Conceptualize the physical and systematic configurations which will enable JIT manufacturing.

(9) Develop a detailed plan for reaching the conceptual configuration. Be certain to include provision for the education which is needed.

Comments:

Although the above strategy, developed by Mayne, is good in that it presents a planned step-by-step guide towards JIT implementation, it does not follow through in enough detail. This aspect is shown in steps one and three, which neglect the issues of who should be educated, how much education should take place, and what to consider for the training and motivation of hourly employees respectively. Steps eight and nine of the strategy are also not specific

enough with respect to the application of the actual JIT techniques, ie. what JIT techniques are to be considered and which techniques should one begin with? The order in which the steps are presented might also be questioned, since the training of hourly employees in small groups is stated as being an advantage of the pilot project approach, and yet the training stage is mentioned before the stage of pilot product line selection. Also, the specific reference to a pilot product line, and not a pilot project, assumes that the company is large enough for a single product line to constitute an area large enough to demonstrate the benefits of JIT. Finally, the strategy does not emphasize the ongoing nature of the philosophy in that step nine leaves the reader stranded, asking the question 'what to do next?'.

2.1.2 Voss' strategy for implementing JIT

Included in the book "Just-in-Time Manufacture" (a collection of articles on various aspects of JIT manufacturing) is an article written by Voss, on "Strategies for Implementing JIT" [18]. Although the article does not present a step-by-step guide towards implementing JIT, it does deal with a number of points which might be taken into account when

considering the introduction of the philosophy. These point are summarized below:

- The use of Bicheno's "Vehicle-Driver" JIT framework [19] as a means of conceptualizing and applying the actual JIT techniques within a company. (This framework is discussed in greater detail at a later stage in the report).
- A pilot project approach towards initiating JIT.
- The establishment of a Steering Committee, Project Manager and Project Team as a means of organizing for the implementation effort.
- A total backing, by management, for the above mentioned groups to implement changes without delay.
- The training of employees by various means such as going on field trips, videos, in company courses, the use of consultants and attending courses run by external institutions.

Comments:

The major criticisms concerned with Voss' strategy are its lack of sequential progression and detail. These are evident in the manner in which the points need to be extracted from the article, and the

brevity with which each of the points are considered. Examples of the lack of detail are clearly evident in the aspects such as *training* and *management* commitment, which are only briefly mentioned as requirements for a successful implementation. Thus it is left up to the reader to decide on where to begin, what is required and in which direction to move with the implementation effort. The article is, therefore, not really successful in presenting a complete plan that may be useful to someone wanting to implement JIT. It does, however, highlight the use of a framework in which various JIT techniques are considered, as well as mention a number of points which might be included into a more detailed, *sequential* approach towards JIT implementation.

2.1.3 Schonberger's "Strategy Revealed"

The third strategy presented is one developed by Schonberger, the man attributed as being one of the first to successfully bring the philosophy of JIT manufacturing to the attention of the West, and is included in his book *"Japanese Manufacturing* Techniques" [20]. Since the strategy is too detailed to present in its entirety within the report (three chapters of the book), the following aspects

represent a summarized version of the actual approach.

Schonberger begins by emphasising the managerial support required to manage the transformation towards JIT manufacturing. Here, a strong executive or at least upper management commitment is required in order to effect the necessary changes and commitment of resources needed for the adoption of the philosophy. In fact, the success of the programme will depend almost entirely on how the transformation towards JIT manufacturing is managed. Thus management itself should evolve to include the involvement of all employees in a type of "blended management" which does not merely arrange resources in order to produce goods and services, but is involved with the marshalling of resources for continual and rapid improvement [21].

The next issue, concerning the question of "where to begin?", is dealt with by the Total Immersion approach. Instead of the usual pilot project approach used when introducing a new concept, Schonberger advocates a total immersion approach where JIT is introduced throughout the company, everywhere at once. The objective is to challenge every stage of manufacture to move away from batches and towards the sales rate [22].

The third issue deals with Training, the importance of which is emphasised in the following statement: "Implementation plans are usually boxes with words in them connected by arrows. I (Schonberger) have such a plan for WCM (JIT). It comprises half a dozen arrow connected boxes, and the word training in each one. If you prefer a fancier word, you can put "education" in a few of them" [23]. Although no single approach to training is suggested, Schonberger states that a common factor in successful programmes is the inclusion of direct labour and first-line supervisors early on in the training programme. Methods such as attending seminars, book reading, formal corporate training, obtaining information from professional societies and schooling are all discussed as a means of providing educational material for training in JIT.

Once these three issues have been considered, the following 17-point action agenda for manufacturing excellence is presented.

1. Get to know the customer.
2. Cut work-in-process.
3. Cut flow times.
4. Cut setup and changeover times.
5. Cut flow distance and space.
6. Increase make/delivery frequency for each required item.

7. Cut number of suppliers down to a few good ones.
8. Cut number of part numbers.
9. Make it easy to manufacture the product without error.
10. Arrange the work place to eliminate search time.
11. Cross-train for mastery of more than one job.
12. Record and retain production, quality, and problem data at the work place.
13. Assure that line people get first crack at problem solving before staff experts.
14. Maintain and improve existing equipment and human work before thinking about new equipment.
15. Look for simple, cheap, movable equipment.
16. Seek to have plural instead of single work stations, machines, cells and lines for each product.
17. Automate incrementally, when process variability cannot otherwise be reduced.

The objective is the solution of those problems that block manufacturing excellence, while striving for continual and rapid improvement.

Comments:

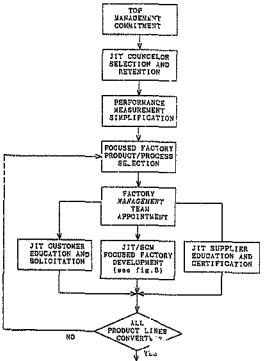
The strategy presented by Schonberger is based on his vast experience gained as a consultant. The plan is

therefore excellent with regard to detail and points considered. A major weakness is, however, the Total Immersion approach, which is flawed in that it assumes a company has sent "busloads of people on training sessions or to tour other advanced JIT/TQC plants" [24]. A second disadvantage of this approach is that training and education programmes are required to be carried out throughout a company, before the Total Immersion approach can be applied. In larger companies, this would require an enormous training effort spaced out over a long period of time, which contradicts Schonberger's statement that "the training effort must somehow be streamlined so that it doesn't keep progress on hold" [25].

With regard to the 17-step action agenda the *treatment of the actual JIT techniques* associated with each of the 17 points is thin, since no actual techniques are mentioned as a means of dealing with any of the points. An advantage of this approach, however, is that the agenda remains highly flexible, leaving it up to the user to decide which techniques to apply so as to meet the requirements of manufacturing excellence.

2.1.4 Heard's JIT implementation plan

This final strategy is taken from an article termed "A JIT implementation plan and a platform for selling it to top management", written by Ed Heard [26]. The implementation plan, which comprises of a number of flow chart diagrams is shown below:



(A)

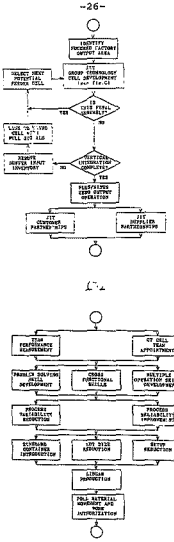


Figure 2.1 Heard's strategy for JIT implementation.

Most of the individual stages shown within each diagram are self explanatory and are individually dealt with in the article itself. Items to note, however, are the emphasis on the selection and development of focused factories or "factories within factories" as the starting point for the selection of a JIT pilot project, the use of the pilot project approach and the inclusion of the actual JIT techniques within the strategy.

Comments:

The presentation of the strategy within a flow chart is good in that it provides the reader with the logical outline of a sequential plan that is detailed, yet easily understood. Also, the plan has been developed so that it "is sufficiently specific for individual plants and general enough for divisions and corporations" [27]. Perhaps, the only criticism is that the strategy is too complex, a fault which is not in accordance with the JIT principle of simplicity, and which might result in confusion or fear when considering such a strategy.

Thus far, the survey has dealt with the strategic

aspects of JIT. Once a strategy has been selected, however, it becomes necessary to begin implementing the actual JIT techniques as a means of striving towards manufacturing excellence.

2.2 JIT tactics

The purpose of this part of the survey is not to enumerate the hundreds of articles and books that have been written on the JIT techniques, but rather to mention those that the author considers worthy of reading and that will provide the reader with a source of reference that will enable a greater understanding and knowledge of the subject.

Books written by Schonberger [28,29] and Hall [30,31] are considered as classical readings on the subject of JIT. Both authors were instrumental in bringing the philosophy to the attention of Western industry and for for showing that it was not culturally bound. Their first books, namely "Japanese Manufacturing Techniques" and "Zero Inventories" respectively present detailed discussions on the various techniques included in the philosophy, offering explanations as to their effectiveness and demonstrating how they may be applied within Western

industry. Although the books are geared specifically towards American industries, they demonstrate the universal nature of the techniques and their applicability within almost any industry. The only criticism of the books is that they tend to become a bit too technically oriented, with the result that they might not appeal to those not directly involved in manufacturing.

Enter Schonberger's and Hall's second generation JIT classics, "World Class Manufacturing" and "Attaining Manufacturing Excellence" respectively. In these books, both authors extend the JIT philosophy to include the entire manufacturing organization. Thus, JIT is presented as a means of improving an entire company's competitive stance. The books both emphasize the important "people" aspects, which need to be considered when implementing the philosophy, and also include a number of examples of manufacturing excellence from companies that have already embarked on the JIT journey. The books are less technical than the previous two, and are aimed at guiding management in the implementation of the philosophy.

The book "Kaizen", by Imai [32], deals more with the philosophical aspects of JIT and its management. The word "kaizen", meaning "gradual, unending

improvement" is used throughout the book as the basis of an analytical approach towards competitive success. Although the book might prove too complex for those wishing to start learning about JIT, and lacking in detail with respect to the application of specific JIT techniques on the production floor, it is excellent in dealing with the more advanced concepts relating to the intended scope of JIT, its integration as a corporate philosophy, and the development of the type of management commitment required to attain manufacturing excellence.

Articles written by Wantuck [33] and Finch [34] also deal with the JIT philosophy and techniques in general. Both authors, however, discuss the topic in relation to small manufacturing environments (ie. within companies employing less than 1500 people), an aspect which is of particular relevance to this project. Wantuck's article goes further than just the presentation of theory and documents a number of JIT applications within small American companies. Bicheno [35] discusses the applicability of the specific JIT techniques within his "Vehicle-Driver" JIT framework (which is discussed in the following chapter) and addresses the application of the techniques to South African industry [36]. Being articles and varying between 4 and 10 pages, the above four references lack detail, especially with regard to considering

the JIT techniques themselves. They do, however, address a number of issues not considered in the above mentioned books, and are therefore useful in contributing to the reader's understanding of the subject.

Some of the individual JIT techniques, namely Total Quality Control (TQC), Layout, Setup Reduction, People Involvement and Training are large enough to be considered complete subjects within their own right.

Groocock's book "The Chain of Quality" [37] presents a comprehensive, "textbook" approach to the topic of TQC. The objective of the book is to highlight the strategic importance of product quality as a means of gaining market dominance, and detail the theory, pitfalls and practices associated with implementing a TQC programme. All aspects of an effective quality programme are discussed, ranging from the determination of a customer's needs through the design and manufacture of a product, to an evaluation of the final product as perceived by the customer. Also included is a discussion on the organization and planning required for the implementation of such a programme, and the role of staff managers within such an environment.

Schonberger [38] and Burbidge [39] both deal with the concepts of Group Technology (G.T) and Cellular Manufacturing (C.M) and their application towards plant layout. Schonberger's article deals specifically with C.M and its applicability as a Just-in-Time concept. Organizational aspects, operational examples and those advantages arising from the formation of U-shaped production cells are also discussed. Burbidge, a pioneer in the application of G.T techniques, presents the most comprehensive coverage of the concept and its application towards plant layout. In his book "The introduction of Group Technology", aspects ranging from motivation for utilizing the concept, through the development of various approaches for implementing G.T to a discussion of actual results are presented. These factors make the book invaluable as a source of reference and guide to the topic.

The concepts of Setup Reduction are best described by Shingo [40], the man responsible for the majority of pioneering work carried out in this field. In his book, Shingo details the theory behind his Single Minute Exchange of Die (SMED) approach towards reducing machine setup times. The book deals not only with the theory and fundamentals surrounding the approach, but also provides practical, comprehensive examples of setup reduction techniques, described

within case studies. The benefits of SMED, including its contribution towards JIT manufacturing are also discussed.

Nickola [41,42], Nestadt [43] and Clark [44] have all dealt with the Training and People Involvement (P.I) aspects of JIT. Nickola and Clark suggest various factors such as worker's needs, attitudes, people leverage, and the concepts of ownership and participation to consider when introducing the techniques, whereas Nestadt cites some specific examples on the application of these "people" techniques at various companies. Both Nickola and Nestadt then relate the introduction of these techniques to the South African environment and include discussions on issues of JIT relating to politics, education, social structure and unions within the country. Clark's article, on the other hand, is more theoretical (ie. dealing with the theory relating to the techniques) with perhaps a slant towards American industry. Suzaki [45] deals specifically with the issue of JIT and worker participation. In his article, comparisons are made between the application of P.I techniques in Japan and America. Insight is given as to why these programmes have been more successful in Japan, thereby highlighting aspects that contribute to the success of P.I.

Finally, the concepts of management and their pivotal role in managing the changes required by JIT have been detailed in the above mentioned references of Imai and Schonberger. Articles by Huge [46] and Bell [47], however, consider these aspects from slightly different viewpoints, dealing with the practical aspects *associated with applying* strategies towards developing the type of leadership commitment required for World Class Manufacturing and the psychological aspects facing the middle manager wanting to bring about these changes within an organization, respectively.

3. A STRATEGY FOR JIT IMPLEMENTATION

The strategy for JIT implementation, presented in this chapter, was developed in response to the criticisms and flaws found in those described in the previous chapter. In developing such a strategy, the positive attributes from each of the previously mentioned strategies were combined so as to meet the following objectives. The strategy should:

1. Be easy to understand and apply.
2. Conform to the "Keep it simple" principle of the JIT philosophy.
3. Be flexible so that it may be applied within almost any company.
4. Be capable of incorporating new JIT innovations.
5. Be detailed enough so that the user will not be left in any doubt as to what is required and in which direction to move.
6. Enhance the probability of successful implementation.

Figure 3.1 presents a schematic of the strategy developed for JIT implementation. When considering the use of the strategy, the stages presented should be tackled in the consecutive order as shown. All stages, however, are interrelated and none have a definite ending, thus a successful implementation

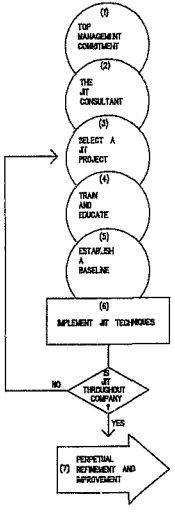


Figure 3.1 A Strategy for JIT Implementation.

will have all stages present, running parallel to each other, with each stage becoming an integrated part of the company's operating philosophy.

3.1 Top management commitment

"Successful implementation to the degree achieved by world class manufacturers requires an enormous change in company culture. This cultural change can only be accomplished by highly committed top management leadership" [48]. This total commitment from top management is conceptually achieved in two phases. The first phase deals with top management education, and the second with the expression of that commitment.

The role education plays in securing top management commitment is described as follows:
Only after becoming aware of some of the benefits of JIT can top management commit to any type of JIT effort. An initial commitment must, therefore, lead to further education which in turn enables management to realize the absolute commitment needed in order to "take a business through the kind of revision of business strategies, structures, policies, procedures, and practices necessary to achieve the

promise of JIT" [49]. In fact, the intensity with which top management pursue an education and investigation into JIT "is an excellent early indication of the likelihood that implementation will succeed" [50]. Ed Heard [51], a JIT consultant, has therefore suggested a minimum of 200 points worth of top management education, where:

one seminar hour = 10 points

one [illegible] hour = 6 points

one [illegible] hour = [illegible] points.

This education could be obtained by reading the referenced books by Hall, Schonberger and Hall, as well as by attending seminars conducted at universities and by professional societies such as the South African Production and Inventory Control Society (SAPICS). However, even with this education, "understanding all the implications necessary to appreciate and commit to the change required takes a while" [52].

"Management commitment is tested and tested until it can be assumed" [53]. Thus, the expression of commitment from top management will reflect the type of dedication required by the company's employees. The following steps are suggested as a means of demonstrating this total commitment:

(a) The company JIT policy - The company should make a statement to the effect of adopting the JIT

philosophy. The statement should reflect the main objectives of JIT, and should be displayed throughout the company. An example of such a statement, displayed at Afrox Gas Equipment Factory, is presented in Appendix C.

(b) Get high level executives to actually conduct classes as part of a JIT educational programme - "It is hard to think of a more effective way for an executive to show genuine backing of a campaign. Serving as a trainer also assures that the executive thoroughly understands. It doesn't matter much whether the executive is particularly good as a trainer. Everyone understands that signalling commitment is the real purpose" [54].

(c) Assign a JIT taskforce - The third step requires the formation of a JIT taskforce. This taskforce should consist of top management representatives from the various areas in the organization. The purpose of the team is to guide, co-ordinate and support efforts towards adopting JIT.

The above phases constitute the basis for top management commitment. Underestimating the importance of this stage will usually lead to superficial results and the eventual downfall of JIT in the company. [55]

3.2 The JIT consultant

Once top management have become convinced of the virtues of JIT, and have committed to its implementation, the next step is to convert that conviction into action. On realizing the scope of the philosophy and the magnitude of the effort required in order to make the changes towards becoming a world class manufacturer, a consultant is usually hired to assist with the structural and cultural changes. Because JIT requires a complete change in the company culture, is not a system that can simply be installed and left to run. The key word, therefore, in determining the extent of the consultant's involvement is ASSISTANCE. The consultant, therefore, assumes the following four roles: [56]

(a) Catalyst - to speed up the rate of productive interaction between interacting areas of the company.

(b) Conscience - to keep the implementation effort on a solid conceptual footing.

(c) Counsellor - to work with management in organizing and planning for the change; ie. to provide assistance in identifying what needs to be done, when it needs to be done, how it should be done, and what resources are necessary to get

it done.

(d) Educator - to train and educate, both white and blue collar workers, in the principles, practices, methods and ideals of JIT.

3.3 Select a JIT project

For a company embarking on the JIT journey, the changes should be seen as evolutionary and not revolutionary. Using a project by project approach enables a gradual and total introduction of JIT throughout the company. Reasons for justifying the use of this approach are:

* The approach has been used many times, when implementing JIT, and has proved highly successful. [57]
* By choosing a self contained project there is a greater chance of earlier success.
* The project provides a means of learning by example. (ie. gaining experience)
* Mistakes, on the whole, will not be devastating to the entire company.
* The approach provides an opportunity to train small numbers of people and gain some experience in effective training methods.
* Results may be used to encourage the adoption of

JIT by other areas in the company.

* The approach provides a learning experience which enables the tailoring of the JIT concepts to a specific business.
* The gradual approach reduces the fears and resistances usually associated with the introduction of new methods and concepts.

The scope of the project depends primarily on the size of the company. Thus, for a large company the project might be a specific product line, whereas for smaller companies the project might include a number of departments. Each project should not be started as a separate entity with all efforts and resources being devoted to it. Rather, the approach should be seen as a number of overlapping operations (see figure 3.2).

Begin with the selection of a pilot project, as described in Chapter One. Once this project has been identified and initiated, transfer the results and experience to the next area where a new project is started. Eventually, using the "staggered" approach, all areas within the manufacturing concern will have begun the journey towards manufacturing excellence.

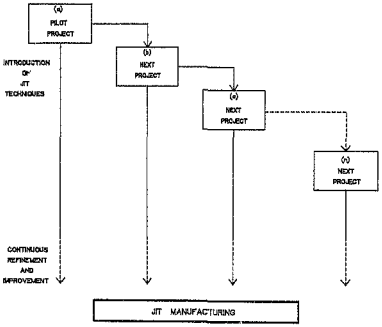


Figure 3.2 Project by project approach to JIT implementation.

3.4 Train and Educate

Training is defined as " an area to which an organization devotes time and effort in order to improve an employee's ability to perform a job or fill a defined role. The primary objective of

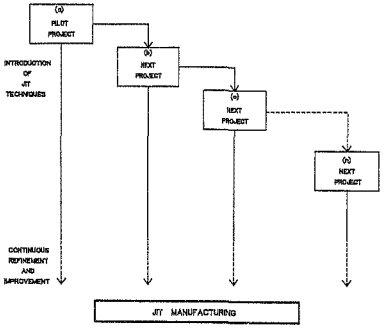


Figure 3.2 Project by project approach to JIT implementation.

3.4 Train and Educate

Training is defined as " an area to which an organization devotes time and effort in order to improve an employee's ability to perform a job or fill a defined role. The primary objective of

training is the acquisition of defined and specified skills, coupled with detailed knowledge. This stands in contrast to education, where the skills acquired are more general in nature and the knowledge more wide ranging." [58]

Schonberger [59] sums up training as "the foundation of (JIT) implementation". Karle [60] states that the common denominator in all successful JIT cases is employee training. These opinions reinforce a number of others, all of which preach "education and training as the keys to success" [61], and serve to emphasize the importance of this stage in the JIT strategy.

In contrast to the first stage, this stage is directed at those levels below top management. More specifically, it is directed at those who are involved with the project selected in the previous stage. In this way, the implementation effort is not held up by a mass, company wide, education/training effort. It should be noted that the lower levels within the organization, namely direct labour, first line supervisors and union stewards must be in on the training from an early stage. The reasons for this are:

a. To stifle false rumours.

b. To show that the worker's opinions are valued and

that their understanding is important.

c. To prevent union resistance by involving them within the training process.

d. Because workers have a clearer view of the waste, excesses and complexities present within their working environment, some of them will tend to become more excited over adopting JIT than anyone else. [62]

With regards to the intensity of the education or training required, Heard [63] suggests between 300 and 500 points (allocated as before). Thus, to ensure successful implementation an education/training programme is required for all personnel - from top management through the lowest levels in the organization, with the type of distribution as shown in figure 3.3.

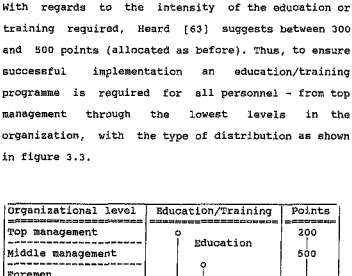


Figure 3.3 Suggested distribution of Education/ Training throughout an organization.

Although the content and length of training differs, depending on who is being trained, a programme should include the principles, tools and techniques of JIT. The broad scope of information required by this type of education cannot be obtained from a single source such as books. Alternate sources of information such as field trips, in-house training and seminars should therefore also be included into the programme.

3.5 Establish a baseline

Preparing for and embarking on the JIT journey involves a complex set of activities whose progress needs to be monitored as it unfolds. It is almost impossible to measure this progress without some baseline which determines the current situation. Thus, before actually introducing any of the JIT techniques, it is suggested that management carry out an audit of the current situation, for the selected project.

Establishing a baseline not only provides a format for monitoring and communicating progress, but it may also serve as a means of establishing specific goals. These goals, in turn, may then be used as motivating factors. The results of the audit may also be used to

define a starting point or to provide a direction in which to proceed when introducing JIT. (Suggestions for baseline measurements are presented in Appendix D.)

3.6 Implement JIT techniques

This stage, often considered as the one and only stage of JIT implementation, deals with the tactical aspects or techniques of JIT. Approximately thirty of these techniques have been identified as contributors towards meeting the JIT objectives. Of these thirty techniques, between ten and fourteen techniques are considered universal, ie. applicable to all types of manufacturing concerns. The presence of these universal techniques are together considered "necessary and sufficient" criteria to represent the structural, cultural, technical, operational and environmental characteristics of a JIT manufacturing organization. [64,65]

A number of JIT frameworks have been developed in order to conceptualize and aid in the understanding of the relationships between the various techniques. "To be effective, it (the framework) must be concise enough for the entire organization to carry around in

its collective and individual heads; comprehensive enough to anticipate most interpretative problems; and coherent enough to pass the most stringent common sense tests" [66]. The framework should also be generalized and flexible enough to be applicable to all manufacturing concerns, and contain those techniques that characterize a JIT organization. To this extent, Nestadt's [67] "Head-Vehicle-Driver" JIT framework, a modified version of Bicheno's [68] "Vehicle-Driver" framework, satisfies the above criteria.

3.6.1 The "Head-Vehicle-Driver" Framework

This framework, as used for implementing the JIT techniques, is presented as a three stage process. In the Vehicle or First Stage of the framework (figure 3.4), the techniques are engineering oriented.

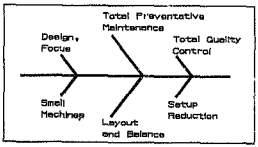


Figure 3.4 Vehicle or First Stage.

"This stage is concerned with preparing the facility and product for: high quality, low cost, minimum lead time, and high flexibility. Thus Stage One sets the essential structure in which the subsequent processes of approaching the JIT goal may take place". [69]

The Second or Driver Stage (see figure 3.5) deals with a set of techniques that allow the ultimate JIT objectives to be approached. This stage "undertakes those processes which are necessary to produce: instantaneously, to market rates, with perfect quality and minimum waste". [70]

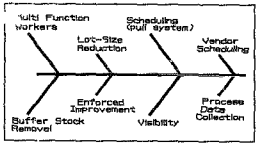


Figure 3.5 Driver or Second Stage.

The Third or Head Stage (see figure 3.6) proposes that people/human involvement steer the Driver and Vehicle stages. "Training provides the human head with the knowledge to steer the vehicle, and this is the key to implementation success". [71]

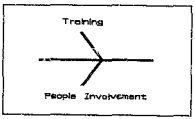


Figure 3.6 Head or Third Stage.

The training aspects of this stage are closely related to those mentioned under the Train and Educate step of the Strategy. In fact, training should precede and then continue throughout all three stages of the framework. People involvement, on the other hand, need not be instituted as a prerequisite to any of the stages. However, involving people early on in the implementation programme will enhance its overall chance of success.

Baseline measurements or an agenda such as the 17 step action agenda proposed by Schonberger [72] (included in the literature survey) may be used as a means of determining which of the JIT techniques or stages to begin with. Since measurements and/or priorities will differ from company to company, no specific technique can be singled out as a starting point, however, certain prerequisites are required before beginning any of the techniques. These

include:

(a) Training, as mentioned above.

(b) The development of skills in quality improvement techniques, so that poor quality and uncontrolled processes will not hamper the JIT effort [73].

(c) The development, by top management, of a Manufacturing Strategy based on the concept of a focused factory, ie. rationalizing and standardizing the existing product range so as to "concentrate on the manufacture of a few products with wide appeal, rather that trying to supply a wide range of products, each with selected appeal" [74].

Thereafter, "the Stage One activities will very often be the best way to move into JIT (or indeed to stay in business), but not in all cases. Although every activity, mentioned in the framework, will have applicability in every operations organization, the emphasis will differ widely. More usually the stages will form a cycle of improvement" [75] (see figure 3.7). Making progress in one stage will facilitate progress in the other stages, which in turn will enable further progress in the original stage. Thus an ongoing cycle of improvement may be established.

It is not necessary to discuss any of the specific techniques at this point, since all have been covered, in detail, by a number of other authors (see

Chapter 2).

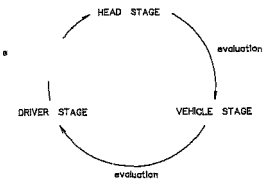


Figure 3.7 Cycle of improvement.

Those techniques that were applied or considered for implementation at Krost Prestige, however, are discussed at a later stage in the report.

3.7 Perpetual refinement and improvement

"Just-In-Time is forever." [76]

This stage reinforces the above statement and serves to emphasize that the JIT journey is endless. An endless pursuit of manufacturing excellence through a commitment to, and the refinement and improvement of the above mentioned stages of the implementation strategy.

3.8 Conclusions

This chapter has dealt with the second level of JIT implementation, namely with a strategy for JIT implementation. A strategy, consisting of the following seven stages: Top Management Commitment, The JIT Consultant, Select a JIT Project, Train and Educate, Establish a Baseline, Implement JIT Techniques, and Perpetual Refinement and Improvement, was developed in response to a number of criteria presented at the beginning of this chapter.

The use of the strategy is important in that is provides a direction in which to proceed and what to proceed with. The aim is to improve the probability of successful JIT implementation and to achieve the fastest and most beneficial results from the JIT techniques themselves.

4. CASE STUDY: JIT AT KROST PRESTIGE

Krost Prestige is a company involved primarily in the manufacture of steel based, consumer household products. The company comprises of four separate departmental buildings, a despatch warehouse, and an administrative building, employing a total of between 450 and 500 people. It is, therefore, classified as a small manufacturing concern, ie. employing less than 1500 people.

As mentioned in the background to the report, at the time of starting this project the company had just undergone a change in ownership. Before selling the company, senior management at Krost Bros. had already entered the first phase of the first stage of the JIT implementation strategy, namely education as part of a commitment from top management. To this extent, many of the company's top and middle managers had already attended a seminar and/or conference on the topic. Some managers had even been on a field trip to Toyota South Africa, in order to obtain first hand knowledge on the actual application of the philosophy. Although this education had already amounted to approximately half the suggested number of educational points, no actual indication of a commitment (ie. declaration of company JIT policy

etc.) towards JIT manufacturing had been made. Rather on realizing the potential benefits of JIT and the magnitude of changes required by the philosophy, management moved into the second stage of the strategy by seeking outside help. Thus the author was approached to assist with an investigation into and the initiation of JIT techniques at the company.

With the sale of the company and the subsequent changes in top management, however, the initial commitment from top management disappeared and was replaced by a reserved, sceptical attitude towards the JIT philosophy. The author's role therefore regressed from JIT assistant to JIT ramrod; trying to break down the barriers and scepticism towards implementation. Finally, a superficial commitment from top management led to the third stage, namely the selection of the Kitchen Units (K.U.) Department as the pilot project. Without the support and commitment from top management, however, it was not possible to continue with the strategy. It was therefore decided to continue with an investigation into the various JIT techniques, as well as to implement those techniques that had a reasonable support from middle management within the department.

Before dealing with any of the techniques, however,

it is necessary to present an overview of the organization of people within th K.U. Department, so that the relationships and interactions between the various personnel levels can be better understood. Following, is a description of the manufacturing process within the department, which is presented as a means of enhancing the reader's understanding of the terminology used and proposals made.

4.1 The organization of people within the K.U. Dept.

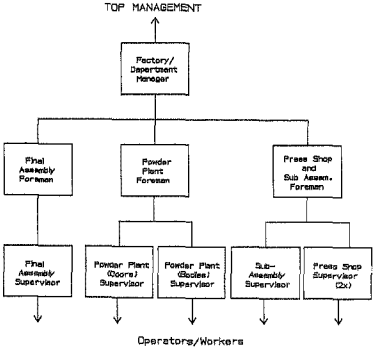


Figure 4.1 Organization chart for K.U. Department.

Figure 4.1 represents an organization chart for the K.U. department at Krost Prestige.

The department is divided into three main areas, namely the Press Shop & Sub-Assembly, the Powder Plant and Final Assembly. Managing each of these areas is a foreman who reports to the Factory/ Department Manager. The duties of the foremen include scheduling, design, quality inspection, machine setting, management of workers and interacting between middle management and the workers. The Powder Plant and Press Shop & Sub-Assembly areas are further subdivided into the Door and Body, and the Press Shop and Sub-Assembly areas respectively. For each of these areas and Final Assembly there exists a supervisor whose main duties are to organize production according to the schedule developed by the foremen, inspect quality and liaise between the workers and the foremen. In the case of the Press Shop, there are two supervisors who are also the two senior toolsetters. Finally, there are approximately 90 workers/operators within the department, all of which are graded according to their specific skills and who are members of the National Union of Metal workers of South Africa (NUMSA).

4.2 A description of the manufacturing process

The K.U. Department is involved in the manufacture of kitchen cupboards, cabinets, sinks and gas stoves from sheet metal. There are six different models of cabinets, most of which are available in seven sizes. The various combinations of cupboards with cabinets, sinks and stoves, together with the options of four different colours for those units with steel doors and draw fronts, and two different finishes for those units with wooden doors and draw fronts, combine to produce approximately 430 different end products.

There are between 250 and 300 components required for the manufacture of the units. These components are grouped into five main categories:

* Bodies and Shelves
* Doors - (i) wood, (ii) steel
* Drawe
* Miscellaneous - (i) wood draw fronts, (ii) steel draw fronts, (iii) tile boards, (iv) drawer runners, (v) runner supports
* Bought outs - locks, keys, handles etc.

All of the components, besides the bought outs, are manufactured from wood or sheet metal within the department.

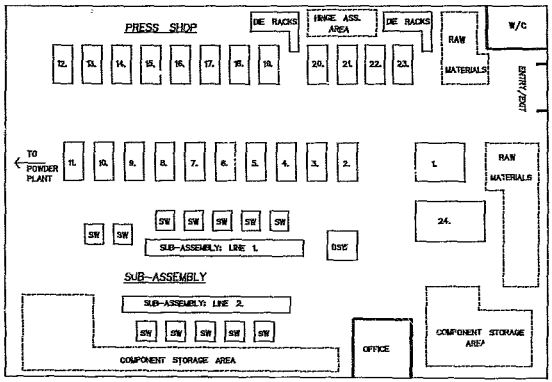


Figure 4.2.a Schematic layout of Press Shop and Sub-Assembly areas.

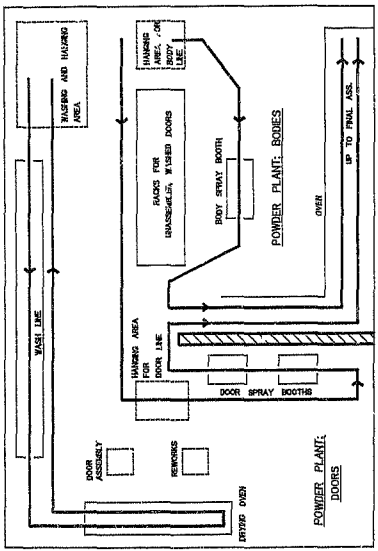


Figure 4.2.b Schematic layout of Powder Plant area.

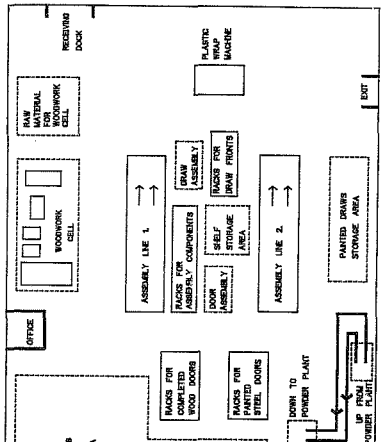


Figure 4.2.c Schematic layout of Final Assembly area.

KEY:

1. Decoiler and Redman Press (6ft)
2. Redman Press (6ft)
3. Brake Press (8ft)
4. Redman Press (4ft)
5. Brake Press (8ft)
6. Back to back Redman Press (2x4ft)
7. Brake Press (6ft)
8. Brake Press (6ft)
9. Redman Press (8ft)
10. Redman Press (6ft)
11. 60 ton Press
12. 60 ton Press
13. 45 ton Press
14. Trimmer
15. 120 ton Press
16. 120 ton Press
17. Air Press
18. 100 ton Press
19. 100 ton Press
20. 45 ton Press
21. 60 ton Press
22. 60 ton Press
23. 45 ton Press
24. Side and End Bender

SW = spot welder

DSW = double spot welder

→ = Overhead Conveyor.

Figure 4.2 (cont) Key to Layout of Kitchen Units Department.

Figure 4.2.a-c presents the current layout of the K.U. dept. Production takes place within a double story building with Final Assembly occupying the first floor, and the Press Shop, Sub-Assembly and Powder Plant areas occupying ground level.

4.2.1 The Press Shop

The steel components, manufactured by the department are formed within the Press Shop (see figure 4.2.a). The metal is ordered from the Guillotine Dept., and is delivered either as precut rectangular sheets or as a coiled continuous sheet to the raw materials storage area of the Press Shop. When required, the coils are then cut into specific sized sheets, depending on what component is to be made.

Each of the machines in the Press Shop are setup to perform one or at most two operations. Since a typical component might require four operations (ie. notch, bend, punch, bend), the average lot will require to be transported three to four times between the various machines and the component storage area. Once the component is complete, it is returned to either a rack or a pre-allocated space within the component storage area. The components are then drawn by the Sub-Assembly area for assembly. Exceptions to the above product flow are draws, which are deep drawn in another department before they reach the Press Shop, and tile boards which proceed, as precut metal sheets, directly from the raw materials storage area to the Powder Plant.

4.2.2 Sub-Assembly

The Sub-Assembly area consists of two assembly lines and a number of spot welding machines (see figure 4.2.b). Assembly line 1 is used to assemble the bodies of the various kitchen units. These units are assembled according to a daily demand schedule issued by Final Assembly to the Powder Plant and Sub-Assembly areas. Sides, backs, supports and bottoms are moved from the component storage area to the assembly line, where they are assembled to form a complete cabinet, cupboard, etc.. Assembly line 2 is used to assemble any of the other components requiring spot weld assembly (eg. draw front supports and draw runners to draw bodies). Complete units from both lines are then moved along to the wash line area of the Powder Plant.

4.2.3 Powder Plant

The Powder Plant (see figure 4.2.b) includes a wash line and door and body powder coating spray lines. Components and units arriving from the Press Shop and Sub-Assembly areas are hung onto the wash line's overhead conveyor, where they proceed through the

wash line and drying oven. The purpose of washing all the items is to remove any deposits (eg. grease and oil) that would react with the powder, causing damage to the finish of the paint job. On emerging from the drying oven, items are transferred to either of the hanging areas of the two spray lines. Doors, however, are packed into racks for unassembled, washed doors, where they are drawn from when required. Before proceeding to the door line, the doors require to be assembled (inner door spot welded to outer door). This assembly takes place within the door assembly area.

The door spray line consists of two booths, one of which is operating at any particular time, the other of which is being prepared for the next colour (almond, blue, green, white or yellow). Automatic spray guns are used to coat the doors and any of the flatter, simpler shaped components that require to be painted.

The body spray booth accommodates the more awkwardly shaped and/or larger items, and utilizes three operators who manually spray the powder onto the units. Only base colours are sprayed in this booth ie. either almond or white. Once powder coated, the units and components are transported, via an overhead conveyor, through the main oven up to Final Assembly.

4.2.4 Final Assembly

There are two conveyor assembly lines, a woodwork cell, a door and draw assembly area, a plastic wrap machine and a number of storage areas located within the Final Assembly area. (see figure 4.2.c)

Painted parts emerging from the oven are inspected and then moved to their respective storage areas. The parts are then drawn from these areas when they are required for assembly. Wooden components such as cabinet tops, draw fronts and doors are manufactured (cut, shaped and partially laminated) within the woodwork cell. When complete, tops are stored within the cell (next to their point of use on the assembly line), whereas doors and draw fronts are transported to their respective storage areas.

Of the two conveyor lines, only one is used for assembly, the other representing excess capacity. Assembly takes place manually, according to a demand schedule issued from the Despatch Warehouse. Those components that are required for assembly are transported to their point of use on the assembly line. Components such as doors and draws require to be pre-assembled (ie. insert locks, handles etc.) before being used on the line. This takes place

within the respective assembly areas. Finally, the completed kitchen unit is inspected, wrapped in plastic and transported to Despatch.

The lead time to produce a single unit will vary between three hours and one week, depending on its colour and the availability of components. Generally, two weeks are allowed for the manufacture of an entire order (up to one thousand units).

The techniques initiated within the department are discussed in the following three chapters. The chapters are divided according to the three stages of the "Head-Vehicle-Driver" JIT framework, with the relevant techniques being considered under each stage.

5. HEAD STAGE TECHNIQUES AT KROST PRESTIGE

"It's people that make Just-in-Time work." [77]
People play an overwhelming role in determining the overall success of the JIT implementation effort. In fact, it is only as a result of people's actions that any changes within an organization can take place. For this reason, the involvement and development of people exists as an important objective of the JIT philosophy, and it is towards satisfying this objective that the Head Stage is directed.

The techniques included under the Head Stage of the JIT framework are Training and People Involvement (P.I). The latter technique includes a further subset of techniques namely Quality Circles, Suggestion Systems and Incentive Schemes. The techniques all involve people, primarily in the lower levels of the organization, ie. those who are directly involved with the technological aspects of JIT, and are aimed at "creating thinking workers". Management, however, also have a role to play by supporting the required changes and realizing the importance of the worker and his potential to contribute towards process improvement and problem solving.

5.1 Training

JIT requires a participative working environment where people from different levels and departments, jointly solve common problems as a means to achieving continuous improvement. "The foundation for this company climate is employee training" [78]. Thus, education/training forms an integral part of JIT implementation. A training programme therefore requires detailed planning and attention so that specific goals may be achieved.

"The training plan must have the potential to move the trainee (learner) through four levels of learning. These four levels of learning which must be reached to cause voluntary and rational behaviour change, are: (1) knowing about; (2) understanding; (3) acceptance; and (4) ability to apply.

The levels are not successive, but rather four different levels of learning.

Some training programmes bring people through the knowing about, understanding and even acceptance levels, but very few ever scratch the surface of the fourth level- ability to apply" [79]. Thus the key to a successful training programme lies in its ability to convey knowledge that may be applied to bring about positive change.

When approached with the idea to begin an education/training programme, top and middle management felt that they were either too busy or that they had had sufficient education. They did, however, encourage the introduction of a training programme for the lower levels within the organization. In developing such a programme, the author took the following factors into consideration:

(a) The four levels of learning as discussed above.

(b) The fact that there is a 50% literacy rate amongst the South African workforce. [80]

(c) The use of examples, taken from the actual workplace or familiar surroundings, so as to facilitate better comprehension when demonstrating specific techniques.

(d) The programme should include theoretical as well as practical sessions.

(e) The training programme is not just a means of informing employees, it brings people together and should therefore also encourage communication and participation.

Table 5.1, presents the structure of a training programme developed for the K.U. Department. The programme was aimed at those levels below the factory manager (middle management), namely the foremen, supervisors and operators.

SESSION CONTENT	TIME
1. JIT principles & ol :tves.	1 Hr.
2. JIT at Krost Prestig	1 Hr.
3. Overview of Stage One chniques.	1 Hr.
4. Overview of Stage Tw techniques.	1 Hr.
5. Overview of Stage Three techniques.	1 Hr.
6. JIT workshops.	1 Hr. each
7. Practical Training.	

Table 5.1 Structure of JIT education/training programme.

Sessions one through five deal mainly with the general, theoretical aspects of JIT. During these sessions, a standard seminar approach is used, in which material is presented by the trainer, to the trainees. An example of the material presented to the foremen and supervisors, as part of the first training session within the department, is shown in Appendix E. Session six comprises of approximately ten JIT workshops, each of which are devoted to a specific chapter of the book "Zero Inventories" by Hall [81]. Participants attending the workshop are required, in their own time, to read up on specifically assigned chapters and then, during one of the workshops, to present their specific material (if necessary with the support of the trainer) to the other participants. In this way, participation, communication and comprehension are all encouraged as part of the training process. Since these workshops require that the trainees have basic skills in

reading and comprehending English, a prior investigation into the suitability of the trainees and their participation in such a scheme should be carried out. Thus, perhaps only foremen might be included into this session. Session seven, on the other hand, deals with practical training, and should therefore include the foremen, supervisors and operators. Firstly, the implementation of the actual JIT techniques might be demonstrated on a "miniature" simulated assembly line, using actual products produced by the company. Ideas for this simulation may be obtained from watching the WITSIE JIT GAME, a video simulation of JIT implementation [82]. The final step is then to move the practical training onto the shop floor, where it may be specifically related to the introduction of techniques as they occur.

Together, these seven sessions contribute a major portion of the educational points as suggested within the JIT Strategy (ie. 170 points attributed to the 17 seminar hours of sessions 1 to 6, 20 points from the reading required in session 6, and between 100 an 200 points resulting from the practical training in session 7). The remaining educational points may be obtained from visiting JIT companies such as AFROX GAS EQUIPMENT FACTORY, DREYER FURNISHERS and TOYOTA SOUTH AFRICA, as well as from reading relevant

material on the topic.

After only one training session, however, on becoming aware of the costs of training (ie. downtime, manhours, educational materials required etc.), management "suspended" the programme. The factory manager then decided that informal training should only take place with the actual introduction of techniques, and that the training should be confined to the "how to" and not "why?", ie. practical and not theoretical aspects of implementation.

Without the support from top and middle management, further considerations relating to the Head stage would be futile. The author therefore decided to move directly into the Vehicle and Driver stages of implementation, since these stages included the more production oriented techniques which had the support of the Factory manager.

5.2 Conclusions

This chapter has considered the most important factor contributing to a successful JIT implementation effort, namely the people within the organization, and has highlighted management's superficial

commitment towards implementation and their disregard for the "people" factor within the company. As a result, the Head Stage techniques of Training and People Involvement could not be applied to those involved within the pilot project. A consequence of this omission is that the overall success and longevity of the implementation effort, as well as the effectiveness of those techniques that were still to be implemented, could be jeopardized.

Although no direct results from the implementation of the Head Stage techniques could be shown, the effort in considering training aspects has led to the establishment and the presentation of an approach that may be applied towards implementing this technique in the future.

6. VEHICLE STAGE TECHNIQUES AT KROST PRESTIGE

This stage deals with those techniques that are concerned with preparing the facility for high quality, low cost, minimum lead time and high flexibility. The techniques that are included under this stage are Design Focus, Small Machines, Total Preventative Maintenance (TPM), Total Quality Control (TQC), Layout and Balance, and Setup Reduction.

The products produced by the K.U. dept. are relatively simple and have, on the whole, been designed in conjunction with the Press Shop foreman to ensure ease of manufacture. The simple, established production techniques, use of cheap materials (sheet metal), and low product liability (ie. failure of the product will not result in dire consequences), are all factors that have resulted in TQC not being considered of immediate importance to the department. Also, as a result of its small size, the company had already achieved a relatively high degree of focus. Thus, of the six techniques falling under this stage of the framework, Layout and Setup Reduction were considered as starting points for introducing JIT.

6.1 Layout

Under the JIT philosophy, layout is not seen as a static concept, but rather as a continuous endeavour towards shortening the manufacturing process length [83]. The technique, therefore, is aimed not only at spacial reduction but also at the elimination or reduction of wastes associated with waiting, transportation and motion. Workplace Organization and Group Technology (GT) are two concepts that fall under the heading of layout and both will be considered for implementation within the K.U. Department.

In dealing with the reorganization and layout of the production facility, a number of constraints needed to be taken into account.

(1) The moving of equipment was to be kept to a minimum, due to the high costs involved in moving most of the machinery (eg. ovens, standard and overhead conveyors, ventilation for spray booths, wash plant etc.). This resulted in changes that were constrained to occur within and not between production areas.

(2) No changes could be made to the overall number of workers.

(3) Flexibility should be maintained.

6.1.1 Workplace Organization

Workplace organization or as Hall puts it "housekeeping with a purpose" may serve as a foundation on which to build the various other JIT techniques [84]. Housekeeping, JIT style, takes on a much broader perspective than its usual connotation of just keeping everything clean. The purpose of the concept is to develop "standardization of operations to the maximum" [85] and to provide an environment conducive to improved work habits, quality and care of facilities. A further result of the concept is the clarification of problems and the highlighting of areas of waste.

Hall mentions five points to consider when introducing the concept of Workplace Organization [86]. These points are summarized as follows:

(1) Clearing and simplifying - Remove everything not required for immediate production activities.
(2) Locating - Assign a Place for everything and ensure that everything remains in its place and is ready for use.
(3) Cleaning - Keep machines and work areas as clean as possible.
(4) Discipline - Work consistently to enforce the above three points.

(5) Participation - Obtain participation by assigning the responsibilities for the above actions to those directly affected.

Worker of the Month

The concepts of workplace organization were introduced to the K.U. dept. by adopting a "Worker of the Month" award system. The system is based on worker participation, where workers are encouraged to compete with each other on the basis of maintaining their workplace according to Hall's five points.

Towards the end of each month the foremen and supervisors, from each of the areas, nominate one worker representing their area, to receive the Worker of the Month award. Of the three workers nominated (one for each of the three main areas), the one deemed to have contributed most to workplace organization is chosen to receive the award. An award ceremony, held at the beginning of the following month, is then used to present the worker with an award: Perhaps two copies of a photograph of the worker being congratulated by the CEO of the company. One copy is pinned onto the department notice board, the other being given to the worker.

Advantages of the *above system are:*

* It is simple to initiate.
* Results are seen very *quickly.*
* Only a small investment is required to run the programme. (ie. time, photographs and *a notice* board)
* The system is fair, in that an area that is easily kept clean need not necessarily win every time.
* Awards are based on recognition which is a motivating factor.
* The system may evolve to include a suggestion system, thereby tying into the technique of People Involvement.

The only disadvantage, is that after some time the system might need refinement so as to maintain worker interest in the programme.

On beginning the programme, positive results were immediately observed in the form of a tidier, more *organized* work environment and improved morale amongst the workers. An example of the type of effort workers made *in competing* for the award is shown in figure 6.1.

Towards the end of the first month, workers from the various areas were nominated to receive the award. Management, however, after encouraging the start of

the programme, refused to allow the presentation of the award. Reasons for this attitude would not be given, but could most probably be attributed to company politics and the previously mentioned attitude of management towards the people within the organization. The initial results from the programme were, however, extremely encouraging.

Figure 6.1 A worker, spending some idle time cleaning his machine.

6.1.2 Group Technology

Group Technology (GT) is defined as "an engineering and manufacturing philosophy which identifies the

'sameness' of parts, equipment or processes. It provides for rapid retrieval of existing designs and anticipates a cellular type production equipment layout." [87]

Cellular Manufacturing (CM), a subset of GT is defined as "the physical division of the manufacturing *facilities (sic) machinery* into production cells. Each cell is designed to produce a part family. A part family is defined as a set of parts that require similar machinery, tooling, machine operations and/or jigs and fixtures. The parts within the family normally will go from raw material to finished products within a single cell. Usually, the manufacturing facility cannot be completely divided into specialized cells. Rather a portion of the facility remains as a large functional job shop which has been termed the 'remainder cell'." [88]

The prime objective of introducing the concepts of GT and CM are the reported benefits usually associated with their introduction. These include reductions in throughput times, setup times, handling costs, raw material inventory, work in progress inventory, finished goods inventory and the costs of production, as well as providing increased flexibility with *respect to changes in demand.* [89]

The area within the K.U. dept., earmarked for introducing these concepts, was the Press Shop & Sub-Assembly. This was due to the almost functional layout of machines in that area, providing an environment conducive to GT concepts. This area is in contrast to the Powder Plant and Final Assembly areas which utilize a linear, flow line, conveyor type of manufacturing system.

Schematics of the existing and suggested improved layouts of the Press Shop & Sub-Assembly area are presented in Figures 6.2.a and 6.2.b (The key to the machine numbers is the same as for figures 4.2.a-c). Superimposed on the diagrams are some typical product flows through the area.

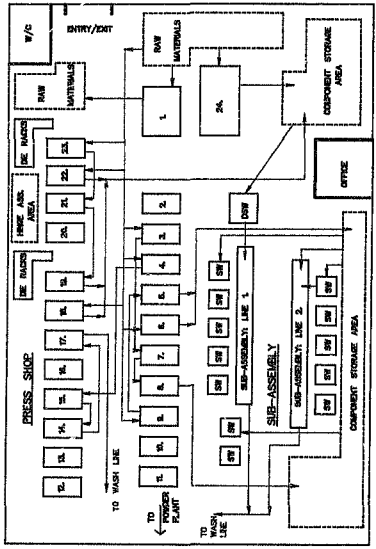


Figure 6.2.a Existing layout of Press Shop & Sub-Assembly area.

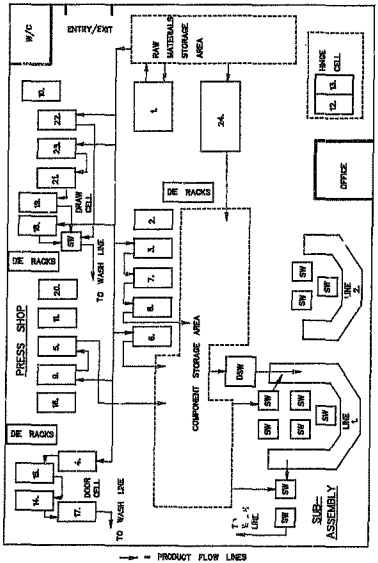


Figure 6.2.b Proposed layout of Press Shop & Sub-Assembly area.

In both cases, identical product flows are shown. By studying the two diagrams, immediate reductions in floor space and the length of the product flow path are noticed. The following changes have been suggested.

(1) The formation of door, draw and hinge production cells - Due to the relatively short period of time that the author was associated with the company, and the extent of the investigation, a full Production Flow Analysis procedure, as suggested by Burbidge [90], could not be performed when devising the proposed GT cells. By observing the flow of operations and the number of components being produced, however, the author was able to identify three product groups (doors, draws and hinges), representing 43% of the entire number of components produced by the Press Shop, around which GT cells might be formed. The machines within each cell enable the manufacture of the entire component and are organized in a 'U' shape. Note that in the case of the Draw cell, a spot welding machine has been relocated from Sub-Assembly to within the cell, so as to enable an entire draw to be manufactured within the cell. Possible problems that might occur are: [91]

* The savings achieved by implementing GT are not immediate. The long delay in payback and uncertainty of savings which will be achieved can

prevent management from attempting its implementation.

* The requirement of multi-function workers and the possible redundancy of material handling jobs may result in worker and/or union adversity to the technique.
* "The restricted variety of products and the limited sources of knowledge with respect to the general application of any particular machine tool make apprentice training more difficult than in a functional layout."

On the other hand, the expected benefits that might occur as a result of setting up the various GT cells include:

* A reduction in throughput times, resulting from the closer proximity of the machines (reduced product flow paths) and the less time spent waiting for setups to be performed or for components to be transported between operations.
* Reduced inventories resulting from reduced throughput times.
* Reduced handling costs due to operators being able to pass parts by hand from one operation to the next.
* An increase in flexibility due to cells being able to react more easily to changes in demand.
* Reduced setup times as a result of the development

of standardized operations as a consequence of the production of similar components requiring similar tooling, within a cell.

* Improved communications, feedback on problems and teamwork as a result of the social consequences of workers working together as a group within a cell.
* Improved quality as a result of a shorter manufacturing throughput time, faster feedback, improved communications, the standardization of setup procedures, and smaller lot sizes.

(2) Layout of the remainder cell - The ten machines within the reminder cell have, on the whole, been left in their functional layout groups. This is to maintain the flexibility which is required in order to process the remainder of components.

(3) The formation of 'U' shaped sub-assembly lines - Assembly lines within the Sub-Assembly area have been rearranged into 'U' shapes. Besides occupying less space, this arrangement offers the following advantages:

* One worker may operate more than one machine due to the close proximity of the machines. This factor provides a simple means of balancing the line according to demand. Thus, as demand increases, more operators may be employed to work the line, thereby reducing assembly cycle time.

* The closer distance between operators on the line facilitates improved feedback and control due to better communication opportunities.
* With a more balanced line occupying less space, the wastes of waiting and transportation are reduced.

(4) Relocation of machine dies, and the component and raw material storage areas - The extra floor space resulting from the establishment of GT cells and 'U' lines enables the grouping of storage areas. Thus, a single raw materials storage area and a single components storage area may be created. The advantage of this structure is the improved ability to monitor and control the stock within the area. By relocating the component storage area, a further benefit in the form of a more simplified flow of materials through the area is also realized. Finally, racks for machine dies have been split into a number of areas so that each rack will only contain the dies for machines within that specific area. Implications of this step enable the assignment of specific areas of responsibility to the three toolsetters within the Press Shop, and a more organized approach to storing the dies. These two aspects, coupled to the standardized approach with respect to tooling requirements for GT cells, will result in significant opportunities for reductions in setup times.

At the time of writing this report, no actual changes had been made to the layout of the Press Shop, due to the fact that the changes could only be carried out during a major shut down. Thus, no actual results could be ascertained. The initial results from the housekeeping effort and the expected results from the improved layout proposals do, however, contribute to the overall objectives of the JIT philosophy and provide a springboard from which the various other JIT techniques may be tackled.

6.2 Setup Reduction

Setup reduction is an important technique, in that it enables the reduction of lot-sizes and consequently the lowering of inventory levels so as to expose problems. Other consequences resulting from reductions in setup times include increased capital turnover rates, increases in productivity, lower production expenses, reduced throughput times and increased production flexibility [92].

When considering the introduction of a setup reduction programme, the objective should be to reduce setup time (ie. the elapsed down time between the last production piece of part A and the first good production piece of part B) to the order of

a single digit minute, with the ultimate goal of zero setup time (ie. with the use of a dedicated machine). In pursuing this goal, the Kaizen concept of "gradual, unending improvement" should be applied as part of a little-by-little approach towards making the improvement, so that workers and setters do not perceive the goal as being idealistic or something unattainable. Thus an initial goal of, say, a 50% reduction in setup times may be established and then refined towards reaching the single minute goal.

This single digit minute goal forms the basis of the "Single Minute Exchange of Die" or SMED approach to setup reduction [93]. The approach utilizes three key steps towards reducing setup times:

The first step deals with separating internal and external setup procedures. In other words, distinguishing those operations relating to setup that require the machine to be stopped (internal setup) and those that might be carried out while the machine is still running (external setup). The second step involves the re-examining of operations and the development of ways to convert internal to external setup. Finally the third step calls for the streamlining of all the setup operations through eliminating adjustments and practising and refining the setup procedures.

Setup reduction was considered only within the Powder Plant and Press Shop areas since Final Assembly was already fully capable of perrorming mixed model assembly (see figure 6.3).

Figure 6.1 Mixed model production in Final Assembly.

6.2.1 Setup Reduction within the Powder Plant

By observing the buildup of inventory, indicative of a bottleneck, the author was able to identify the spray booths within the Powder Plant as being primary candidates on which to begin setup reduction techniques.

When first joining the company, the current setup or

changeover times for a spray booth were noted to vary between two and three hours. This time, consisting mainly of cleaning procedures for the booths, filters and spray gun nozzels, was considered as being totally internal since the machines could not operate while the various parts were being cleaned. The approach adopted towards shortening the setup times was therefore concerned with converting the internal procedures to external procedures.

In the case of the Door Powder Line, setup time was dramatically reduced when it was decided to dismantle the existing large spray booth and replace it with two smaller booths. This action was in accordance with the JIT technique of using smaller machines so as to ensure flexibility and the ability to produce according to market rates of demand. Without any further effort, the setup time was reduced by 50% to the order of one hour, due to the smaller booth size and the fact that the booths had been designed for easier maintenance.

Although still only one set of spray guns were used, the second booth enabled the transfer of the internal procedures of cleaning the booth and filters to external procedures. Thus, by preparing for the change over, ie. by carrying out the external procedures while a specific colour was still being

sprayed, the setup procedure was further reduced to the order of 20 minutes (the time needed to clean the nozzles of the automatic spray guns and move them over to the next booth). This further reduction in setup time resulted in an overall reduction of 83% from the original time of two hours.

As a result, change over frequency between the various colours was increased from one change over every 2 or 3 days to one or two change overs every day. This increased flexibility was immediately followed up with reductions in production lot sizes. The result was a 77% decrease in inventory holdings for steel doors and draw fronts (ie. from 15 days inventory to 3 days inventory). Removing the racks that held the inventory also led to an approximate 2% saving in floor space.

The setup time for the Body Powder Line, however, has received very little attention. The reason for this is that more complex, manual spray guns are used, and that specific ventilation had been installed, allowing the use of only a single booth. By obtaining a second set of filters, however, the filter cleaning procedure could be transferred to external setup, as was done with the door line. Another suggestion, involving the use of plastic sheeting to coat the inside of the booth, would also result in reduced

cleaning times, since all the powder could be quickly gathered up into the plastic and removed from the booth. Due to the limited time, suggestions relating to setup reduction on the body line could not be implemented. The potential for reducing the setup times within the area have, however been demonstrated.

6.2.2 Setup Reduction within the Press Shop

Increased flexibility within the Powder Plant resulted in an increase in demand for more components from the Press Shop. As a result, symptoms of a bottleneck situation began to develop within this area.

Setup procedures within the Press Shop are concerned with the removal, insertion and adjustment of dies for a number of presses. At present all of the procedures are carried out internally. There are three toolsetters within the area, two of which are senior toolsetters, the third being a trainee. The foreman of the area is also capable of setting any of the machines. Each toolsetter is responsible for setting the machine, adjusting jig positions and for certifying the quality of the first good piece

produced.

Before the author had joined the company, a "haphazard" approach to setup reduction had already been started within the area. A tool maker had been assigned to the department, and the use of jigs (see figure 6.4) for multi-die setups had already resulted in significant but isolated setup reductions. (eg. The setup time on machine 9 had been reduced from 4 to 3 hours, a reduction of 25%).

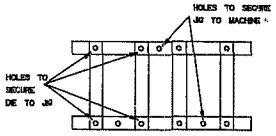


Figure 6.4 Jig used for multiple die setups.

Since a large number of components are manufactured on a number of different machines, no single machine could be singled out as contributing specifically to the bottleneck situation. A complete reduction of setup times on all machines is therefore required before the benefits from the application of the technique can be truly experienced.

The first step taken to focus and expand upon the existing setup reduction effort within the area, was to educate the foreman in the theory of the SMED approach and the importance of setup reduction in the exposure and elimination of waste. The next step was to establish current setup times on the various machines. This was done with the use of clock cards which the ... were required to clock at the beginning and end of each setup. The resulting setup times for machines within the Press Shop are presented in the table of setup times for August 1987 in Appendix F. The following proposals were then made.

The first group of proposals are aimed at organizing for more efficient preparation so as to transfer the current internal procedures of locating and fetching dies, bolts, tools etc. to external procedures.

* Lights fitted onto the machines could be switched on by the operator, a specified time before the production run finishes. This time would, however, depend upon the amount of time needed for the preparation and external setup on that particular machine. In this way, the setter may begin preparing for the following setup, while the machine is still running.
* Figures 6.5 and 6.6 indicate the current methods for storing dies, and bolts and spacers

respectively. Organization of the various components is clearly haphazard, confusing and inefficient.

Figure 6.5 Racks used to store dies for presses.

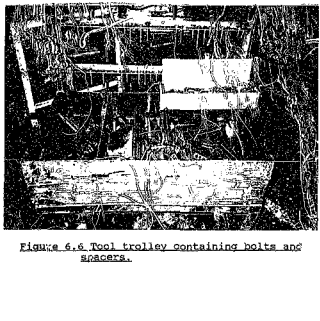


Figure 6.6 Tool trolley containing bolts and spacers.

To overcome this, die racks could be separated with each rack containing only those dies required by machines in the immediate vicinity. Furthermore, the numbering of dies and their positions in the racks will enable easier and faster die location. The idea of separate storage areas could then also be extended to the storage of bolts and tools. Here, a type of colour coding might also be introduced as a means of identifying specific dies, tools, bolts and machines that are used together.

* The use of setup tables to facilitate the setting up of dies onto jigs, whilst the machine is still running, will enable the transfer of internal setup to external setup procedures.

Figure 6.7 The setup of a die within a press.

The second group of proposals are concerned with standardization and are aimed at reducing internal setup times. Figure 6.7 indicates the typical setup of a die on one of the presses. Attention is drawn to the various pieces of metal used as spacers and clamps.

* By standardizing the shut heights and clamp heights on each of the dies, and by using standardized clamps, the time taken to search for specific spacers, clamps and to make adjustments to the closing heights of the presses would be eliminated.
* Standardizing bolts and/or bolt head sizes would eliminate the need to search for specific bolts and the use of different size tools when performing the setup.

The third group of proposals are more *people oriented* and deal with responsibility.

* By giving each setter his own toolbox, tools and area of responsibility, the setter might be encouraged to have more pride in the job he is performing and thus carry out the task more efficiently. This suggestion would also enable the setter to become more familiar with the setup operations in his area enabling methods to be

developed so as to streamline, standardize and refine the setup procedures within that area.

Comparative figures, resulting from the more focused approach to setup reduction are presented in table 6.1. The results show that nine of the eleven machine groups within the area have experienced a decrease in setup times. By performing a Kruskal-Wallis test of statistical significance on the changes in mean setup times (see Appendix F for calculations), however, the outcome indicates that only four of the decreases are statistically significant.

Machine Group	Sa	Sf	% Change	Significant
A	161	154	-4.35	NO
B	30	23	-23.33	YES
C	26	24	-7.69	NO
D	54	45	-16.67	YES
E	24	26	+8.33	NO
F	172	128	-25.58	YES
G	30	27	-10	NO
H	41	36	-12.20	NO
I	46	51	+10.87	NO
J	44	37	-15.91	YES
K	33	29	-12.12	NO

Where: Sa = Average setup time, in mins. for August 1987.
Sf = Average setup time, in mins. for February 1988.
A-K = Machine groups as defined in Appendix F.

Table 6.1 Results from setup reduction in Press Shop from August '87 to February '88.

The positive influences contributing to the decrease may be attributed to a move to standardize the shut and clamp heights of all the dies, the provision of tools for each of the toolsetters, the increase in skill of the third (trainee) toolsetter and Hawthorne effects (increased worker performance due to a feeling of participating in something new and special) [94].

The negative influences that have resulted in decreases, not being shown throughout all machine groups may be attributed to the low priority of importance which has been attached to the programme (by the department manager and area foreman), and an unfavourable attitude from the toolsetters, thought by the author, to be a consequence of them perceiving the simplification and time reduction concepts as a threat to their job security and status. This attitude might be overcome through job enlargement, ie. by assigning the setters greater responsibility such as the training of operators in basic setup procedures, educating them so as to reduce their fears associated with change, and by management issueing a policy statement to the effect that no person will lose their job as a result of improvements from the programme. Furthermore, the technique of Lot-Size reduction may be applied so as

to force attention onto the issue of setup reduction within this area. Thus, by attaching priority importance to the technique and adopting the suggestions made with respect to setup reduction, setup times approaching those of SMED are clearly achievable, as are the potential benefits.

6.3 The remaining techniques

The fact that this chapter has dealt specifically with the techniques of Layout and Setup Reduction does not indicate that the other techniques, falling under this stage of the framework, are not applicable to the department or less important than those already discussed. In fact, the implementation of JIT cannot be considered complete without the application of all these techniques. Layout and Setup Reduction were, therefore, considered merely as starting techniques that could be initiated within the relatively short time that the author was involved with the company. The inclusion of the remaining Vehicle Stage techniques are necessary, however, to constitute the solid JIT foundation on which to build a World Class Manufacturing organization.

6.4 Conclusions

The chapter has dealt with those JIT techniques, specifically Layout and Setup Reduction, that were introduced to the K.U. department and that fell under the Vehicle Stage of the JIT framework. Each of the two techniques were then discussed with particular attention given to their introduction within the department. Various suggestions were given and, where possible, the results from implementation were presented.

The chapter served to indicate the influence of the various techniques on eachother. How improvements in one area might provide a springboard from which to leap into the next technique (eg. a consequence of GT is standardized setup operations which enable setup reduction. This in turn may lead to smaller lot sizes, less inventory and therefore more space, which might require further layout changes etc.). This is in accordance with the cycle of improvement concept mentioned in Chapter 3.

7. DRIVER STAGE TECHNIQUES AT KROST PRESTIGE

This stage is aimed at building on the structure created in the Vehicle Stage, and allows the company to approach the JIT goal of producing instantaneously, to market rates, with perfect quality and minimum waste [95]. The techniques included in this stage are Multi-Function Workers, Visibility, Scheduling (KANBAN), Lot-Size Reduction, Process Data Collection, Vendor Scheduling, Enforced Improvement and Buffer Stock Removal. Of these techniques, Scheduling and Lot-Size Reduction were considered for introduction to the K.U. department.

7.1 Scheduling (KANBAN)

Kanban, a Japanese word meaning "visible record", is the name given to a pull type of scheduling system that operates within the JIT environment. This visible record, typically represented by a card, is used to authorize the production (P-Kanban) and/or conveyance (C-Kanban) of parts from one work centre to the next [96]. The Kanban is initiated at the work station needing the parts and acts as a signal to the preceding work station to produce a specified number

of a particular part. Without the Kanban to act as an authorization, the part may not be produced or transferred. As a result, production is pulled, ie. it is based on the need for items from the following work station.

Although there are a variety of Kanban systems, each may be considered a variation of the Toyota Dual-Card Kanban system which is described by the following sequence of events:

"1. A user in need of parts takes an empty container and its C-kanban to the producer area.

2. The user attaches the C-kanban to a full container and detaches the P-kanban. The user takes the full container and its C-kanban back to the user area for immediate use.

3. The detached P-kanban goes into a dispatch box (behind other P-kanban) in the producing area. The P-kanban in the box are production orders. The producer makes the part numbers in order of arrival of their P-kanban in the producing area. The P-kanban is attached to the container as each container is filled.

Two rules of the system are:

1. No production takes place without a P-kanban.

2. Each container holds the exact quantity stated on its kanban, no more, no less." [97]

The system that was implemented within the K.U.

department may be described as a Tri-colour, single card, P-Kanban system. Suggestions for the implementation of a Kanban container , P-Kanban system are also presented.

7.1.1 A Tri-Colour, Single card, P-Kanban system

The system was introduced to control the scheduling of production between the Final Assembly, Powder Plant, and Sub-Assembly areas. The reason for including these areas within the system , was that a single Kanban card could be used to initiate the production of a specific quantity of units throughout all three areas. Thus, a Kanban card issued by Final Assembly, could be used to initiate production in Sub-Assembly . A description of the operation of the system is presented below.

System Operation

Three coloured Kanban cards are issued for each specific part. Each of the three Kanban cards (in this case painted steel disks) contain the necessary information to produce a part. An example of the

Kanban cards for a 46cm, almond coloured, grocery cabinet is shown in figure 7.1.

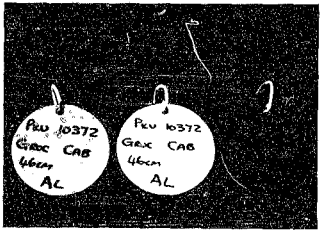


Figure 7.1 Kanban cards for 46cm, almond, grocery cabinet.

On the reverse side of the three cards are identical sets of numbers indicating the production quantity of the part. These numbers also indicate the exact amount of parts to be stored in the container. Because of a large variation in part size, and the fact that all parts require individual transportation via an overhead conveyor, no standardized container could be used to transport and store a group of parts. Thus, floor areas, within Final Assembly, were painted to represent a container for a specific number of parts. Figure 7.2 indicates the "containers" for each Kanban quantity of a particular draw.

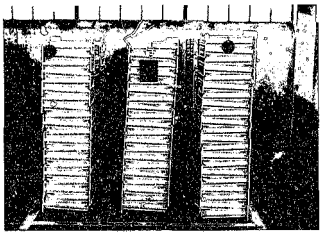


Figure 7.2 Painted floors used as "containers" to hold a specified quantity of a particular part.

As required for assembly, parts are drawn first from the green, then from the yellow and finally from the red "container". Once a container is emptied, its Kanban card is taken to the Powder Plant, and is placed in a pre-allocated position on the Kanban board (see figure 7.3). Since parts are always drawn firstly from the green, then yellow and finally red containers, the placement of a particular colour Kanban card on the Kanban board will indicate the current status of stock in Final Assembly. The various colours will then indicate to the Powder Plant, the priority of the parts required. Thus, the colours take on the following significance:

green Kanban = ATTENTION, parts needed.

yellow Kanban = WARNING, stocks low.

red Kanban = DANGER, no stock.

Once the foreman in the Powder Plant has decided to paint a number of parts, the Kanban card for these parts are taken to a Kanban board in the Sub-Assembly area. Only when the Kanban cards are received in this area can production take place. As a Kanban quantity of parts are produced, the Kanban card accompanies the lot back through the Powder Plant and up to Final Assembly. On receiving the parts with their Kanban card, the parts are moved to their specific "containers". The "containers" are then filled in reverse order of use, beginning with the red and moving to the green "container". Finally, the Kanban card is replaced in its "container" and the cycle is repeated.

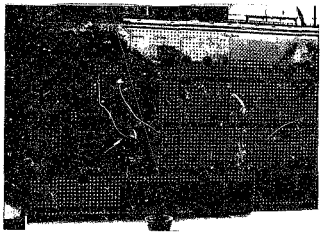


Figure 7.3 Kanban board in Powder Plant.

Calculation of Kanban Quantities

A limitation of the Kanban system is that it works best in conjunction with parts that are regularly used [98]. For this reason, the groups of components that were considered for inclusion into the system were the more frequently requested components such as bodies, shelves, draws and tile boards. Within each group of components, a Pareto analysis was carried out to determine those part numbers that had the highest usage. The foremen from the different areas were also consulted as to which components would best be suited to be included into the system.

Once all the component numbers had been identified, the following standard Kanban formula [99] was used in order to calculate the Kanban quantities.

Kanban Quantity = Daily demand x (wait + processing time) x (1 + safety factor) / (total number of Kanban cards)

where:

Kanban quantity = no. of parts per standard container.
wait + processing time = throughput time.
total no. of Kanban cards = 3 ie. one green one yellow and one red.

Table 7.1 presents an example of the calculations made with regard to converting the scheduling of the

production of shelves to the Kanban system. Calculations for the other groups ie. bodies, draws and tile boards are presented in Appendix G.

Shelf no.	Usage to date		Kanban Quantity	
	white	almond	white	almond
10108	5694	2932	75	75
10114	2017	776	25	25
10127	382	499	25	25
10186	8484	5012	100	100
10218	1779	1	25	0
10219	1779	1	25	0
10225	513	0	25	0
10226	513	0	25	0
10246	764	0	25	0
10316	1397	1	25	0
10317	4191	3	50	0

where : wait + process time = 3 days for white, and
6 days for almond.
safety factor = 1 day.
no. of kanban cards = 3.
no. of days to date = 209.

Furthermore, because of their size and the small amount of space occupied by each shelf, figures have been rounded up to the nearest twenty five.

eg. For white shelf no. 10186:
Kanban Qty. = 8484/209 x 3 x 2 / 3
= 81.2 round up to 100.
---->

Table 7.1 Calculation of Kanban Quantities for shelves.

Introduction of system

The way in which the Kanban system was introduced to the departm[illegible] to be an important factor in determining i[illegible] operation. The approach followed is now describe[illegible]

Before introducing the system, foremen and supervisors from the various departmental areas were included in discussions on the operation of the system. They were also consulted on the inclusion of certain components into the system and on the verification of kanban quantities. The objective of including these people within the early stages of development was to enhance their understanding of the system, thereby reducing the normal aversion and fears associated with the introduction of a new system, and to encourage participation so as to gain the necessary support and co-operation when installing the system.

To begin with, only the scheduling of production for bodies was transferred onto the Kanban system. Standardized "containers" were painted and stocks repacked. Those workers working with these specific components were then trained in the operation of the system and how to pick and pack components according

to the Tri-colour priority system. Only when this area was functioning correctly was the introduction of the following component considered. Those workers who were already familiar with the workings of the system were then asked to train those workers who were being introduced to the system. Thus a greater sense of pride, understanding, ownership and participation was developed within those who were involved with the system. In each case, more and more responsibility was handed over to the workers and foremen, who became responsible for the reorganization of areas, the development of standardized containers and the running of the entire system.

An example of the re-organization of shelving inventory, from the original "push" scheduling system to the Kanban "pull" type of scheduling system is shown in the "before and after" figures below. In this case, most of the re-organization was carried out by the foreman, supervisor and workers within the area.

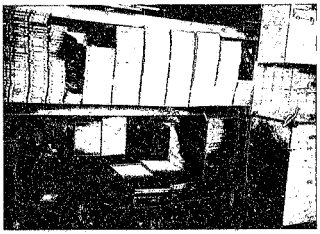


Figure 7.4.a Organization of shelves before converting to the Kanban scheduling system.

Figure 7.4.b Organization of shelves after converting to the Kanban scheduling system.

Initial Results from Implementation

Although not enough time was available to obtain quantitative results, perceived results and benefits from the implementation of the Kanban system are discussed below.

* The author observed an improvement in the morale of those workers associated with the system. This improvement, which may lead to an improvement in worker productivity [100], could be attributed to the participation of the workers in implementing the system and also the previously mentioned Hawthorne effects.
* Smaller lot sizes (between 50% and 60% of previous production lot sizes), arising from the calculation of the Kanban quantities, resulted in reduced work in progress inventories and queuing times.
* Unlike the former scheduling system which utilized monthly forecasts and actual sales to produce a schedule, the simplified Kanban system has removed much of the guess work, calculations and confusion associated with the former method. A further result is a more stable schedule.
* An improvement in the customer service level is also expected since production planning is now able to take into account the priority with which

each part is required.

* The reorganization of components into standardized "containers" has resulted in improved visibility and simplified stock taking procedures.
* Improved visibility results in improved communication and feedback, which both contribute to a reduction in waste and an improvement in quality.

The disadvantages associated with the system are:

* Three separate lots are required for each part.
* The system can only be effectively used for those parts that are regularly used. Thus the original system is still required to be used for other parts.
* The system is dependant on a relatively stable schedule and cannot, therefore cope with large fluctuations in demand.
* The tri-colour system is more complex than the usual single card type systems.
* Finally, the system requires extreme discipline in the handling of Kanban cards and the filling of Kanban containers, since a lost card or incorrectly filled container could result in extensive stockouts or a shutdown in production.

7.1.2 A Kanban container, P-Kanban system

As mentioned, the operation of the previously described Kanban system could not be extended throughout the department. The reason for this is the parts explosion that occurs between Sub-Assembly and the Press Shop. For example, the production of a single cabinet might require the assembly of, say, 50 separate components, some of which are also used in the production of other cabinets. Thus a Kanban card, requesting a cabinet, cannot be used to initiate the production of components required for that cabinet, since confusion will arise as to which components have been requested by which cabinets. Furthermore, the relatively large variety of components produced by the Press Shop require the establishment of a component store so as to decouple the Press Shop production from Sub-Assembly.

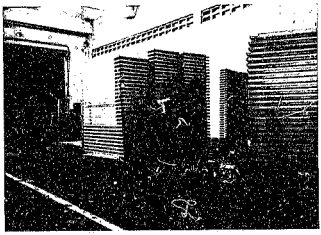
The current method of scheduling production within the Press Shop utilizes a monthly forecast which is generated from a bill of materials explosion of the forecasted sales of units. Due to the inherent inexact nature of forecasts [101], the system often results in the over or under production of components. This in turn leads to obsolete stock or delays in production respectively. The following Kanban system is suggested as a means of replacing

the current method of scheduling production.

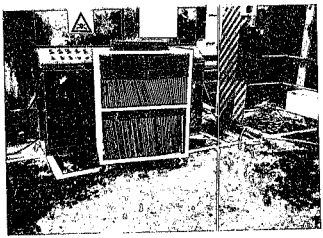
System operation

The use of a Tri-colour Kanban system is not feasible, due to the large spacial requirements that would be needed to hold three containers of each component. The suggested system is, therefore, based on a standard single card, P-Kanban system that operates as follows:

Sub-Assembly draws components from a particular standardized container, as needed. If there are two containers containing the same component, operators must draw from only one of the containers, until that container is empty. The empty container will then serve as a Kanban for the Press Shop to produce more of that component. The component's empty container, labelled with the part number and its Kanban quantity (calculated as before) may be used in place of an actual Kanban card to initiate production. Hence the name Kanban container. Examples of containers, currently in use throughout the department, and which may be used for Kanban purposes are shown in figure 7.5 below.



(a)



(b)

Figure 7.5 Examples of potential Kanban containers.

An advantage of using such containers is that they may be transported manually, since they have wheels. This eliminates wasted time while waiting for mechanical transport devices such as forklift trucks. Finally, as the containers are emptied, they are placed in a queue which is serviced on a first in first out basis, thereby simplifying the entire production scheduling process.

Although no time was available to implement the system, favourable results from the previous system installation led to immediate considerations for its implementation. At the time of writing this report, however, no results from actual implementation could be obtained.

7.2 The remaining techniques

As was the case with the Vehicle Stage techniques, time restrictions resulted in the consideration of only those techniques that had the support of management and that could be reasonably initiated within a relatively short period of time. The Kanban system was selected specifically as a means of addressing problems experienced with the scheduling

of part production within the department. As a result, small but significant inroads were also made in the areas of Lot-Size Reduction and Visibility. The successful implementation of these Driver Stage techniques, however, depends upon the extent to which the more basic Head and Vehicle Stage techniques have been applied. Thus, perhaps with the exception of Lot-Size Reduction, which might be considered as a means of forcing attention on Setup Reduction improvements, these techniques should be considered at a later stage in the JIT journey; once solid foundations in the areas of lead time reduction, training, people involvement, TQC, and TPM have been established.

7.3 Conclusions

Although the techniques falling under the Driver Stage of the JIT framework are considered "more sophisticated and difficult to manage" [103] than those of the other two stages, one of the techniques, namely Scheduling was considered for introduction to the K.U. dept.

Kanban, a pull type of scheduling system was introduced as a means of simplifying the existing

system. Two Kanban systems were suggested for implementation. One a Tri-colour, single card, P-Kanban system, operating from Final Assembly back through to Sub-Assembly, and the second, a Kanban container, P-Kanban system operating between the component storage areas and the Press Shop. In both cases, suggestions were presented for the installation and operation of the systems. Successful results from the initial installation of the Tri-colour system were also discussed.

Finally, the chapter has, once again, been able to highlight the cycle of improvement and interdependant relationships that exist between the various techniques.

8. CONCLUSION

Just-In-Time (JIT) comprises of a set of ideals, objectives, concepts and techniques which combine to form an operating philosophy that is aimed at directing an entire company towards manufacturing excellence. This report has dealt with the introduction of JIT to Krost Prestige, a company involved in the manufacture of steel based, consumer, household products, and has been structured according to the three levels at which the topic can be discussed; ie. the JIT philosophy, strategy and tactics.

The philosophical aspects were presented as a means of briefly introducing the reader to the scope, ideals and concepts of JIT. Furthermore, this discussion served to establish a link between the objectives of JIT and their applicability towards solving the problems currently being experienced by the company.

After examining four previous strategies that had been developed as a means of implementing JIT, a new strategy was devised to meet the following criteria. The strategy should:

1. Be easy to understand and apply.

2. Conform to the "Keep it simple" principle of the JIT philosophy.
3. Be flexible so that it may be applied within almost any company.
4. Be capable of incorporating new JIT innovations.
5. Be detailed enough so that the user will not be left in any doubt as to what is required and in which direction to move.
6. Enhance the probability of successful implementation.

This strategy included the following seven stages:

(1) Top Management Commitment, (2) The JIT Consultant, (3) Select a JIT Project, (4) Train and Educate, (5) Establish a Baseline, (6) Implement JIT techniques, (7) Perpetual Refinement and Improvement.

The objective was to define a starting point and then to direct the implementation effort so as to enhance its probability of success.

Results from trying to implement the strategy within the company indicated that Top Management Commitment and Train and Educate were the most critical stages of implementation. Without them the effort and co-operation required to support the adoption of JIT, as a company wide philosophy, would not be apparent and neither would the ongoing nature of the philosophy be fulfilled.

Within stage 6 (Implement JIT techniques) of the strategy, a "Head- Vehicle-Driver", JIT framework was presented as a means of conceptualizing the relationships between the various JIT techniques. This framework was then also used as a structure in which to present the tactical aspects (JIT techniques) that were applied to a JIT pilot project scheme, carried out within the Kitchen Units (K.U.) Department of the company.

Under the Head Stage of the framework, the technique of Training was discussed and its implementation attempted. It was at this early stage of implementation that a lack of commitment and support, from top management, became apparent. Thus, it was decided to discontinue with further efforts in the implementation of techniques falling under this "people" stage of the framework and persue those production oriented techniques, included in the Vehicle and Drivar stages of the JIT framework, that had the moderate support of middle management.

Next, the techniques of Layout and Setup Reduction, included within the Vehicle Stage of the framework were considered. With regard to Layout, the concepts of Workplace Organization and Group Technology were discussed. A "Worker of the Month " award was created to encourage the objectives of Workplace Organization

and housekeeping with a purpose. The initial results from implementation of the concept were extremely positive and included improvements in worker morale and a cleaner more organized workplace. Once again, however, due to a lack of management commitment, the programme was suspended. The other concept of Group Technology, was considered as part of a proposed improved layout of the Press Shop. Although actual implementation of the proposals could only be carried out during the next major shut down period, expected results include reductions in product throughput times, product flow lengths and inventories, as well as improvements in stock control, flexibility and communication throughout the area.

The second technique considered as part of the Vehicle Stage was Setup Reduction. This technique was applied to the Powder Plant and Press Shop areas within the department. Steps taken in this area included educating the foremen in the SMED approach to setup reduction, establishing current setup times, and encouraging the implementation of the technique. Initial results from its application included setup time reductions ranging from 4% to 83%.

The final technique considered for implementation, and falling under the Driver Stage of the framework, was Scheduling (Kanban). Scheduling considerations

included the introduction of a Tri-colour, single card, P-Kanban system and a proposed Kanban container, P-Kanban system. Results from implementing this technique included an improved and simplified scheduling system, reduced work-in-process, reductions in floor space, improved visibility and improvements in morale. Longer term potential benefits include reduced throughput times and improvements in customer service.

The initial results from the application of the above techniques were seen to complement one another and tie into the "cycle of improvement" concept mentioned as part of the JIT framework. Furthermore, the improvements were seen to address, directly, the original problems of reduced cash flows, large work in progress inventories, long lead times, scheduling, motivation and competitiveness that are currently being experienced by the department.

Finally, although some progress was made with the initiation of the JIT techniques within the K.U. department, more substantial and far reaching results can be achieved with a company wide adoption of the philosophy. This, however, can only be achieved with top management support, a greater commitment to education and training, and a will to progress towards becoming a World Class Manufacturer.

APPENDIX A

Management musts for JIT implementation.

Source: [103]

1. Management must lead the transition, accepting the potency of Manufacturing as a competitive weapon, and recognizing that competitive advantages can be secured by developing these Operational potentials.
2. Management must exercise humility, recognizing that people really are the most important asset. Employees, both blue collar and white, must be invited into the transition process, educated and motivated to participate in it with energetic enthusiasm, authorized to enact their solutions, rewarded for their successes, and encouraged to keep trying even when their ideas don't solve the problems.
3. Management must focus on the right things to measure. The measurements espoused by the conventional wisdom which reward pieces of the production process but not the whole of it are misleading and counterproductive. Efficiency and utilization measures reward output which is not really needed. They must be abandoned and replaced with measures of things which really count.
4. Management must accept failure as the surest path to long term success. Policies which reward entrepreneurship and risk taking will encourage employees to try innovative approaches in solving the problems which inhibit improvements in products and processes. The Japanese literally

treat a defect as a jewel, because their dogged pursuit of the reason(s) for the defect allows them to solve the problem(s) once and for all.

5. Management must be honest in defining the real constraints to reaching goals. Penetrating assessment of managerial policies, practices and procedures, of employee behaviour, and of logistical and physical characteristics are critical to the specification of strategic and tactical action plans. Otherwise, you're liable to install a new ASRS instead of a fast flow production process to satisify your customer service deficiencies.
6. Management must assure total reliability. This means Product design must facilitate ease of production. Product quality must be an uncompromisable objective. Tools of all kinds must be maintained in a constant state of readiness.
7. Management must recognize and authorize you to implement the enabling technical capabilities.

Rapid changeover
Small lot sizes
Simplified flow
Cellular manufacturing
Linear execution of a level schedule (mixed modeling)
Pull system for schedule execution
Total quality commitment
Partnership with suppliers
Simplified MRP/CRP systems

8. Management must commit to ongoing improvement.

Dont forget --- Just In Time is forever.

APPENDIX B

The assignment of responsibility to the various disciplines within an organization.
Source: [104]

TOP MANAGEMENT

- Commit to the process.
- Understand that it is a process - no light at the end of the tunnel.
- Fund efforts; loosen R-O-I hurdle rates.
- Given recognition and visibility.

MARKETING

- Help get stability in the master schedule.
- Get feedback on what customers want quickly, constructively.

HUMAN RESOURCES

- Communication with union.
- Education programmes development.
- Team work development (behaviorial science).
- Worker group structuring.
- Suggestion programme administration.
- Worker cross training programmes.
- Newsletter visibility.

PRODUCT DESIGN

- Design for producibility (C.A.D.)
- Bill of material accuracy.

QUALITY ASSURANCE

- Early participation in
  - * *product design: review of critical characteristics.*
  - * supplier sourcing.
- Statistical process control.
- Measure in part per million, not AQL.
- Supplier certification.
- Quick dock-to-stock performance.
- Measure/monitor/publicize cost of quality.

MANUFACTURING ENGINEERING

- Product oriented (rather than functional) plant layout.
- Conveyors, not forktrucks.
- Flexible tooling.
- Rapid set-ups, changeovers.
- Increase processing speeds.
- Dedicated, specifically sized parts containers:
  - * for plant.
  - * for suppliers.
- Simplified processes and procedures.

Integration of C.A.M. with C.A.D.

MAINTENANCE

- Operators pull first echelon maintenance.
  - * feel
  - * inspect
  - * tighten
  - * clean
  - * adjust
  - * lubricate
- "Sure fire, can't miss" preventative maintenance.

- Smart inventory of backup spares.
  * bottlenecks cannot go down.
- Fast reaction to downers.
  * in-depth analysis.
  * "permanent" repair.
  * minimize quick fixes.

PRODUCTION PLANNING

- Simplified MRP.
- Schedules based on run rates.
- Level production
  * every product produced every week.
- T.^{2}R.P.
  * tools and technical documents requirements planning.

PRODUCTION AND INVENTORY CONTROL

- High degree of inventory record accuracy.
- "Pull" system, not "Push".
  * Kanban.
  * daily schedule.
  * automatic container replenishment.
- Fixed quantities per container.
- E.O.Q. is passe.
  * "schedule" only what's needed for when it's needed.

PURCHASING

- Re-think supplier selection criteria from "lowest bidder" to:
  * total cost of quality.
  * geographic location.
  * delivery capability.
  * financial stability.
- Long term contracts with a smaller number of suppliers.
- Supplier education:
  * exact quantities.
  * container sizes.
  * small delivery time windows.
- Focus factories and/or stockpiles.

TRANSPORTATION

- Re-think carrier selection criteria from "greatest discount" to:
  * condition of goods on arrival.
  * delivery timing reliability.
  * equipment design/capability.
  * financial stability.
- Long term contracts with fewer carriers.

PRODUCTION

- Involve workers in the process.
- Cross train workers.
- Housekeeping.
- *New mentality*

* produce only what you need, not what you can.
* payoff only on good parts produced.
* shut down production if bad parts are being produced.
* repair problems, don't just fix them.
* make schedule every hour of every shift of every day.
* Realize that bottlenecks limit total output and that there's only waste when other in-line operations produce more than the bottleneck can process. Break the bottleneck, if more production is needed, that is, saleable.

FINANCIAL

- Product costing based on process, not job.
- Overhead allocation based on cycle time, not D/L.
- Incentives based on group performance, not individual, and on performance to need, not gross output.
- Or, no incentive system - daywork only.
- Efficiency based on time per part, not utilization.
- Payables based on backflushing or schedule.
- New looks at R-O-I criteria.

APPENDIX C

Statement of JIT philosophy at AFROX Gas Equipment Factory.

"Our JUST-IN-TIME/TOTAL QUALITY CONTROL (JIT/TQC) philosophy is to create TEAM SPIRIT in a workplace where EVERY EMPLOYEE can ENJOY SUCCESS through INVOLVEMENT in continuous bit by bit REDUCTION of waste (mainly WORK IN PROGRESS, STOCKS, SCRAP and SET-UP TIME), thereby enhancing our chances of FUTURE PROSPERITY."

"Ons JUST-IN-TIME/TOTAL QUALITY CONTROL (JIT/TQC) filosofie is om SPANGEES by die werkplek aan te wakker sodat ELKE WERKNEMER se bydrae om VERMORSING te bekamp bekroon word met SUKSES. Hierdie doelwit word sigbaar bereik soos VOORRADE, WERK IN PROSES, SKROT en OPSTELTYE stukgewys VERMINDER. WELVAART word VOORTDUURREND GESKEP."

APPENDIX D

Suggested measurements for establishing baselines.

The following, is a list of suggested measurements to be made when establishing a baseline for current performance levels within the organization. Source: [105,106].

(1) Inventory Turnover - indicates the value of inventory that was used to support a given level of sales.

Inventory Turnover = cost of goods sold divided by average inventory value.

(2) Cycle Times:

a. Cycle Time - provides an estimate of the average cycle (or throughput) time of inventory.

Cycle time = 1 / Inventory Turnover.

b. Customer order cycle time.

c. Purchase order cycle time.

d. Time parts spend in storage area.

e. Transportation time of parts to the line and back and forth to storage areas or between work centres.

f. Setup and run times at each work centre.

g. Final Assembly times.

h. Time stock sits in finished goods inventory.

i. Total throughput time.

(3) Trends in quality (defect rates).

(4) Trends in work-in-process inventory.

(5) Customer service level (no. of stockouts).

(6) Skill improvement of people.

a. In depth (quality checks, setups, interpreting orders, etc.).

b. In breadth (cross-training for different positions).

(7) Co. .cion of plant equipment and people.

a. Total Productivity.

b. Morale.

c. Workplace organization.

d. Visibility of condidtions.

e. Equipment availability and maintenance status.

f. Layout (material travel distances).

g. Absenteeism.

h. Safety.

i. Suggestion rates.

(8) Capital budgets.

(9) Departmental expenses.

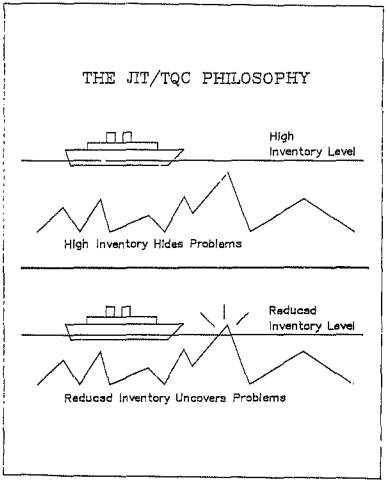
APPENDIX E

Lecture material on JIT principles and objectives, presented to foremen and supervisors.

Just-In-Time (JIT)

JIT is <u>not</u>:

- An inventory programme.
- For suppliers only.
- A labour reduction programme.
- A cultural phenomenon.
- A programme relating only to production.


THE JIT/TQC PHILOSOPHY
High
Inventory Level
High Inventory Hides Problems
Reduced
Inventory Level
Reduced Inventory Uncovers Problems

Just-In-Time (JIT)

- JIT objectives:
  - Eliminate waste
  - Reduce lead times
  - Improve quality
  - Reduce costs
  - Develop people
  - Continuous improvement

- JIT uses simple methods to eliminate problems.

ELIMINATE WASTE

- WASTE is anything that does not add value to the product.
- The seven wastes are:
  - Waste of overproduction
  - Waste of waiting
  - Waste of transportation
  - Waste of processing
  - Waste of stocks
  - Waste of motion
  - Waste of making defects

JIT TOOLS

- HEAD STAGE:
  - Training
  - People Involvement
- VEHICLE STAGE:
  - Design, Focus
  - Small Machines
  - Total Preventative Maintenance
  - Total Quality Control
  - Setup Reduction
  - Layout and Balance

JIT TOOLS (cont.)

- DRIVER STAGE:
  - Multi-Function Workers
  - Buffer Stock Removal
  - Lot-Size Reduction
  - Enforced Improvement
  - Scheduling (KANBAN)
  - Visibility
  - Vendor Scheduling
  - Process Data Collection

JIT RESULTS

- 50% reduction in factory space.
- 85% reduction in throughput time.
- 97% reduction in setup times.
- 80% reduction in work in process.
- 3 times improvement in quality.
- 3 times improvement in inventory turnover.
- 2 times improvement in asset turnover.

APPENDIX F

Tables and calculations for Setup Reduction within the Press Shop.

Setup Reduction: Press Shop

Machine Group	Machine no.	Machine type
A	1	DECOILER
B	2,10	R. PRESS (6ft)
C	3,5	B. PRESS (8ft)
D	4	R. PRESS (4ft)
E	7,8	B. PRESS (6ft)
F	9	R. PRESS (8ft)
G	11,12,21,22	60t PRESS
H	13,20,23	45t PRESS
I	14	TRIMMER
J	15,16	120t PRESS
K	18,19	100t PRESS

where: R. = Redman type of press.
B. = Brake type of press.

Note: Machines 6, 17 and 24 are permanently setup.

Table F.1 Table of machine groups within Press Shop.

Machine Group	S1	S2	S3	S4	S5	S6	S7	Stot	Sav.
A	76	242	208	135	153	95	217	112	161
B	25	16	28	37	41	27	33	207	30
C	27	30	28	26	28	19	24	182	26
D	61	79	75	50	47	16	52	380	54
E	18	11	31	29	22	39	17	167	24
F	192	228	163	95	188	206	131	1203	172
G	37	19	28	29	34	41	20	208	30
H	28	67	71	44	18	22	38	288	41
I	34	88	50	41	69	29	43	321	46
J	42	45	15	37	60	54	525	305	44
K	40	39	25	33	46	21	28	232	33

where: Sn = Setup time, observation n, in minutes.
Stot = Total sum of setup times, in minutes.
Sav. = Average group setup time, in minutes.

Table F.2 Machine setup times in August 1987.

Machine Group	S1	S2	S3	S4	S5	S6	S7	Stot	Sav	Tmn	Tmx
A	140	232	153	180	96	210	165	1076	154	7	24
B	17	20	28	17	37	20	23	162	23	0	1D
C	32	11	29	18	22	37	17	166	24	0	140
D	11	75	49	38	27	50	62	312	45	0	147
E	38	10	33	26	32	25	16	180	26	0	84
F	138	74	80	167	144	105	187	895	128	5	56
G	29	23	35	25	17	39	19	187	27	0	1D
H	14	35	52	29	39	63	22	254	36	0	1D
I	63	28	45	68	32	57	45	338	51	0	191
J	30	50	15	38	46	38	40	257	37	61	180
K	25	42	23	19	36	28	33	206	29	15	52

where: Sn = Setup time, observation n, in minutes.
Stot = Total sum of setup times, in minutes.
Sav. = Average group setup time, in minutes.
Tmn = Minimum time machine was idle, while waiting for an operator.
Tmx = Maximum time machine was idle, while waiting for an operator
D = Day.

Table F.3 Machine setup times in February 1988.

Calculations for Kruskal-Wallis test of statistical significance between means of group setup times. [101]

Setting up the Hypothesis:

1. Ho : Sav.A = Sav.F
   H1 : The means are not equal.

Where: Sav.A = Average setup time in August.
       Sav.F = Average setup time in February.

2. Kruskal-Wallis test, 0.05 level of significance, one degree of freedom.

3. From chi-square tables, if H > 3.841, reject Ho.

Now,

$$H = \frac{12}{n(n+1)} \times \left[\sum \frac{Ti^2}{ni}\right] - [3(n+1)]$$

where: ni = size of sample in ith group = 7.
       n = SUM(ni) = sample size for all groups combined = 14.
       Ti^2 = Sum of ranks squared for each of the groups.

Example, for machine group A.

Observation no.	Setup times August	Setup times February
1	76 (13)	40 (14)
2	242 (1)	232 (2)
3	208 (5)	153 (8.5)
4	135 (10)	180 (6)
5	153 (8.5)	96 (11)
6	95 (12)	210 (4)
7	217 (3)	165 (7)
SUMXi	1126 (52.5)	1076 (52.5)
ni	7	7

(x) = rank order.

$$\Longrightarrow H = \frac{12}{14(15)} \times \left[\frac{(52,5)^2}{7} + \frac{(52,5)^2}{7} \right] - 3(15)$$

$$= 0.$$

Therefore accept Hypothesis, ie. change in means is not significant.

---->

Similar calculations were performed for the other machine groups, the results of which are shown in the table below:

Machine Group	H - value	Significant?
A	0	NO
B	4.89	YES
C	0.20	NO
D	3.86	YES
E	0.10	NO
F	4.26	YES
G	0.47	NO
H	3.12	NO
I	2.39	NO
J	3.85	YES
K	3.62	NO

Table F.4 Results of Kruskal-Wallis tests on changes in mean setup times.

APPENDIX G

Calculations for Kanban Quantities.

Calculation of kanban quantities for cabinets:

Cabinet Number.	Usage to Date		Kanban Quantity	
	White	Almond	White	Almond
10256	53	369	0	10
10257	120	937	5	20
10258	46	155	0	5
10259	0	39	0	5
10260	31	132	0	5
10261	26	145	0	5
10263	0	37	0	5
10342	546	1	5	0
10343	5574	1995	55	40
10344	2671	879	30	20
10356	1397	1	15	0
10358	513	0	5	0
10361	851	0	10	0
10364	382	460	5	10
10365	210	448	5	10
10368	76	0	5	0
10371	53	592	0	15
10372	2773	1078	30	25
10374	278	0	5	0
10378	344	461	5	10
10379	240	419	5	10
10385	2030	0	20	0
10386	1971	621	20	15
10387	1779	1	20	0
10388	382	0	5	0
10396	2030	0	20	0

Where: wait + process time = 3 days for white, and
6 days for almond.
safety factor = 1 day.
no. of Kanban cards = 3.
no. of days to date = 209.

Furthermore, quantities have been rounded up to the *nearest five.*

eg. For almond cabinet no. 10372:
Kanban Quantity = 1078/209 x 6 x 2 / 3
= 20.6 round up to 25.
--->

Calculation of kanban quantities for draws:

Draw Number.	Usage to Date		Kanban Quantity	
	White	Almond	White	Almond
20345	8059	6	120	0
20389	3942	1242	60	40
20417	1702	0	25	0
20493		1993	0	60
20502		310	0	10
20535	4226	5364	65	155

Where: wait + process time = 3 days for white, and
6 days for almond.
safety factor = 2 days.
no. of Kanban cards = 3.
no. of days to date = 209.

Note: safety factor has been increased so as to account for increased uncertainty in process time, since draws are first deep drawn in another department.

Furthermore, quantities have been rounded up to the nearest five.

eg. For white draw no. 20345:
Kanban Quantity = 8059/209 x 3 x 3 / 3
= 115.7 round up to 120.
---->

Calculation of kanban quantities for tile boards:

Tile board Number.	Usage to Date White	Almond	Kanban Quantity White	Almond
10222	1307	1	[illegible]	0
10229	[illegible]	4180	[illegible]	100
10199	[illegible]	0	[illegible]	[illegible]
10143	[illegible]	4025	[illegible]	[illegible]
10242	[illegible]	[illegible]	25	25

Where: wait + process time = [illegible] days for white, and
[illegible] days for almond.
safety factor = [illegible].
no. of Kanban cards = [illegible].
no. of days to date = [illegible].

Furthermore, because of their size and the small amount of spaceoccupied by each tile board, figures have been rounded up to the nearest twenty five.

eg. For almond tile board no. 10229:
Kanban Quantity = 4180/209 x 6 x 2 / 3
= 80 round up to 100.
---->

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