International Management Journals

www.managementjournals.com

International Journal of Applied Quality Management

Volume 1 Issue 3

TPM - A Strategic Issue for Stelrad

Philip Taylor

TPM Manager, Caradon Sterland

ISSN 1742-2647

www.managementjournals.com

This is the first of three papers designed to test the hypothesis that the use of total productive maintenance (TPM – a Japanese manufacturing technique) will reduce costs at Stelrad Mexborough, a South Yorkshire factory. This paper analyses the need for this cost reduction to clearly show its scope and strategic importance to the organisation.

The History of the Problem Issue

Stelrad Mexborough is the manufacturing site of Stelrad UK, a producer of domestic central heating radiators. Stelrad UK itself is part of the European radiator arm of Caradon PLC's plumbing division. At the time of writing Stelrad employed the author as a Kaizen Engineer with responsibility for continuous improvement. In November 1999 he was given the task of implementing TPM by the UK Operations Director in order to improve operational efficiencies and reduce costs. The improvement was necessary to address urgent strategic issues that were having a detrimental effect on the business.

Stelrad UK performed badly for the whole of the 1990's with each year seeing a fall in market share. During 1998 marketing forecasts showed that Stelrad would be running at a loss by 2002 unless market share could be increased. There were many reasons for the loss of market share (cheap foreign imports, increased number of competitors in the industry), but the major cause was Stelrad's premium pricing policy. Stelrad's products were priced at around 20 percent higher than a comparable competitor's product. This policy relied on product differentiation (Porter 1985) based on the close relationship that Stelrad had with its merchant customers, its superior quality and service and the value of its brand name. The company had considered these to be its core competencies but it had in fact neglected the three recognised factors that constitute a core competency (Hamel and Heene 1994, Johnston and Scholes 1997, Prahalad and Hamel 1990) which are:

- The customer must value it.
- It must be different to the competitors.
- It must be sustainable over time.

The relationship with the customers had eroded as they switched to the cheaper imports due to them placing greater value on price rather than on relationships and service. Also the quality advantage that Stelrad had over the rest of the market[2] was not sustainable since all major players could now match it. Although the brand name still held some sway it could not sustain a price, vis-à-vis quality that was 20 percent above market norm.

The decision was belatedly made (considering the previous decade of year on year market share loss) to drop prices to market level in order to win back custom. This required immediate savings in costs and, in order to do this, the two manufacturing sites were amalgamated into one. Thus the plant at Dalbeattie, Scotland was closed with the loss of 160 jobs and all production was moved to Mexborough, South Yorkshire with the expected increase of 50 jobs. Although the movement of machinery during this transition was handled very efficiently[3], the movement of people was not, since only five of the Dalbeattie workforce (all managers) took up the 200 mile relocation package and Stelrad lost the experience of the 'hands on' Scottish operators.

The Strategic Impact of the Issue

The above scenario gave rise to the strategic issue that forms the basis of these papers. Mexborough had been the high volume, low variety producer whilst Dalbeattie had manufactured the small batch, high variety radiators and had consequently suffered slightly worse efficiencies (Slack et al 1990: 60). Each site had been proficient at their own particular skills; with Mexborough producing 200 of the 1200 products in the Stelrad portfolio and Dalbeattie the remaining 1000. Stelrad's management had under-estimated the difficulties in doubling output from one facility with unfamiliar products and without the benefit of Dalbeattie's experienced workforce. This put Mexborough on a steep learning curve and operating efficiencies, which had been running in the high seventy percents, fell to the low fifty percents. This was exacerbated by the success of the new pricing policy, which increased demand by ten percent during 1999. Stelrad had planned its manning and production costs around Mexborough retaining its previous levels of efficiency, but now it found that on these terms it could not meet demand. To cope with this situation, temporary workers were employed and extra running shifts added.

The costs incurred by the extra heads (around 100 people) and running time negated all savings made in fixed costs by shutting Dalbeattie and the impact of the twenty percent price drop had to come directly out of profits. If operational strategy can be described as the integration of resources, processes, people and skills which are pulled together to deliver organisational strategy (Johnston and Scholes 1997: 12), then the situation at Mexborough showed that the operational and organisational strategies were not aligned.

The financial figures for 1999 made frightening reading:

Table 1

STELRADS KEY PERFORMANCE MEASURES		
	1998	**1999**
Volume	**2.1 Million radiators**	**2.3 Million radiators**
Sales	£50.4 M	£47.8 M
Profit	-42%	-86%
ROS	11.2%	5%
ROCE	19.5%	2.9%
Contribution	43.7%	20.7%

The company expected the poor results of 1998, as money was set-aside for the Dalbeattie closure and paying for the relocation of the equipment. The 1999 results however, while not expected to be good, caused consternation in the higher echelons of management. Axel Schulmeyer, the European MD, left the company early in 1999 to be replaced with Stewart Rolland, who also left the company, at the end of the year. This was mirrored in Britain as Kash Pandya, UK operations Director, left during the spring of 1999 to be replaced with Brian McCluskey who lasted until the autumn. Their current replacements are Henk Van De Boom and Bill Todd respectively.[4]

Table 2

MEXBOROUGH SITE PERFORMANCE FIGURES		
Measure	**1998**	**1999**
Accident rate	86%	115%
Staff turnover	8%	14%
Absenteeism	3.2%	5.3%
Complete on time delivery	99.8%	96%

Many of the softer ‘people’ issues also showed an alarming slide, which can be an indicator of the pressure that this situation is placing on the workforce and a possible decline in their morale.

The entire European radiator market was running at under capacity and any cost inefficient business was at risk in this environment. Stelrad was under the same threat of closure that the current strategy aimed to avoid and, if trends were not reversed, it could cease to exist as a company. The 250 people employed at Mexborough could join the 160 from Dalbeattie in losing their jobs. These were the stakes at risk if the situation was not addressed.

The Scope of the Project

Stelrad, as a company, has had an interest in Japanese management techniques since the introduction of TQM during 1993. Several members of the management team (including the author) have visited Japan to study their best practices in manufacturing methods. As part of this interest, Stelrad invited Professor Yamashina[5] to England to consult for us and, during November 1999, presented the company’s situation to him. The professor was head of the examining board of the JIPM (Japanese Institute of Plant Management) who controlled the implementation of TPM in Japan (they were even credited with inventing the term TPM) and as such his opinion carried considerable weight. He stated that any manufacturing site could benefit from the application of TPM and that in our situation it was essential. The task of implementing this initiative was handed to myself by the UK Operations Director with a report of progress to be presented to the professor on his next visit (March 2000).

What is TPM?

During the 1970’s and 1980’s the Japanese economy expanded rapidly, far out stripping its western rivals. This expansion was fuelled by the increasing efficiency of Japan’s manufacturing industry and this instigated a rush of ‘fact finding’ missions by American and European manufacturing Leaders. They discovered that the secret of Japan’s success was TPM, which the Japanese Institute of Plant Maintenance defines as:

> *"A system of maintenance covering the entire life of the equipment in every division including planning, manufacturing and maintenance."* (Ho 1995: 49).

TPM covers the use of a number of manufacturing techniques, which were themselves built upon many of the American quality models that were already in existence. Only recently with the progression of the ‘Total Quality Management’ and ‘Just In Time’ ethos has the ‘toolbox’ that is TPM been labelled as such. One of the main characteristics of industry in Japan is that they rely on the creativity of the group rather than the originality of the individual (Sakurai 1996: 215), which is covered in more detail in section 2.3. TPM uses this teamwork combined with measurement to produce zero defects (Crosby 1979). This then reduces the lifecycle cost of any equipment and extends the useful life-span of that equipment by reducing unplanned downtime and maintaining full output throughout its life – in effect treating unplanned downtime as a defect in itself. (Nakajima 1988: 19, Imai 1980: 3-4 and Sukarai 1996: 164).

If TPM were easy to implement however, all factories would do it. A survey carried out by Samuel K. Ho (1995) shows that over 50 percent of all Japanese companies have practised TPM compared to ten percent of UK companies. The Japanese companies that do not use TPM are not, on average, as efficient as their American counterparts (Sakurai 1996: XV1); the ones that do implement it successfully however, excel.

TPM has evolved gradually as environmental conditions changed and new needs emerged. Only since the involvement of operators in autonomous maintenance during the 1970's has TPM been labelled as such.

TPM embodies the Japanese technique of kaizen, which translates as continuous improvement. Oakland (1993) suggests that kaizen is a never ending journey and that each day should be started on the principle that methods can always be improved. Whilst Imai (1986) suggests that kaizen is the single most important concept in Japanese management and is the key to competitive success. Gurus such as Deming, Juran, Crosby and Taguchi elevated the concept during the 1960's and early 1970's with various tools for improving quality. Sakurai (1996) however alleges that it is the willingness to undertake fundamental as well as gradual change that has been the driving force behind Japanese management's success in manufacturing.

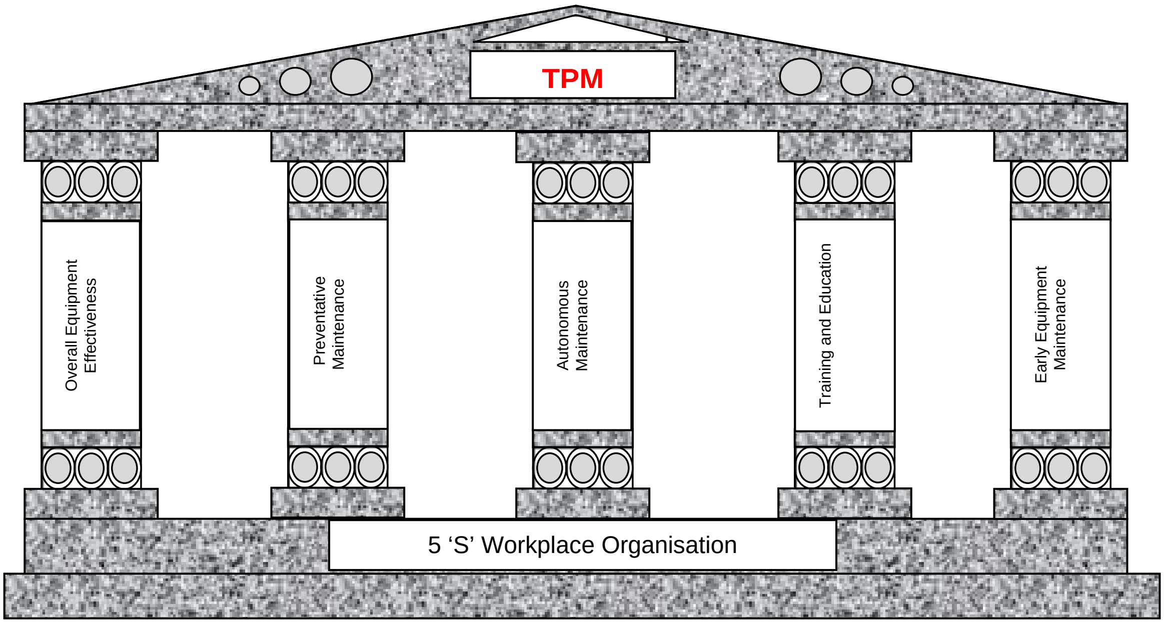
Table 3

DESCRIPTION OF THE TECHNIQUES DEVELOPED IN TPM	
Preventative Maintenance (PM)	A technique involving only the maintenance department that takes three forms: Preventative maintenance (PM) - a series of scheduled checks designed to cure or detect possible breakdowns before they occur Maintenance prevention (MP) – designing new equipment to be free of maintenance Maintainability improvement (MI) – modification of existing machinery to prevent breakdown or to facilitate ease of maintenance
5 'S'	A team based technique, which motivates people for plant maintenance through teamwork and training in basic housekeeping activities (see appendix 2 for a more detailed description)
Autonomous Maintenance (AM)	A seven step methodology based on teamwork, training and empowerment designed to allow operators to participate and take ownership of the maintenance of their machines (see appendix III)
Overall Equipment Effectiveness (OEE)	A method of measurement which specifies where the greatest losses are occurring
Training and education	Used in conjunction with autonomous maintenance, a technique for defining what training should be given and where it should be applied

Predictive Maintenance (PM)	Condition based monitoring of equipment using specialist techniques such as vibration analysis and heat sensitive cameras
Early equipment maintenance	A technique designed to allow all stakeholders in new equipment (operators, engineers, production managers, commercial) to have a hand in the design of new equipment – solving problems before it reaches site
Office TPM	A team based technique designed to reduce none valued activities in the office
Safety	A team based technique designed to reduce accidents
Quality maintenance (QM)	A team based technique designed to reduce quality issues in manufacturing
Unmanned operations	A team based technique designed to produce unmanned operations
Concurrent engineering	A team based technique for designing new products, and the machines that produce them, concurrently in order to reduce start up problems
Cost and volume deployment	A team based technique for determining the areas of greatest cost or constraint to production

The previous tools and techniques have become more and more sophisticated as time has gone on, however the techniques from 1981 onwards are specialist and are not essential to the implementation of TPM. Yamashina (1996) explains that in Japan during the period up to 1974 (from the war), increased production was needed as demand exceeded supply. To cope with this situation simple techniques, such as 5 'S' for organising the workplace correctly (see appendix 2) and preventative maintenance (PM) systems, to eliminate breakdown and reduce downtime were necessary. It was noted, however, that the benefits of PM levelled off after 3 years and that, outside the scope of PM, was set up time, minor stoppages and adjustments. From 1974 onwards, as markets reached saturation, variations in production were needed to create new markets and fill new niches. This needed greater involvement from the operators to enable flexible manufacturing and was the originator of autonomous maintenance (AM). This compares easily to the operational strategy at Stelrad in that an effective PM system has proved not able to cope with the need to move to flexible production. Coupled with autonomous maintenance were education and training and the use of OEE to allow improvement to be focussed into the correct area. During the 1980's EEM was developed to solve problems with new equipment before it reached the factory. These first techniques were identified as being the essential pillars of TPM by Nakajima (1982: 49 - 52) and were also supported by Tajiri and Gotoh (1982: 1) and Suzuki (1994: 35).

Figure 2: The Five Pillars of TPM



- Attack 6 losses and improve overall equipment effectiveness (OEE).
- Set up planned preventative maintenance (PM).
- Establish autonomous maintenance (AM).
- Training and education.
- Equipment improvement, maintenance prevention (EEM).

It is noticeable that 5 'S' does not form part of these pillars but forms a base upon which TPM is built. This is because at the stage where TPM is able to be implemented workplace cleanliness should be taken for granted (like brushing ones teeth in the morning for example). Stelrad Mexborough has used 5 'S' for the last four years and is greatly changed in terms of cleanliness and workplace organisation.

The concept of TPM was widely introduced to the western world by Nakajima in his book 'TPM Development Program' (1982) which is considered to be the seminal work on TPM. His descriptions of the features of TPM are that:

> TPM aims to maximise equipment effectiveness.
>
> TPM establishes a thorough system of PM for the equipment's entire life span.
>
> TPM is implemented by various departments (engineering, operations and management).
>
> TPM involves every single employee from top management to workers on the shop floor.
>
> TPM is based on the promotion of PM through motivational management; autonomous small group activities.

He goes on to define three meanings of the word 'total' in the above list;

1. Total effectiveness (referred to in point 1 above) indicates TPM's pursuit of economic efficiency or profitability.
2. Total maintenance system (point 2) includes MP, MI as well as PM.

3. Total participation of all employees (points 3, 4 and 5) includes autonomous maintenance by operators and small group activities at all levels.

Although TPM is a discipline for the entire organisation (including research and development, marketing, planning and logistics) the only aspects that can be affected by Stelrad Mexborough at present are manufacturing operations and engineering. When considering Nakajima's definitions above; Stelrad already attempts to perform PM through the use of maintenance improvement teams and a computerised maintenance system which issues scheduled engineering checks for each machine in the factory. This takes a considerable amount of time to complete and, although effective prior to the Dalbeattie closure, under present circumstances is rarely completed fully.

The engineers are at the moment having so many breakdowns that they are performing 'reactive maintenance': solving problems as they occur but only attacking the symptoms not providing a cure. This is becoming self-perpetuating in that, the more breakdowns and short stops that occur, the less time there is to perform preventative maintenance due to the pressure of the production schedule. It also ties the engineers time up to such an extent that they are unable to improve the design or maintainability of the equipment, although it is realised that doing this would be beneficial to the organisations overall strategy. If the full PM system could be implemented, this cycle could be broken and improvement could take place. The maintenance department on its own has not got the resource to stem the tide of breakdown and set up losses and, since costs need to be reduced, more engineers cannot be employed. Although traditionally 'operators operate' and 'maintenance maintain', it is necessary for help to be found from another source and the operators through the use of autonomous maintenance could provide this help. In order to do this the skills of every employee needs to be strengthened:

> *"Developing stronger employees and equipment builds a stronger more resilient company."* (Japanese Institute of Plant Maintenance ed. 1996: 14).

The following table shows the effects that the different types of maintenance strategy could have on the company.

Table 4

COMPARISON OF EFFECTS OF DIFFERENT MAINTENANCE ACTIVITIES			
Maintenance activity	**Will maintain present standard of equipment**	**Will improve standard of equipment**	**Will involve operators in equipment maintenance**
Reactive maintenance	√		
Full PM system (MP, PM, MI)	√	√	
TPM	√	√	√

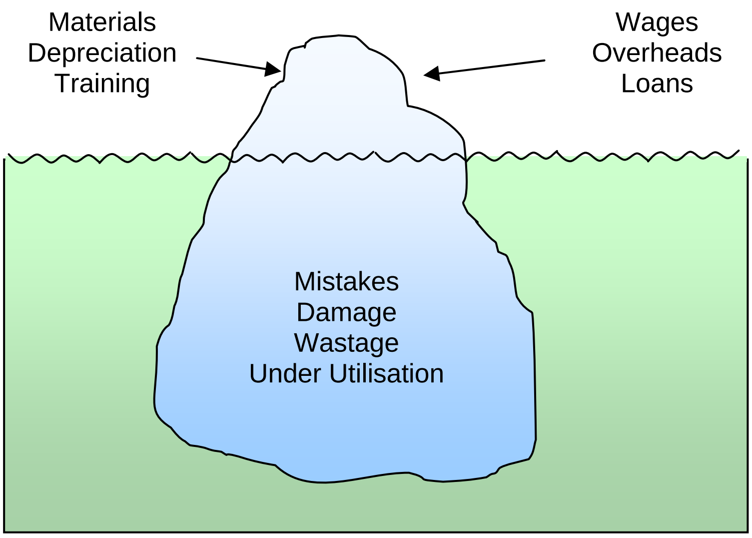
Only the TPM strategy will involve the operators and this must be the course to follow since the maintenance department that Stelrad has put its faith in so far cannot cope on its own.

It can be seen that Japan's development of TPM compares to the situation at Stelrad. Just as Japan first aimed to improve its manufacturing efficiency by installing 5'S' and then by relying wholly on its maintenance system - so has Stelrad. While this worked satisfactorily for a while, the need for more flexibility revealed that PM does not attack losses due to set up time or adjustments. Japan solved this problem by involving operators in autonomous maintenance, introducing measurement by OEE and training. Considering the five pillars of TPM (Figure Two), Stelrad already uses PM, OEE and 5 'S' workplace organisation. Early equipment management (EEM) is not a major factor in Mexborough since very little investment in new machinery is planned in the near future. It would appear that autonomous maintenance, backed up by training, would be the logical next step. The implementation of autonomous maintenance will form the basis of the rest of this dissertation. The next section explores in greater detail the benefits that are available to Stelrad through the use of TPM.

The Benefits of TPM to Stelrad

The over-riding strategic need for Stelrad is to reduce costs and (in common with the majority of industry) maintenance costs could provide those reductions. According to Tudor (1994: 8), rising maintenance costs account for between 4 and 14 percent of total production costs and is often greater than the plant profits. While Walker (1994: 20) maintains that the industries annual spend on maintenance of around £14 billion is almost a fifth of the total value of its plant and equipment, to be included on top of this is the cost of maintenance failures, downtime and quality failures. Yoshida et al (1986: XI) sets this figure even higher at 15 – 40 percent of total manufacturing costs and attribute up to 75 percent of life cycle costs to maintenance activities. Other studies have considered the cost of quality which, in the western industrial world, is considered to be between 10 - 20 percent of sales. In Japan however, through the implementation of TQM and TPM, the cost is 2.5 – 4 percent (Roth and Morse 1983: 50, Sakurai 1996: 135). The fact that these figures do not cause consternation in the industrial world is due in the main to them being hidden amongst general running costs

Figure 3: The Iceberg Effect, The majority of losses are hidden



TPM can reduce these costs initially by its proven tendency to increase the reliability of machines – as demonstrated in Japan (JMA Research Institute 1983, Yoshikawa 1984). Since the early 80's Japan has led the way in efficient automation techniques, the world population of robots, for example, in 1993 was 610,000; 66 percent of which operated in Japan (Japan Robot Association 1994).

However the clearest benefit from the introduction of TPM is reduction of direct heads as production is completed in a shorter time. This can lead to other benefits – support staff should decrease in the long term, as more reliable machinery needs less attention. The costly replacement of parts due to breakdown should cease. Reliability of process flow can lead to decreased inventories and even making to order which gives increased stock turns and floor space. Also, as the quality of finished product increases – so does the yield, as defective parts are no longer produced. This in turn shortens lead times for each batch of radiators, which leads to the next strategic need for Stelrad - that of flexibility. This need has been encountered in Japan since the 1970's as revealed in the preceding section and it remains a major factor in the 1990's. In a survey of the number one concern of the top manufacturing companies listed on the Tokyo stock exchange the top three answers were:

- 74 percent - reducing lead times.
- 58 percent - increasing linkages between production, engineering and marketing.
- 52 percent - coping with high variety and low volume.

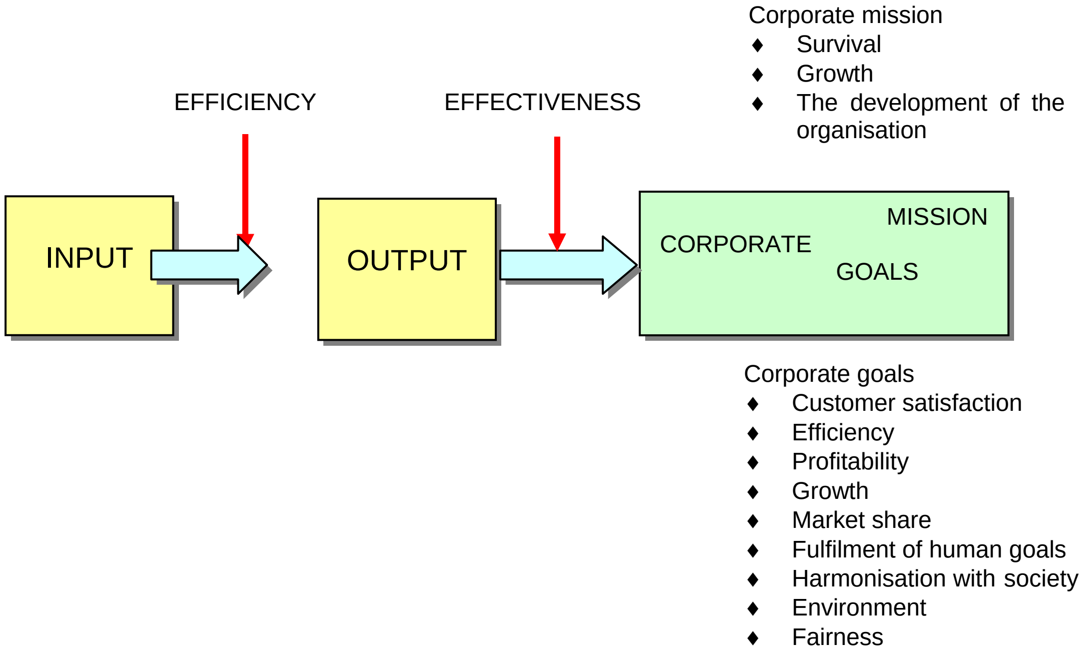
(Source: Japan Management Survey 1990)

All of which relate to flexibility and for Stelrad, along with most successful companies, economy of scope must replace economy of scale (Sakurai 1996: 4). Quantitatively evaluating increased flexibility at Stelrad is difficult, but certainly making different batch types in shorter times allows more to be processed in a specified time. The increase in output can mean that overtime or additional running hours is not needed or extra output for the same running time will reduce costs as the fixed costs are spread over a greater amount of products. The option is then given to undercut the opposition and maintain profits or to maintain price and increase profits.

The figures shown in table two (section 1.2) indicate problems with increased turnover, absenteeism and accidents. Mullins (1989) explains that high labour turnover unnecessarily burdens the organisation with recruitment and labour costs. There are also intangible costs such as production shortages, low morale, job satisfaction and motivation. For an organisation to benefit from being at the bottom of the product 'experience curve' experienced staff are critical. This is because they are more likely to know how to overcome the sporadic problems that affect productivity. This is certainly an issue at Stelrad that needs improvement and Suzuki (1992) implies that, apart from improving productivity and quality through measurability, TPM can show measurable improvements in cost, delivery, safety and morale.

Another aspect to consider is whether increasing the efficiency of the plant would be effective in terms of overall company strategy. Sakurai (1996) advocates the word 'effective' rather than 'efficient' in conjunction with management as shown in the diagram below. This takes a more holistic view of the situation; which process, or part of a process, is it most effective, in terms of company benefits, to run efficiently. Discovering this is the only way to make effective improvements that will quickly benefit Stelrad in a strategic sense.

Figure 4: The relationship between efficiency and effectiveness



(Source: Sakurai 1996:11)

If the situation at Stelrad is compared to the mission and goals indicated in that Sakurai's model above, then a test of the TPM initiatives possible effectiveness can be obtained.

Corporate mission

- **Survival:** considering the present European radiator markets over capacity, then this is no exaggeration of the situation that Stelrad is facing.
- **Growth:** to supply the growth that Stelrad has generated, more radiators are needed in less time from fewer men.
- **Development of the organisation:** with growth Stelrad can capture the British market by breaking and buying up the smaller players.

Corporate goals

- **Customer satisfaction:** this has been identified as requiring: a good quality product, delivered on time and, most importantly, at a price that is comparable to the rest of the market. TPM would, according to the literature search, deliver benefits in these areas.
- **Efficiency:** TPM's sole purpose is to improve machine efficiency (Sakurai 1996:13)
- **Profitability:** reducing losses will have a direct effect on transformation costs, increasing profits.
- **Growth:** the entire reasoning behind Stelrad's corporate strategy is market growth after years of decline.
- **Market share:** with all players at a level the market is extremely competitive. The only way out of this situation is to win market share and use economy of scale.
- **Fulfilment of human goals:** this will be somewhat of a paradigm in that the success of the initiative will result in Stelrad losing a portion of its temporary

staff. The remaining permanent workers will however be better trained and participate more in the running of the factory's operations. If this could be said to fulfil their goals then TPM will have been effective.

- **Harmonisation with society:** the Dearne Valley area in which Stelrad is situated is an employment black spot. Any initiative that ensures the continued existence of a major employer would be considered to be in harmonisation with society.
- **Environment:** the reduction of losses and scrap and rework would mean less energy and resources being used, which would benefit the environment.
- **Fairness:** the use of TPM is open to all manufacturers and could not be deemed unfair in any way.

Sakurai's model gives weight to the argument for improving operational efficiency in Mexborough but leaves the question open of whether TPM is the only answer. There are many tools, techniques and continuous improvement programmes other than TPM that could be used by Stelrad to solve its problems. A selection of possible solutions and their definitions are listed below:

Statistical process control (SPC): can be defined as the use of statistical techniques (such as control charts) to analyse a process or its outputs. The aim of this is to take appropriate actions to achieve and maintain a state of statistical control and to improve the process capability (Chrysler et al 1993: 153).

Just in time (JIT): is a technique designed to meet demand instantaneously, with perfect quality and no waste (Bicheno 1991). This works on 'pull' systems such as 'kanban' and is aimed at reducing raw material stock to a minimum.

Taguchi theory: is defined as an efficient method of experimentation, which identifies factors that affect the mean and variation of a product or process with minimum testing (Chrysler et al 1995: 55). This technique could be used to eliminate losses due to poor quality.

Quality circles (QC): are teams of people from the same work area who meet voluntarily to solve quality issues in their own area and then present their proposals to management and are usually involved in implementing them (Russell and Dale 1989).

Failure mode effect analysis (FMEA): is defined as a systemised group of activities to recognise and evaluate the potential failure of a product / process and its effects in order to identify actions to eliminate that failure from occurring and to document the process (Chrysler et al 1995: 1).

Business process re-engineering (BPR): is a technique defined as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality service and speed (Slack et al 1998: 696).

It is useful to consider the effects of the above techniques on internal supply chain weaknesses compared to TPM as shown in table 5 below.

Table 5

TOOLS	INTERNAL SUPPLY CHAIN WEAKNESSES				
	Internal competition	**Poor communicat ion**	**Inefficient methods**	**Waste**	**Hidden Costs**
SPC	-	-	√	√	-
JIT	-	-	√	√	-
TPM	√	√	√	√	√
Taguchi	-	-	√	-	-
QC	√	√	-	√	-
FMEA	-	-	√	-	-
BPR	-	-	√	√	√

Only TPM will attack all the internal supply chain weaknesses indicated in the above table.

Empirical evidence also states that, in terms of overall company strategy, investing time and resources in the people and machines involved in operations is suitable for pursuing the strategies of low cost leadership or differentiation as defined by Porter (1985). Companies that can produce high quality products cheaply and that are flexible enough to change product lines quickly have a distinct competitive advantage (Hall 1980: 75 - 88, Gilbert and Strebel 1988: 82 - 94 and Loomis 1989: 83 - 86).

It has been demonstrated that maintenance costs are excessive for Stelrad and the industry as a whole and that (in Japan’s experience) TPM can reduce these costs whilst also increasing flexibility. Stelrad’s problems with softer people issues such as absenteeism and accidents could be improved through TPM. Sakurai’s model of effectiveness was then used to give a holistic view of the benefits to the organisation as a whole of improving operating efficiencies at Mexborough and this added weight to the argument for using TPM. Finally various other tools for improving efficiencies were compared to show their effects on internal supply chain weaknesses and TPM again proved to be the most effective.

References

Argyris C. (1964) was integrating the individual and the organisation, Wiley.

Argyris C. (1998), Empowerment: The Emperors New Clothes, Harvard Business Review, May June.

Bamber, C.J., Sharp, J.M., and Hides, M.T, 1999. Factors affecting successful implementation of total productive maintenance: A UK manufacturing case study perspective. Journal of Quality in Maintenance (online), 5(3). Available at: -URL: http {/www. emerald-library, corn (Accessed Jan 2000)

Beckhard R. (1969), Organisation Development, Addison — Wesley.

Belbin R.M. (1981), Management Teams: Why They Succeed or Fail, Heinemann: London.

Bicheno J. (1991), Implementing Just In Time, IFS (quoted in Slack et al: 548).

Blanchard B. (1997), An Enhanced Approach for Introducing Total Productive Maintenance in the Manufacturing Environment, Journal of Quality in Maintenance, 3 (2), pp 69-80.

Buchanan D. and Boddy D. (1992), The Expertise of the Change Agent, Prentice Hall

Bray O.H. (1988), Computer Integrated Manufacturing: The Data Management Strategy, Bedford MA: Digital Press.

Brown A. (1992). TQM: Implications for training, Industrial and Commercial Training, Vol. 24, No 10.

Crosby P. (1979), Quality is Free, New York: McGraw-Hill.

Child J. (1979), Organisation, Harper and Row, London, 1979.

Chrysler Corporation, Ford Motor Company and General Motors Corporation (1993), Statistical Process Control (SPC), Reference Manual, Carwin Continuous Ltd.

Chrysler Corporation, Ford Motor Company and General Motors Corporation (1995), Potential Failure Mode and Effect Analysis (FMEA), Reference Manual, Second Edition, Carwin Continuous Ltd.

Deming W.E. (1982), Out of Crisis, MIT Cambridge, Mass (USA).

Garvin D.A. (1984), Product Quality; an Important Strategic Weapon, Business Horizons (March — April).
Greiner L.E. (1967), Patterns of Organisational Change, Harvard Business Review, Vol. 45.

Feigenbaum A.V. (1986), Total Quality Control, McGraw-Hill.

Ghoshal S. and Bartlet C.A (1996), Rebuilding Behavioural Context: A blueprint for Corporate Renewal, Sloane Management Review, Winter, Vol. 37, No 2.

Gilbert and Strebel (1988), Developing Competitive Advantage in the Strategy Process, Englewood Cliffs: Prentice Hall.

Goldratt E. and Cox J. (1992), The Goal — A Process of Ongoing Improvement, North River Press, 2nd Revised Edition.

Goodwin M. (2000), Using Japanese Techniques to Enhance Employee Involvement and Empowerment, Proceedings of Japanese Success Factors for World Class Manufacturing Conference, Brussels, Sheraton Airport Hotel, 20th March 2000.

Haigh R. and Morris D. (1996), Total Quality Management, Sheffield Business School, Sheffield Hallam University.

Hall W.K. (1980), Survival Strategies in Hostile Environments, Harvard Business Review, Vol. 58, September — October.

Hamel G., Heene A. (1994), Competence Based Competition, Wiley.

Ho S.K. (1995), TQM an Integrated Approach, London, Kogan Page.

Honey P. and Mumford A. (1989), A Manual of Learning Opportunities, Maidenhead: Peter honey.

Imai M. (1986), Kaizen — The Key to Japan's Competitive Success, First Edition, McGraw-Hill.

Imai K. (1980), The Theory and Reality of Lifecycle, Japan Management Association.
Ishikawa K. (1985, What is Total Quality Control? — The Japanese Way, Prentice hall.

Japanese Institute of Plant Maintenance, ed (1996), TPM for every Operator, Oregon, Productivity press.

Japan Management Survey (1990), Management Issues Survey (Production), Japan Management Association, November.

Japan Robot Association (1994), The Present State and Outlook for Industrial Robots, October.

JMA Research Institute (1983), Robotisation: Its implications for Management, Fuji Corporation.

Johnson and Scholes (1997), Exploring Corporate Strategy, Prentice Hall.

Juran J.M. (1989), Management and Organisational Behaviour, Pitman, Second Edition.

Koenig D.T. (1990), Computer Integrated Manufacturing: Theory and Practice, New York: Hemisphere Publishing Corporation

Laraia A.C., Moody P.E. and Hall R.W. (1999), The Kaizen Blitz, John Wiley and Sons.

Likert R. (1961), New Patterns of Management, New York, McGraw-Hill.

Loomis C.J. (1989), Stars of the Service 500, Fortune, Vol. 119, June 5th.

Morris D.S., Haigh R.H. and Kanji G. (1994), How to Stop Quality Improvement Teams from Quitting, Total Quality Management, Vol. 5, No 4.

Mullins L.J. (1989), Management and Organisational Behaviour, Pitman, second Edition.

Nakajima S. (1982), TPM Development Program, Productivity Press.

Oakland J.S. (1990), Total Quality Management, Butterworth-Heinemann, Oxford.

Ouichi W.G. (1981), Theory Z; How American Businessmen Can Meet the Japanese Challenge, New York, Avon Books.

Porter M. (1985), Competitive Advantage ‘Creating and Sustaining Superior Performance’, Free Press.

Prahalad, C.K. and Hamel G (1990), The role of core competence of the corporation, Harvard Business Review, May — June.

Prentice G. (1990), Adapting Management Style to the Organisation of the -Future, Personnel Management, Vol. 22, No6, June.

Revans R.W. (1979), Action Learning, London, Blond and Briggs.

Revans R.W. (1982), The Origins and Growth of Action Learning, Chatwell Bratt.

Roth H.P., Morse W.J. (1983), Lets Help Measure and Report Quality Costs, Management Accounting, August.

Russell S. and Dale B. (1989) Quality Circles: A Broader Perspective, WRU occasional paper, No43, London, ACAS.

Sakurai M. (1996), Integrated Cost Management: A Company Wide Prescription for Higher Profits and Lower costs, Productivity Press, Portland, Oregon.

Slack, Chambers, Harland, Harrison and Johnston (1998), Operations Management, Seventh Edition, Pitman.

Sheridan J. (1999), How’s your takt time? Industry week, July 19th 1999, vol. 248.

Suzuki T. (1992), New Trends for TPM in Japan, Total Productive Maintenance Conference, MCE Brussels, April.

Suzuki T. (1994), TPM in Process Industries, Productivity Press.

Tajiri M. and Gotoh F. (1982), TPM Implementation — A Japanese Approach, McGraw-Hill.

Toyota (1996), Toyota Production System Training Manual, Toyota company training material.

Tudor A. (1994), Achieving World Class Maintenance Status, Manufacturing Management, Volume 3, No l, January.

Walker G. (1994), Five Steps to Better Asset Care, Works Management, February.

Williamson R.J. (1981), Business Organisation, Heinemann, London.

Yamashina H. (1996), Japanese Manufacturing Strategy: Competing With the Tigers, Business Strategy Review, Vol. 7, Issue 2, Summer.

Yoshida K., Ei'ichi H., Yoshifumi K., Yasuhide U., Yoshihiro M., Mitsugu K., Tadahiro M. (1986), Training for TPM — A Manufacturing Success Story, Productivity Press.

Endnotes

[2] Stelrad tested its radiators at the highest pressure, had the longest guarantee time, a no questions money back guarantee and had the shortest lead times in the industry. All these factors, with the exception of the fastest lead times, have been matched by the competitors.

[3] The move was completed two months ahead of schedule.

[4] There is no official connection between the departures of these people and the performance of the company and they may be totally circumstantial.

[5] Hajime Yamashina – Professor of precision engineering at Kyoto University and affilitated professor of operations at London Business School.