A focused system model for strategic quality management

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Introduction

From the days of the Industrial Revolution, technological developments, innovations and improvements have not been new phenomena to the industrial world. However, these have escalated during the past ten years as a result of the increased demands of customers. Today, the industrial world experiences a situation which is characterized by the emergence of broad, competitive and dynamic market conditions, being collectively known as a global competitive market. As a result, the manufacturing community has begun to search for new technologies and strategies to face the challenges posed in this tough global competitive market, with the intention of not only entering it but also sustaining their position with an improved competitive edge. Nevertheless, with the ultimate goal being to satisfy customers, the whole industrial world shows a keen interest in finding ways to enhance "quality" in all spheres of manufacturing activity. This has resulted in an upsurge in the evolution of new approaches to attaining quality under different terminologies such as company-wide quality control, total quality control, total quality management, etc. Also, the concepts proclaimed by quality management experts like Juran[1], Feigenbaum[2], Ishikawa[3], Crosby[4] and Deming[5], which had not received much attention, emerged into prominence and other experts like Taguchi[6] and Saylor[7] became popular with their new ideas of approaching quality in products, processes and services. At this juncture, with the evolution and emergence of so many quality management experts with their concepts and ideas, the industrial world, from the early 1980s, finally acknowledged its belief in the approaches which are today collectively known as total quality management (TQM).

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Once the manufacturing community began to accept the concepts of TQM, the industrial world became inundated with its related information and programmes such as conferences, seminars, etc. and began to listen, with interest, to the preachings of quality management experts. This trend received a significant impetus from the mid-1980s when Japanese products began to dominate the global market by exhibiting extraordinary excellence in quality. As a result, manufacturers who earlier believed in autocracy began to introduce Japanese-based techniques like quality circle programmes which facilitated employees' participation in quality improvement programmes. Also, employees, who had hitherto been doing routine and monotonous work, were deputed by manufacturing firms to attend various training courses and programmes. Also, the industrial world began to witness abundant investments in terms of time and money on TQM programmes. However, ten years after the TQM movement gained momentum, manufacturers and quality managers started to re-examine the real benefits accruing from it. In this context, it was realized that exhaustive research work, covering the study of the present status, with a firm commitment to develop practical implementation strategies of TQM, was found to be necessary. This paper reports the results of the research work which was started three years ago with the primary intention of meeting this objective by bridging various theories on TQM with practice. In a nutshell, this paper reports the research work which aimed to build a bridge between visionaries (quality experts) and decision makers (manufacturers) to take the industrial world towards effective TQM through systematic, structured and focused quality management strategies which are collectively referred to in this paper as strategic quality management (SQM).

Objectives and methodologies of research

As discussed earlier, the industrial world is currently flooded with the concepts and ideas of numerous quality management experts, whose individual definitions of quality differ[8]. This has given the manufacturing community wider options that confuse the situation rather than clarify. This envisaged the need for streamlining clear-cut procedures and models which combine the useful approaches proposed by different quality management experts. In this context, this research work was planned with the objective of accomplishing the following tasks:

- Carrying out literature surveys to study thoroughly the preachings of various quality management experts.
- Conducting surveys to study the implementation trends of TQM in today's manufacturing firms.
- Carrying out comparative analyses to compare the results obtained after fulfilling the above two objectives.
- Identification of the critical areas, tools and techniques which the manufacturing firms must have to make progress in order to reduce the gap that exists between theory and practice of TQM implementation.

- Devising quality improvement strategies based on the outcomes after meeting the above objectives.
- Studying the implementation features of the devised quality improvement strategies through systematic investigations.
- Analysing critically the findings of the above investigations.
- Evolving a system model that is focused towards quality enhancement.
- Validating the developed system model.

This paper reports the experiences and difficulties overcome during this research work, which progressed in phases to accomplish the above objectives successfully.

Research framework of reference

The beginning of this research work was marked by efforts to identify a framework as a reference for proceeding further in the right direction. As this research work was committed to the practical implementation of feasibilities rather than theories, greater importance was given to the views of manufacturers. Accordingly, with a view to assessing the overall awareness of TQM among manufacturers, a simple questionnaire comprising ten questions on the foundation of TQM, as shown in Table I, was prepared and posted to more than 200 manufacturers in various countries. This process faced a severe setback, not only because of poor response, but also because of incorrect completion of the questionnaires. Subsequent follow-up action in many cases revealed that manufacturers did not wish to disclose certain facts about themselves and their firms which were required to be furnished as the replies in the questionnaire. As a result of this, the process was modified. We decided to meet the manufacturers and personnel involved in quality improvement programmes with the same questionnaire and interview them to get the replies for all the ten questions, with the strict condition that the information derived would be kept highly confidential and the identity of the respondents would not be revealed in any instance. There was no difficulty in interviewing manufacturers and quality management personnel stationed within this country. However, difficulties were faced when attempts were made to collect responses from manufacturers and quality management personnel overseas. Because of the paucity of money and time, the authors were not able to travel widely to conduct interviews. Hence, the authors participated in various international conferences held within the country and interviewed the manufacturers and quality management personnel who had come over from various parts of the world to participate. In addition, the help of fellow researchers who visited other countries was sought to conduct interviews on behalf of the authors and collect responses. At the end of these hectic efforts, 152 completed questionnaires were available, out of which 48 were from within this country. The rest of the responses were from other parts of the world, including the USA, Europe, Asia and the Asia Pacific region. This ensured global coverage of manufacturers and quality management personnel.

	Responses	
	Number	Percentage
1. Have you installed "quality circles" or any other similar employee involvement programme in your firm as a means to tap human knowledge?	152	100
2. Have you incorporated quality information management as a module in your management information system (MIS)	4	2.60
3. Are you taking efforts to segregate quality costs and use them to evaluate the cost effectiveness of quality improvement programmes?	6	4.00
4. Are you using any scientific tool like failure modes and effects analysis (FMEA) to prevent the occurrence of quality failures?	7	4.60
5. Have you installed any technical or management strategy to continually poise towards target as a means to effect zero defect manufacturing?	1	0.01
6. Are you adopting techniques like quality function deployment to transfer continually the customer's voice and desires?	5	3.30
7. After installing a quality system, are you taking steps to manage its constituents like policy, procedures and records?	54	35.50
8. Are you reacting sharply to the quality audit reports by effecting appropriate changes?	11	7.00
9. Are you adopting any model (in the form of a clear-cut, step by step procedure) to take your firm towards continuous quality improvement?	1	0.01
10. At the outset, are you confident to claim that significant breakthrough has been achieved after the initiation of quality improvement efforts?	2	0.01

Table I.
Survey questions and results on the status of TQM foundation

The systematic analysis of the collected questionnaires revealed an interesting feature. This was that no manufacturer was in a position to identify clearly a fully-fledged, quality-focused model, which should have been their fundamental requirement in the process of attaining the ultimate goals of TQM. Also, there was a clear indication that manufacturing firms are largely devoid of fundamental TQM imperatives such as quality cost evaluation, zero-defect manufacturing, etc. This can be clearly inferred from Table I. Moreover, inferences drawn from the respondents of countries other than Japan indicated that manufacturers are attempting to mimic Japanese quality improvement practices, as they have developed a blind belief that all Japanese manufacturing firms follow fully-fledged and flawless TQM. However, the responses from Japan proved that it is a misconception for they, too, experience varying degrees of TQM implementation problems. This has now been further confirmed by Dale in her article[9]. These inferences led to a conclusion that deciding merely to adopt quality management strategies followed by any Japanese manufacturing firm would prove only to be a wrong decision for effecting TQM.

At this juncture, the models, procedures and step-by-step methodologies proposed by various quality engineering and management experts were studied[1-7] and their merits and demerits were synthesized and analysed. The contributions of Yunus Kathawala[8] in this direction were also studied and

analysed. These thorough analyses, which were marked by a series of brainstorming discussions held with both academics and manufacturers, led to the conclusion that the consideration of the early single manufacturer model indicated by Juran[1] would prove to be the right framework for pursuing the research work further in the correct direction.

Single manufacturer TQM framework

It is interesting to note that, before the evolution of the Industrial Revolution, TQM was well practised. This is because, during this era, entire manufacturing activities were carried out by single manufacturers like carpenters and artisans who were in a position to infuse quality at all stages because of a simpler business network. However, TQM practices began to vanish from the manufacturing arena with the evolution of the Industrial Revolution, which outdated single manufacturer systems. Based on the single manufacturer model, Juran identified a framework of TQM called "quality spiral" for today's complex manufacturing firms. With little modification this has been standardized in ISO 9004 as "quality loop". While these frameworks guide the quality system development by incorporating all departments of a firm, no generalized model which can integrate the various strategies adopted by numerous quality management and engineering experts and focus towards quality enhancement is reported in the literature. The outcome of both casual talks and brainstorming sessions with a number of quality management professionals indicated that the absence of such a generalized focused model is the root cause of the prevailing retarded implementation trends of TQM. Subsequently, critical syntheses and analyses were made over the TQM practices followed by the early single manufacturer, which culminated in the identification and recognition of eight vital quality strategies which would have facilitated the implementation of TQM.

Vital quality strategies

The following are the salient features of vital quality strategies identified from the single manufacturer model.

Continuous use of human knowledge. The characteristic feature of the single manufacturer system was that there was an instantaneous, spontaneous and continuous harnessing of human knowledge towards quality improvement. This was possible because of the fundamental factor that a single manufacturer in former days was required to carry out all the business and manufacturing activities, which started from procurement of raw materials to despatch of finished products and subsequent service. Another factor was that the quality of the final product contributed by him had an effect on his business life and prosperity. These two factors combined to create a forceful awareness which made him increasingly direct his knowledge towards quality enhancement. However, this vital strategy began to vanish from the industrial arena after the evolution of the Industrial Revolution, as the manufacturing systems became too complex to use human knowledge continuously and exhaustively.

Continuous quality information management. A single manufacturer in former days was able to manage information very efficiently owing to the absence of a complex business cycle. As a matter of fact, the information which was easily planned, controlled and improved to enhance the quality level continuously formed a basic reason for the ideal TQM that he was able to practise. Moreover, another feature to be noted is that his mind was acting as a central unit which enabled the integration of all information. Hence, management of information with regard to quality on a continual basis constitutes a vital quality strategy.

Continuous approach towards target. The single manufacturer, who was maintaining a constant quest for increasing the quality levels, kept a strict vigil on approaching the target quality. He was moving closer and closer towards target quality on a continual basis with each and every business cycle he completed. This enabled him to adopt a zero-defect manufacturing approach that formed a vital quality strategy in the ideal TQM which he practised.

Continuous checking of failures. Occurrence of failures is a common phenomenon in a business and manufacturing environment. Though this fact was also true with the single manufacturer, he was able to correct the system after each and every failure was detected, so that the further occurrence of failures was either prevented or reduced to the least possible extent. Thus, continuous checking of failures envisages the continuous improvement of quality and forms a vital quality strategy during TQM implementation.

Continuous control of quality costs. Any investment made in manufacturing firms will be a waste unless it is cost effective. This is especially true from the manufacturer's point of view. Similarly, TQM programmes cannot be appreciated unless they are cost-effective. As for the the single manufacturer, every expenditure was incurred by him and he was in a position to monitor it continuously. He was also able to gauge the effectiveness and efficiency of each expenditure made with regard to quality enhancement. Hence an appropriate model and procedures to check continuously the quality costs form a vital quality strategy while effecting TQM.

Continuous transfer of customers' feedback. Significant quality improvement was witnessed at the end of each and every business cycle in the case of the old single manufacturing system, since customers' reactions were received instantaneously and subsequently implemented. This was possible because of the simpler and smaller customers' and manufacturer network. However, the situation prevailing in today's industrial arena is quite different in the sense that the customer manufacturer network is so large that even obtaining customers' feedback is found to be a tedious task. Unlike the old single manufacturer system, customers and manufacturers in today's business environment are bridged by numerous dealers, retailers and sales representatives. Moreover, the products made in today's manufacturing firms are so complex that customers are not in a position to express their opinions clearly. Adding to this, the implementation of customers' feedback in today's manufacturing firms is not so easy as it often calls for change in complete set-ups. As the continuous implementation of customers' feedback characterized one of the vital strategies for quality improvement in the case of the old single manufacturer system, the

same should be attempted in today's complex manufacturing situation by adopting proper scientific techniques.

Continuous management of the quality system. The single manufacturer was able to maintain the system continuously and exclusively for quality enhancement by utilizing three main components, namely a quality policy, procedures and records. Though he did not use documents, he was able to maintain the information in his mind. Also, he was able to retrieve them easily as and when required and use them for further manipulation. The same methodology is required to be adopted in today's complex manufacturing firms through systematic documentation which will entail continuous quality improvement. Hence, continuous management of a quality system, which is a vital strategy, should find its place in manufacturing firms while implementing TQM.

Periodical quality audit covering both manufacturer and customers. A single manufacturer was able to audit his quality system by means of continuous consultation with his customers. The audit was marked mainly by continuous bargaining between him and his customers on terms and conditions with respect to quality. To be correct, he was able to convince the customers regarding the level of expectation that they should have in relation to the price paid by them for the products and service. This facilitated meaningful quality audit reports which received immediate action. Hence, quality audits covering both manufacturer and customers is a vital strategy in the TQM process.

All the above strategies are linked to each other by strategic quality planning, continuous quality control, evaluation and improvement procedures which facilitate the focusing of all strategies towards quality enhancement. This is illustrated as a framework in Figure 1. Since this framework emulates the ideal TQM which is warranted today, the decision was made to keep this as the reference for pursuing the research work further through investigations. Though some strategies are applied in a scattered manner in some firms as part of their efforts to implement TQM, they are seldom focused towards quality enhancement, which results in a wastage of money and time. In this context, it was found necessary to reorient the traditional concepts of TQM from those which were planned to be evolved out of this research work to focus quality strategies towards quality enhancement. Considering the importance of strategies in modified concepts, the term "strategic quality management" (SQM) was adopted.

SQM – defined

The terminology "SQM" is not new to the industrial world, especially to academics, for Juran has already used it in his book[10]. Juran defines SQM as a "systematic approach for setting and meeting quality goals throughout the company." In the opinion of the authors, this definition is not exhaustive, taking into consideration the enormous developments that have taken place recently in the field of "strategic management"[11]. Moreover, Juran equates SQM with traditional approaches like "company-wide quality control", "total quality management" and so forth[10]. The fundamental weakness behind these traditional approaches is that they are not supported by clear definitions. Also,

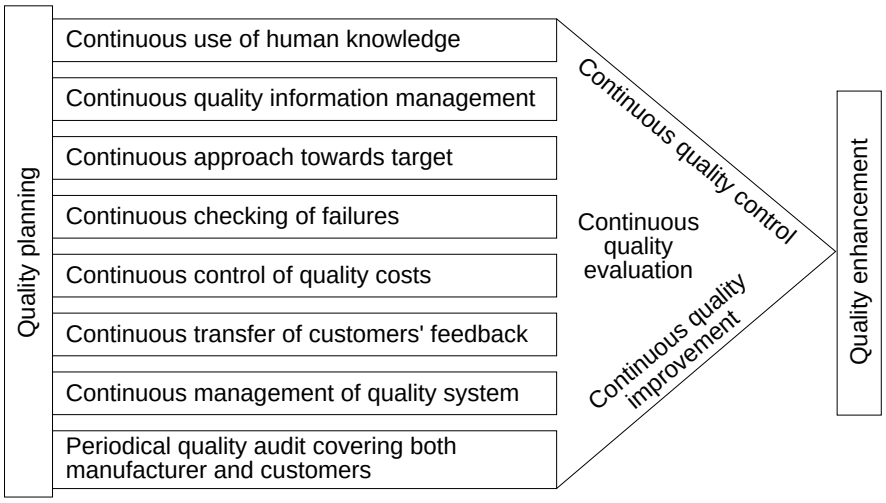

Figure 1.
Research framework – integrated approach for quality enhancement

critical studies made on these approaches by the authors and other researchers indicated that none of these approaches is found to be complete and focused in attaining vital quality strategies. However, the terminology SQM, adopted during this research work, envisages broader coverage than the traditional interpretations of quality enhancement approaches. On adopting the advances in strategic management[11], the terminology SQM used during the course of this research work is defined as "the process by which quality management activities focus towards the long range direction and progress of quality enhancement strategies by ensuring the careful formulation through strategic quality planning, proper implementation through vital quality strategies, and continuous evaluation through quality improvement and control".

Five phases of SQM

The fundamental nature of SQM is to ensure a continuous assessment of internal and external changes with regard to quality and an adjustment of the competitive approach on the basis of that assessment. Based on this concept, five phases involved in SQM are identified as a continuous process. This is depicted in Figure 2. As shown, phase I marks the beginning of SQM, during which the quality mission of the firm is established with the involvement of the manufacturer. Phase II passes through the development of a quality profile with the considerations of quality mission and external environment comprising competitors' and customers' perceptions. The end of phase II is marked by the declaration of a quality policy. Phase III is devoted to listing or modifying long-term and annual quality objectives. During phase IV, efforts are made to infuse quality at the design stage. Phase V constitutes the development of the SQM system, which signifies the whole process of SQM. The results obtained after phase V are compared with the desired performance at the global level. The outcome of this comparison determines the need for further refinement of the SQM process presently being followed.

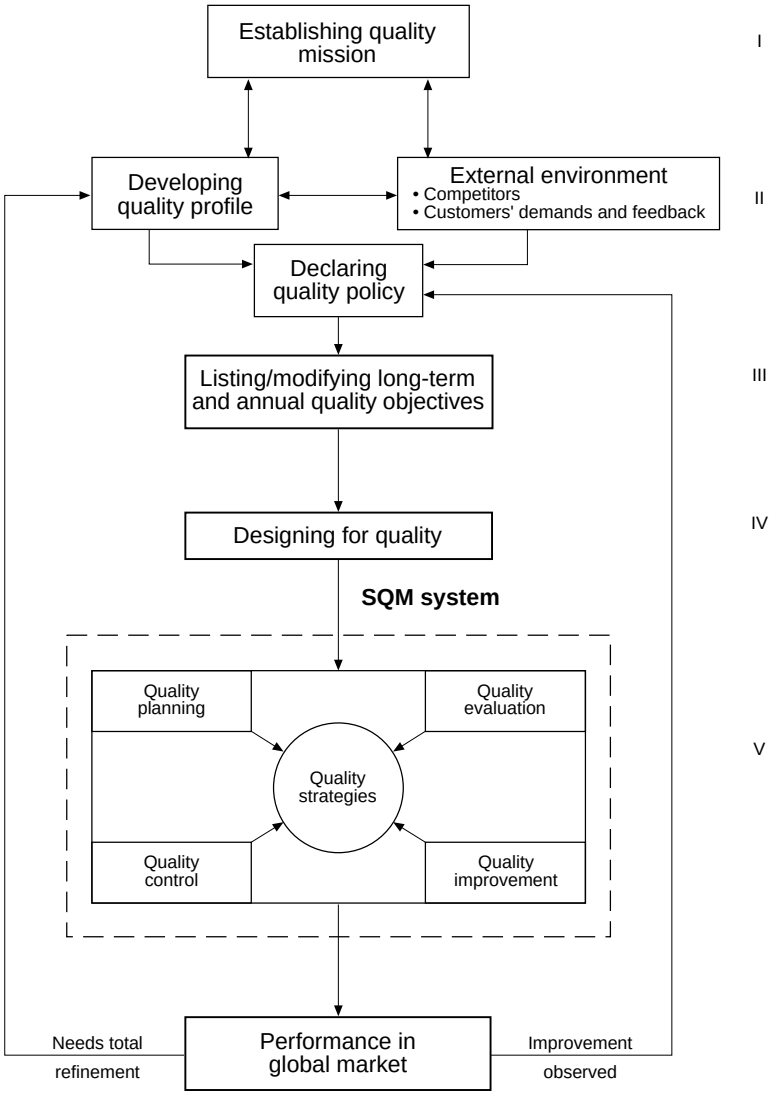

Figure 2.
Five phases of SQM

A brief observation of the SQM process suggests that the practices followed during phases I to III are analogous to that of modern strategic management. This indicated that the developments in strategic management could be adapted during these phases and there existed no necessity to carry out research in this direction. The activities of phase IV play a key role in the success of SQM by providing strategic decisions, namely built-in quality and quality at source. For the past two decades, the industrial world has been witnessing developments in the form of techniques and tools for infusing quality at the design stage. One of them is Taguchi's off-line quality control method, the

benefits of which have been witnessed in the industrial world to a very great extent[12]. These developments indicated that any research that would be done thereafter in this direction would yield only overlapping results. Hence, it was concluded that no more research was required covering the activities of phase IV. As was stated earlier, phase V denotes the heart of SQM and the survey conducted in this regard revealed that the industrial world had to go a long way to attain the expected end result of this phase. In particular, the industrial world is lacking a clear focused approach to attaining quality strategies. The activities of this phase are collectively referred to as the SQM system and, interestingly, their features coincided with those of the framework identified at the beginning of the research work. Hence, it was decided to undertake investigations in this direction. As phase V requires the results of phase IV, the conduct of studies and investigations covering the activities of this phase were deferred and marked for future work. As the SQM system forms the core of the SQM process, it is simply referred to as SQM in the following sections of the paper.

Investigation procedure

In order to maintain uniformity in approach, the investigations were carried out after devising a systematic procedure. As can be inferred from Figure 3, this procedure systematically alternated between theory and practice and consisted of six steps. The tasks carried out during each step pertaining to all vital quality strategies are briefly described in the following subsections.

Study of the literature

A thorough search was made to obtain literature in the area of each quality strategy in order to study the theories and implementation experiences of researchers and manufacturers. A literature survey in each and every quality strategy ended with the identification of the presently available procedures, tools and techniques.

On-the-spot study

During this step, visits were made to the premises of a number of manufacturing firms of various sizes, which had made unsuccessful attempts at deriving an effective outcome from quality improvement programmes. Investigations were conducted in these firms with regard to the practical implementation features of SQM. This step of the investigation was necessary as it ensured the compatibility of theoretical conclusions made in the previous step with practical situations.

Conduct of interviews

Interviews were conducted with manufacturers and managerial personnel associated with quality improvement programmes either through face-to-face contact or through various communication media. This step of the investigation was very useful as it helped to understand the perceptions of quality managers and manufacturers.

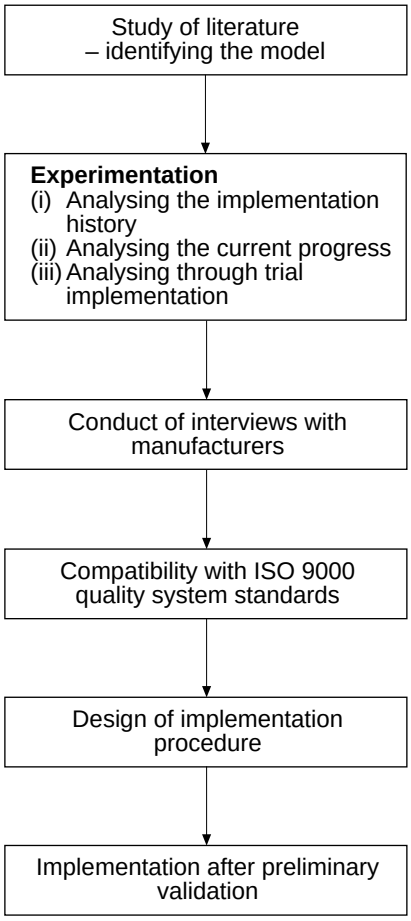

Figure 3.
Investigation methodology

Study of quality system standards

This step of the investigation was vital because of the fact that there existed a direct or indirect compulsion throughout the world to adopt ISO 9000 series (or its equivalent) quality system standards[13]. In order to cope with this trend, both the theoretical and practical implementations of quality system standards were studied and it was ensured that the quality system evolved was compatible with these standards.

Design of methodologies

The comparative studies which involved the syntheses and analyses of the information obtained during the above steps of the investigation were used for designing systematic implementation methodologies which encompassed well structured procedures, techniques and tools.

Validation
The resulting methodologies were tested for their validity in practical situations by attempting to implement them in manufacturing firms. This step was concluded by drawing inferences based on the implementation experiences.

Investigations of quality strategies
The investigations were initiated based on the procedure designed for the quality strategies to focus on quality enhancement. Though it is beyond the scope of this paper to cover the detailed investigations carried out on each quality strategy, brief descriptions of them are given in the following subsections. The investigations on each quality strategy comprised strategic quality planning, continuous quality control and improvement features.

Continuous use of human knowledge
The earlier part of the investigation, which consisted mainly of a literature survey, revealed that quality circle programmes are the best means of obtaining and utilizing human knowledge, which is possessed by all levels of a manufacturing firm, for continuous quality improvement[14-21]. Among other factors, the primary reason for selecting quality circle programmes was that they were already being implemented in the majority of manufacturing firms. Subsequently, investigations were conducted over the practical implementation of quality circle programmes, at the end of which a systematic methodology was devised to ensure successful implementation. Although the industrial world is inundated with literature on implementation experiences regarding quality circles, investigations carried out during this step revealed that there should be more emphasis on:

- the realization of the need to inform manufacturers and personnel of the latest trends;
- the development of an action plan;
- the adoption of planning procedures before implementation; and
- devising methodologies to diagnose failures.

Continuous quality information
The systematic procedures and practices required to implement an efficient quality information system were investigated[1,22]. It was realized that, unlike the conventional information management systems[23-25], the quality information system compatible with focused SQM practice must possess unique features such as flexibility to tolerate the sudden upsurge in customers' demands, policy changes, modifications, etc. At the end of the investigation on this strategy, a systematic methodology was developed to install and manage a quality information system compatible with SQM practice.

Continuous checking of failures
The rudimentary feature of SQM relies primarily on the procedures that ensure continuous quality improvement on the basis of the analysis of quality failures

in products, processes and services. In order to achieve this objective, an investigation was carried out over the implementation strategies of failure mode and effects analysis[1,26] during both the design and process stages.

Continuous quality cost control

In order to evaluate continuously the cost effectiveness of SQM practice in complex manufacturing systems, an investigation involving the approach known as "total quality cost control" was conducted[1,27]. The attempts made to segregate quality costs from traditional accounting systems proved to be tedious in many cases and impractical in others. Hence, an IBM-compatible software, developed exclusively for this purpose, was used during the investigation. This software, named TOLQC, was very helpful in generating the statistical results and inferences while investigating the control of quality costs throughout the progress of the quality improvement programme.

Continuous approach towards target

The initial study on SQM revealed that the statistical techniques and tools which are popular in present-day manufacturing firms act as hurdles to a continuous approach towards target specifications to pave the way for the development of a zero-defect manufacturing culture. In this context, Taguchi's on-line quality control (TOLQC) methods[6,28] were considered and investigated for practical implementation in manufacturing firms. The reason for adopting TOLQC methods is that they envisage an approach which identifies the deviation from the target specification as a fraction of quality loss in monetary value. This approach recognizes the importance of attaining the target in contrast to statistical techniques and tools which concede deviation from the target to a certain extent. Though feeble theoretical contributions[6,28] are available on TOLQC methods, there exists no evidence in the literature to support practical implementation attempts. Hence, the investigations conducted in this direction uncovered a number of useful contributions which included a managerial implementation methodology for TOLQC methods.

Continuous transfer of customers' feedback

One of the critical activities concerning SQM is the process of designing flexible quality planning to cater for the dynamically changing demands of customers. This called for the systematic, fast and accurate transfer of customers' comments and wishes. In order to fulfil this requirement, the technique "quality function deployment" was investigated[29,30] and the issues involved in its implementation strategies were studied, analysed and inferred.

Continuous management of the quality system

Initial investigations on this strategy, which was marked by a systematic survey, revealed that, in the present industrial scenario, especially that prevailing in developing countries, many manufacturing firms still have to set their policies, procedures and records concerning quality. However, during the

past five years, there has been an upsurge in understanding the need for policies, procedures and records concerning quality, and many manufacturers have documented and begun to implement their quality systems. This is very much in evidence from the survey made to date covering many developing countries. This survey reveals that, in the past five years alone, as many as 500 manufacturing firms have been accredited to ISO 9000 series quality system standards. However, in order to effect SQM, mere documentation and implementation of a quality system is not sufficient, rather one that tolerates technical advancements, improvements and changing attitudes of customers and personnel. In these circumstances, investigations were carried out regarding the implementation of such refined, planned and reformed quality systems in manufacturing firms. The essential feature of these investigations is that they concerned the integrated management of quality-related policies, procedures and records[1].

Total quality auditing

As indicated in the earlier part of the paper, any business in a manufacturing firm takes place between two "kings", namely the manufacturer and the customer. This statement gives rise to a contradiction in comparison to the preachings of modern quality experts who refer only to the customer as the "king"[7]. This approach often looks quite unbalanced from the viewpoint of the manufacturer and calls for a new concept – total quality auditing. This new approach envisages a set of quality auditing procedures based on the principles of the quality audit followed in the old single manufacturing system and covers the manufacturer's quality efforts and customers' expectations and perceptions. This is based on the practically and intuitively agreed fact that it is impossible to meet customers' demands if their value exceeds the price they pay. The output of total quality auditing is marked by the report that is drawn after balancing the perceptions and views of customers and manufacturer. This report makes quality auditing meaningful and useful for further quality improvement. Investigations were carried out to evaluate the credibility of this new approach and, based on the inferences drawn, an implementation methodology was developed.

Personnel quality training system

The primary inputs to SQM practice are the systematically and appropriately trained personnel required for accomplishing long-term continuous quality improvement strategies. The initial investigations revealed that, although manufacturing firms invest considerably in the training of personnel, seldom were the benefits accrued in the form of enhanced quality. Hence, it was concluded that a quality system exclusively for the systematic monitoring of personnel training was imperative to effect SQM. Accordingly, a personnel quality system was developed and investigations were carried out to ensure its validity.

System modelling

The hectic investigations which constituted the major part of this research work culminated in the evolution of a focused system model[31] for applying a well-defined, structured and reoriented SQM system in manufacturing firms. The framework of this model is shown in Figure 4. All results, inferences and conclusions of the investigations were carefully studied and integrated to develop this focused SQM system model. Since this model has been developed as a result of continuous implementation study, on implementation it ensures promising results to effect SQM. Also, the development methodologies adopted for the evolution of this model made a good balance between theory and practice. In addition, the study has aided in identifying wrong perceptions that prevail in the minds of manufacturers as regards making efforts for continuous quality improvement, and fills the gap which exists between theory and practice.

Conclusions

The investigations carried out during this research work over the past three years resulted in achieving major breakthroughs which are considered to be timely and significant in this era of tough global competition, in which manufacturers are in search of ways which will impart higher quality in their products, processes and service. In particular, these investigations were aimed at filling the wide gap that exists between preachings and practice in achieving excellence in TQM in manufacturing firms. Besides the evolution of a focused system model, the research work brought the following major findings to the fore:

- Although modern manufacturing firms are moving towards effecting TQM, they have yet to formulate the concepts of many vital quality strategies which form its foundation.
- The majority of manufacturing firms, including those which have been accredited to ISO 9000 series quality systems standards, have yet to witness even the entry of modern techniques such as quality function deployment, Taguchi's on-line quality control methods, etc. which are imperative in effecting the proposed SQM model. However, quality circle programmes are exceptions to this statement (Table I).
- Wrong perceptions dominate the minds of the leaders of manufacturing firms regarding TQM. For example, many manufacturers feel that TQM means merely writing slogans on the walls and investing money in training programmes without any evaluation.
- The statistical techniques and tools which dominate today's manufacturing systems act as hurdles in approaching zero-defect manufacturing because these techniques and tools justify deviation from the target. Though, occasionally, the industrial world has witnessed the application of Taguchi's off-line quality control methods[32], it has not yet witnessed the benefits of TOLQC methods which aim continuously towards attaining the target.

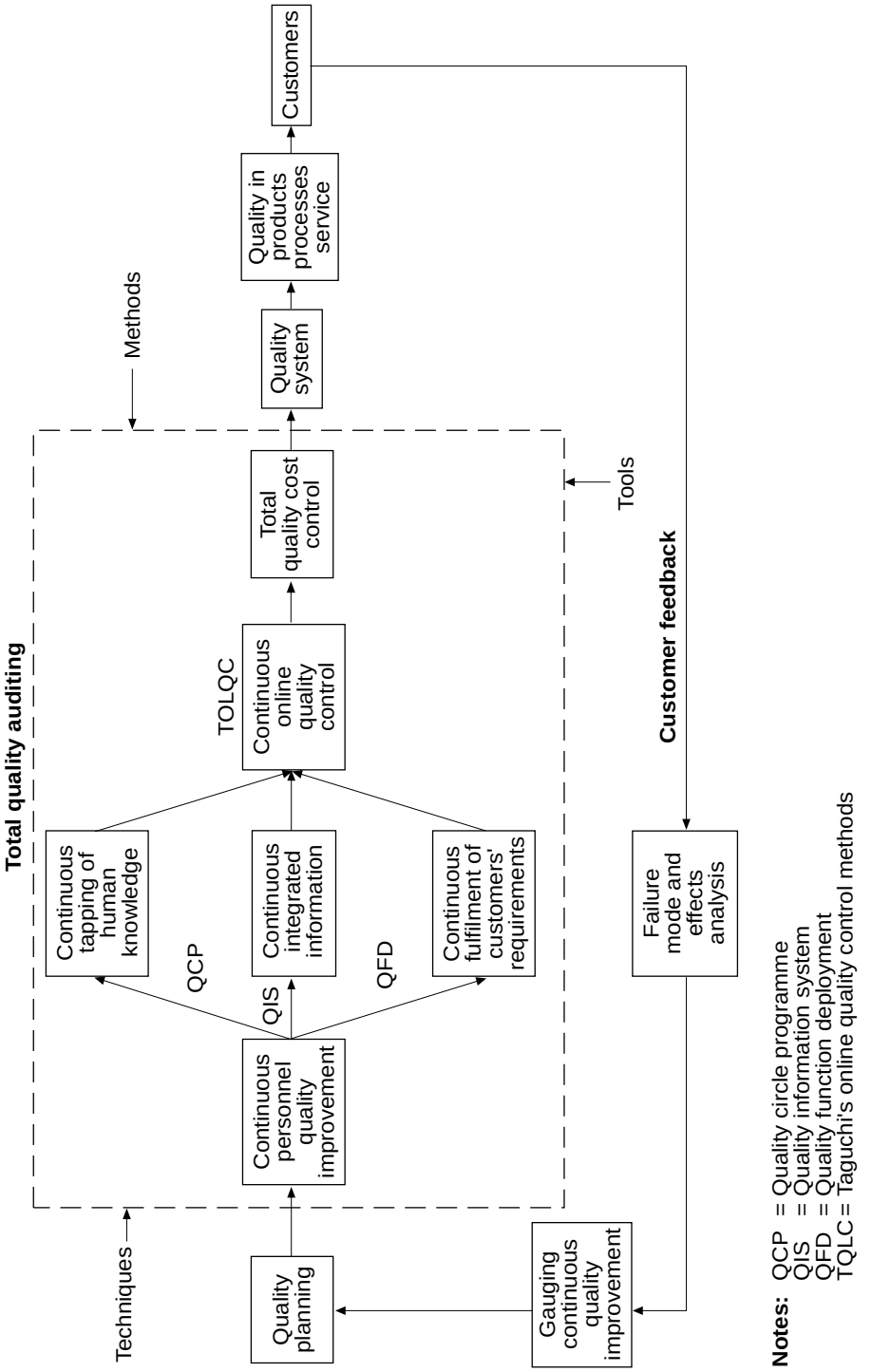

Figure 4.
Framework of strategic quality management (SQM) system model

- The manufacturing community has yet to realize the importance of quality information management in effecting TQM (Table I).
- The prevailing cost-accounting systems do not make proper provision for quality costing, which acts as a major hurdle in cost evaluation of TQM practices.
- Since the industrial world has witnessed in the last ten years the proliferation of quality engineering experts with their own distinct methods of preaching, the manufacturers and personnel involved in implementing quality improvement programmes are confused over the methodologies which they ought to follow to execute TQM.

Apart from the above major findings, a number of other macro and micro results which are found to act as bottlenecks in implementing TQM have been incorporated in the proposed SQM system model, which on application guarantees the means of a focused approach in transferring the ideas of quality experts to the manufacturing premises.

Extraordinary efforts were taken throughout this research work to ensure global validation of the findings, results and conclusions which emerged as a result of investigations and also of the developed system model, by reporting them in the form of papers in various conferences, conventions and other such meetings attended by the manufacturing community and their feedback was systematically collected and incorporated. During these validation attempts, one common remark made by manufacturers and quality managers was that the SQM practices being proposed as a result of this research work would lead to the expending of a great deal of time during the initial stages of implementation. Although it was proved in many instances during the research work that this extra time spent could be saved once the system was installed, the authors preferred to go one step further by exploiting the latest easily accessible information technology to combat this remark. Accordingly, an expert system (ES) for the implementation of quality circle programmes was developed, which formed an extended part of the research work. This ES provides expertise to its users during the different phases of implementing quality circle programmes. Because of a lack of space, its constructional and functioning details have not been included in this paper.

To conclude, it is appropriate to mention that this research work, which portrays a new dimension to the process of effecting fully-fledged TQM in manufacturing firms by the set of practices called SQM, is significant in this tough global competitive era where manufacturers and quality engineering personnel are anxious to find the means to infuse quality in all spheres and attain the highest competitive edge.

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