Indian manufacturing industry has witnessed irrepressible competition in the recent times in terms of low costs, improved quality and diverse products with superior performance. Indian entrepreneurs have now understood that to meet the challenges posed by the competitive environment, the manufacturing organizations must infuse quality and maintenance improvement initiatives in all aspects of their processes to improve their competitiveness. Out of various lean manufacturing practices Total Quality Management (TQM) and Total productive Maintenance (TPM), are such popular initiatives employed by the manufacturing organizations in synergy as Organizational Performance Improvement Techniques.

TQM and TPM accelerates the benefits of continuous improvement activities within any manufacturing environment by challenging inefficient working practices, realizing true potential of workforce, targeting effectiveness and making processes work as planned. Indian manufacturing organizations have moved ahead aggressively by developing and adapting proactive TQM and TPM practices for overcoming inherent deficiencies in manufacturing systems for harnessing distinct competencies in comparison to their global competitors. In the quest for achieving manufacturing excellence through quality and as well as maintenance improvement initiatives, leading Indian entrepreneurs have made sincere efforts to adopt these practices in last one decade. Though, due to inactive organizational approaches and colonial roots of manufacturing environment, Indian entrepreneurs have faced difficulties and road blocks in effectively adapting to TQM and TPM principles.

7.1 Conclusions and Findings from the Research

The study is aimed at identifying the barriers of TQM and TPM implementations for evaluating the challenges, being faced by the Indian manufacturing organizations in order to adapt these proactive quality drives. The study also critically examine the factors affecting the implementation of these quality drives and then devise various critical success factors for overcoming the obstacles for successful implementation of TQM and TPM in the Indian manufacturing industry. Moreover, the study illustrates how the synergistic relationship of transfusion of TQM and TPM Paradigms can be
helpful for Indian Manufacturing Industries to have overall business performance, through a specially designed TQM-TPM Questionnaire. The major objective of this research is to examine, how effectiveness is the support of TPM in providing a synergetic effect on TQMs contribution in improving business performance. Finally, the research culminates with development of a strategic TQM-TPM model for Indian Manufacturing Industry for sustained growth and competitiveness.

The conclusions drawn from research work have been highlighted below:

1. The research provides an insight into exploits of Indian entrepreneurs regarding quality and maintenance initiatives and provides an assessment of prevailing status of Indian entrepreneurs regarding practices like Organizational Structure, Policies; General Quality and Maintenance practices; Core TQM and TPM practices; Transfusion of TQM-TPM practices.

   a. The research analysis of data obtained from the survey has revealed that most of the organizations have reasonably scored quite high rating (percent point scored PPS) regarding major Top Management Involvement and Leadership issues. The data showed that most of the organizations have their own defined quality policy (PPS=86.17) and they have well communicated the quality policy to all employees (PPS=82.98). Not only they have communicated the quality policy, they also encourage the employees to improve further quality (PPS=89.36) and have complete check of quality being produced (PPS=82.71).

   b. The research data for Human Resouse Management has revealed relatively poor performance regarding effectiveness of employees involved in education and training programs (PPS=61.97) and relatively poor in maintaining training programs for higher-level managers and top management as well (PPS=63.03). The survey has also revealed relatively low use well-administered training and testing program in effect in the organization (PPS=75) and at the same time less number of employees are encouraged to submit their suggestions (PPS=76.86). A reasonable improvement has been observed in organisations encouraging their employees to participate in QC circles (PPS=78.46) and emphasis laid on achieving multi-skilling of employees (PPS=78.99).

   c. The analysis of various issues related to TQM has revealed that the organization’s intent on providing reliable quality at competitive price
(PPS=88.61) and commitment to provide quality conformance (PPS=88), still management just reasonably encourages the use of new Manufacturing Technologies for enhancing business performance (PPS=68.61). The organizations have shown a reasonable improvement in demonstrating its business vision, strategy and implementation plan to the employees (PPS=73.71) and many organisations have used their vision statement as a guideline to formulate their business strategies (PPS=73.11).

d. The close analysis of various issues related to maintenance organization has indicated that most of the organizations have generally scored quite high rating (PPS) regarding major maintenance organization issues (PPS=80.85). The data has indicated that most of the organizations have reasonably well planned and structured maintenance organization (PPS=77.93), while some improvement can be suggested for relating company policies to use advanced statistical techniques to improve process suitable for ensuring maintenance quality (PPS=74.73), ensuring motivation of maintenance department for the operators which are involved in the autonomous maintenance of equipment (PPS=73.40).

e. The analysis of data obtained from the survey has indicated that most of the organizations have shown reasonably moderate deployment of preventive maintenance (PM) programs (PPS=68.62), with large proportion of plant equipment being covered under PM programs (PPS=66.49). Though a considerable high rating has been observed in company carrying out a complete annual audit on maintenance quality improvement activities (PPS=73.67) and companies updating the maintenance program periodically in accordance with management of change (PPS=74.73).

f. The analysis of various issues related to TPM revealed that most of the organizations have shown a reasonable rating (PPS) regarding major TPM issues. The data has indicated that though Indian entrepreneurs have been successful to communicate their endeavor to employees regarding implementing TPM initiatives in the respective organizations and but considerably low rating has been observed in promoting maintenance quality policy and objectives at various levels in organizations (PPS=65.43). However, some improvements in this regard must be keenly pursueded. This underlines need for enhanced
proactiveness, participative management and demonstration of commitment from top management in manufacturing organizations.

g. A reasonable rating has been observed from the survey about the fact that companies making efforts to track the root cause of all the losses affecting the equipment performance (PPS=71.54), and identifying the equipment bottlenecks and tackling effectively (PPS=71.54), which is done by monitoring every machine failures, analyzing and taking required actions to prevent recurrences (PPS=75.80).

h. The analysis of various issues related to Transfusion of TQM-TPM has revealed that most of the organizations have shown a reasonable good rating (PPS) regarding major quality and maintenance issues. The organizations have shown acceptable performance in this regard with majority of the organizations carrying out in-process inspection and or self-inspection according to maintenance quality procedures (PPS=75), organisations carrying out a complete annual audit inspection on maintenance and quality improvement activities (PPS=75.53), Maintenance Quality Circles functioning in the organizations has been observed to be satisfactory (PPS=74.20), which has helped employees in getting awareness of the basic principles of maintenance and quality in the program (PPS=76.86), effective enough to lead them to self development and add to their leadership qualities (PPS=74.73), helpful in solving the their production and maintenance related problems (PPS=76.33).

2. The research has highlighted contributions of various TQM and TPM implementation initiatives in Indian industry for accruing strategic benefits for meeting challenges posed by global competition. The empirical analysis has been employed in this study to investigate role of success factors of TQM and TPM in achieving significant manufacturing performance improvements in the organizations. For the purpose, various success factors, manufacturing performance parameters that have been established in the research (Figures – 3.2).

The inter-relationships between success factors and manufacturing performance parameters has been used to develop an understanding of contributions of various TQM and TPM factors towards realization of organizational objectives of growth and sustainability. The manufacturing managers must be aware of existing
interdependencies within the system to be able to manage strategic TQM-TPM initiatives effectively towards achieving world-class-manufacturing performance standards. The findings suggest that effective initiatives of these quality drives can significantly contribute towards improvements for competing in the highly dynamic global marketplace.

a. The analysis of data obtained from survey has indicated that Total Productive Maintenance (TPM) initiatives have yielded considerable benefits to Indian manufacturing organizations, whereas Transfusion of strategic TQM and TPM initiatives in manufacturing organizations has contributed toward much significantly improved achievements in terms of enhancing the productivity, quality, equipment availability and reliability, ensuring participation of employees at all levels and aiming at long term success through customer satisfaction, with benefits to all stake-holders of the organization and to society (Table – 4.8, 4.9).

b. The transfusion of TQM-TPM initiatives have led to complete overhaul of quality as well as maintenance practices in manufacturing plants and facilitated realization of enhanced organizational performance including enhanced returns on net assets (RONA), returns on capital employed (ROCE), quality, flexibility, labor productivity, overall equipment effectiveness, capacity, equipment uptime, health and safety of employees, customer order compliance, skills and knowledge of operators, and clarification of the roles and responsibilities of employees.

c. The detailed analysis of inter-relationships between various success factors and manufacturing performance parameters for TPM companies has indicated that there is a strong correlation of X1-Top Management involvement and Leadership with Y2-Employees Competencies (r-0.395*), Y4-Production (r-0.450*), Y5-Cost (r-0.433*), Y6-Flexibility and Delivery (r-0.433*) and Y8-Employees Morale and Contributions (r-0.284*). Moreover, X6-TPM Core Attributes has observed to be closely related to Y1-Strategic Business Performance (r-0.520*), Y2-Employees Competencies (r-0.520*), Y3-Quality (r-0.442*) and Y5-Cost (r-0.310).
d. The results obtained from the analysis have revealed many critical findings for the TPM alone companies, which indicated that improvement in TPM Core Attributes like Jishu Hozen and Kobestu Kaizen (X6), organizations can significantly contribute towards improvement of Strategic Business Performance (Y1), Employees Competencies (Y2) and Quality (Y3). It has also been observed that Top Management involvement and Leadership (X1) factor plays an important role and is critically required to get improvement in various performance factors (Table – 4.15).

e. The detailed inter-relationships between various success factors and manufacturing performance parameters for TQM-TPM combined companies has indicated significant correlations of Top Management involvement and Leadership (X1) with approximately all performance parameters at 0.05 significance level. Also Transfusion of TQM-TPM (X7) has been observed to have a strong correlation with Safety of the employees (Y7) (r=0.546*) and Employees Morale and Contributions (Y8) (r=0.636*).

f. The result of multi-regression for the combined companies has indicated that the importance X1-Top Management involvement and Leadership has again gained a strong significant association with Y3-Quality, Y4-Production, Y5-Cost, Y6-Flexibility and Delivery, Y7-Safety and Y8-Employees Morale and Contributions. These factors have also been observed to be closely associated with performance parameters in TPM. In addition X7-Transfusion of TQM-TPM and X6-TPM Core Attributes have also been significantly associated with many performance factors in combined approach (Table – 4.18).

g. The results of two-tailed t-tests at 5 percent significance level has indicated that for parameters of Y1-Strategic Business Performance, Y3-Quality, Y5-Cost, Y7-Safety and Y8-Employees Morale and Contributions, t(Combined TQM-TPM/TPM)A values obtained are Y1-2.115(p=0.048), Y3-2.864(p=0.008), Y5-3.775(p=0.001), Y7-2.199(p=0.037), Y8-3.213(p=0.003) respectively, with p values being less than 0.05. This implies that the mean values of Y1, Y3, Y5, Y7 and Y8 for combined TQM-TPM approach are higher than for TPM at 5 percent significance level, which means that the improvement in these performance
parameters contributed by combined TQM-TPM strategy is more than that of TPM alone (Table – 4.20,21,22).

3. The research has been extended further to prove the synergistic suitability of Transfusion of TQM-TPM using Fuzzy Based Model Simulation. For the study, the most relevant factors affecting these drives like Quality, Cost and Maintenance has been considered and further these factors has been simulated by the data given by experts in this field using Fuzzy Logic Toolbox of MATLAB which provides the steps for designing fuzzy inference systems using graphical tools, and a Simulink block for analyzing, designing, and simulating systems based on fuzzy logic.

a. A continuum of fuzzy solutions for TPM alone equation has been presented using the rule viewer of fuzzy tool box of Matlab. The two inputs, that is, Maintenance and Cost can be set within the upper and lower specification limits, and the output response has been calculated as a score that can be translated into linguistic terms. In this instance the order output of 7.5 indicates Acceptable system linguistically (Table – 4.25).

b. A continuum of fuzzy solutions for Transfusion of TQM-TPM equation is presented using the rule viewer of fuzzy tool box of Matlab. The three inputs, that is, Quality, Maintenance and Cost can be set within the upper and lower specification limits, and the output response has been calculated as a score that can be translated into linguistic terms. In this instance if the value of quality is entered 0.5 (optimal value), maintenance 10 (max. value) and cost 1(optimal value), the order output is observed to be equal to 8.6 which specifies the system is highly Optimum linguistically (Table – 4.28). The result proves that the synergistic suitability of Transfusion of TQM-TPM is much better than suitability of TPM alone for Indian manufacturing industries.

4. For validating the fuzzy study empirically, the Structural Equation Modeling (SEM) analysis has been conducted. This study uses the confirmatory factor analysis (CFA) approach using Structural Equation Modeling (SEM) in AMOS 20.0 (Analysis of Moment Structures) software to employ the inter-relationship among TQM and TPM variables in the study.

a. Model Fit summary of SEM_TPM model after doing the Modification Indices indicates slight improvement in the fuzzy_TPM model as the value of RMR after
doing the modification indices further decrease to 0.69, which is less as compared to RMR value before doing the modification indices. Similarly, the value of GFI increased to 0.782 which is close to 1 (Table – 4.37).

b. Model Fit summary of SEM_TQM-TPM model after doing the Modification Indices indicated that the RMR value was observed 0.035, and also the Goodness-of-Fit Index (GFI) for the model was observed 0.892. This indicated that the model after modifications does provide a better fit with respect to the Normed Fit Index (NFI) also which was observed 0.932 (Table – 4.42). Thus, the SEM study confirms and validate TQM-TPM fuzzy model, which justifies the previous study.

5. Further, the Justification of TQM-TPM implementation in manufacturing organisations has been made using analytical hierarchy process (AHP). Thus calculating Consistency Ratio (CR), which is a comparison between Consistency Index (CI) and Random Consistency Index (RI). For the study the value of CR has been obtained as less than 0.1 (10%), which means the judgments considered for the study have been consistent and acceptable.

6. Further, detailed multiple-descriptive case study has been conducted in selected manufacturing organization across the country that has made serious interventions regarding TPM as well as TQM-TPM implementation over a considerable period of time and has reaped significant organizational performance enhancements as a result of successful adaptation of these initiatives. The following key issues have been highlighted through the case study:

a. The case study has indicated that organization has adopted proactive TQM and TPM principals for meeting the competition thereby affecting significant production system improvements, improving cost effectiveness of production, reducing production defects/losses, aligning the workforce with organizational growth and development objectives, improving employee competencies through empowerment and facilitation, and realizing improved workplace environment.

b. The organization has deployed eight pillar TPM implementation approach as suggested by JIPM. The various TPM pillar initiatives adopted by the organization included: Jishu Hozen; Kobetsu Kaizen; Planned Maintenance;
Quality Maintenance; Education and Training; and Safety Health and Environment.

c. The Manufacturing organizations has been successful in creating a congenial atmosphere for implementation of these initiatives and could overcome various obstacles by demonstrating its endeavor to adopt TQM and TPM programs through establishing improved communication in the organizations, ensuring enhanced employee involvement, motivation and empowerment; and by putting in resources for improving the employee competencies through training and multi-skilling.

d. Finally, a comparison of achievements accrued through various TQM and TPM initiatives has been documented to evolve the consensus on strategic potential of these programs in building and enhancing organizational competencies for meeting challenges posed by the highly competitive environment. The study reveals that the holistic approach of combining TQM with TPM implementation has resulted in host of significant benefits for the organization. A brief account of benefits realized by making proactive investments in these initiatives have been presented in Figure - 5.39 (a-n) to highlight the contributions made by TQM in TPM initiatives for enhancing the manufacturing performance of the Indian Manufacturing Industries.

7. Finally, research presents the evolution of a strategic TQM-TPM Methodology for successful implementation of these drives in Indian Manufacturing Industry. The methodology has been carefully worked out based upon the extensive literature review, learnings from TQM-TPM Questionnaire analysis and results from case study conducted in selected manufacturing organizations. The research has revealed that following issues must be strategically considered while implementing these quality initiatives in Indian manufacturing organizations:

a. The concept of TQM and TPM is neither a strategy nor a goal, but a tool that can lift manufacturing enterprises out of mediocrity. These are Lean-based approach to quality and maintenance that focuses on a life-cycle approach using teams to improve availability, performance and quality of critical machines.
b. The pursuit of sustainable TQM-TPM requires a change of employee’s attitude and their values, which takes time to accomplish. The successful deployment also demands long-range vision and planning.

c. Top management must demonstrate its commitment to these programs by providing leadership, devoting time, allocating resources to create and sustain the required cultural change, and inculcating employee involvement and empowerment in the organizations for achieving the major goals. The organizations should deploy encouraging company culture and learn techniques to affect cultural change that lead to a continuously learning company working to add value to the customer.

d. Institutionalizing mindset change of employees is one of the key aspects of successful implementation. Top management must constantly communicate with the workforce, towards ensuring total employee involvement, dedication and emotional commitment. The top management must communicate vision and goals of the organization to shop-floor employees at every available opportunity.

e. Creating a climate of trust in the organization so that people feel free to share their thoughts without fear of repercussions is very important. The training and development opportunities made available to employees are important ingredients of the change program.

f. The research has observed that long-term benefits of these drives are the results of considerable investments in human resource competencies accrued through consistent training and education of employees.

g. The manufacturing organizations must develop behavioral skills of facilitators to foster and manage culture change while preparing them to focus teams on a process for achieving continuous improvement.

h. The effective monitoring and management of KPIs lead to sustaining continuous improvement through strategic TQM-TPM initiatives by encouraging ownership and raising self-esteem of employees, measurement (agreeing the KPIs, visibility, responsibility and accountability) and enhanced team performance (improved motivation, morale, sense of achievement).

i. Strategic TQM-TPM model can help users to avoid common problems and pitfalls during the implementation and suggested sequence of activities can be modified to fit the needs of different industries.
Thus, it can be concluded that, in a highly competitive scenario, transfusion of TQM and TPM has proven to be the most significant proactive strategic initiative that can lead the organizations to scale new levels of achievements and could really make the difference between success and failure of Indian manufacturing organizations. Transfusion of TQM-TPM initiatives can prove to be an effective global strategy for Indian manufacturing organizations, rendering firms a consistent enhancement of performance in terms of achieving strategic core competencies.

7.2 Limitations of the Research

The methodology for the study has following limitations:

i. The research is aimed at developing a strategic TQM-TPM implementation plan for Indian manufacturing organizations, while some modifications will have to be made to adapt this approach for process industries.

ii. The present methodology has been developed for adopting TQM and TPM strategies in manufacturing organizations, some modifications have to be incorporated in the suggested philosophies for adapting the proposed methodology to service, marketing and other related situations.

iii. The research suggests a generalized implementation of TQM-TPM approach for Indian manufacturing industry as a whole and all manufacturing organizations have been treated alike, without paying attention to specific requirements of various sectors. Thus, minor changes might have to be incorporated to effectively adopt this program.

iv. The methodology is designed to be used by experienced and skilled quality facilitators and may warrant use of a flexible approach depending upon varying situations, requirements of the organizations. These facilitators are assumed to be knowledgeable of transformation concepts and skilled in implementing these concepts. Any attempt of using this methodology by individuals who are not competent in deploying these programs shall only have limited success.

7.3 Scope for Future Work

The present research is aimed at developing strategies for TQM and TPM implementation for manufacturing organizations, while the similar study can also be conducted in future for Indian process industries and service industries as well.
The study is aimed at developing strategic TQM-TPM methodology for Indian manufacturing organizations and various manufacturers have been treated alike irrespective of the type of products manufactured. Another direction for future research is developing sector-wise implementation of these programs. Thus, individual case study could be conducted for different sectors of manufacturing industry and accordingly the typical methodologies for individual sectors can also be evolved in future.

The research is aimed at evaluating contributions of successful Transfusion of TQM-TPM initiatives in Indian manufacturing industry. In this research the role of TQM is studied with respect to business performance, if TPM is supported by TQM in industries. However, as a future research work, the contributions of these drives in conjunction with other related lean manufacturing initiatives like Just-in-Time manufacturing (JIT), Quality Function Deployment (QFD), Six Sigma, Business Process Reengineering (BPR) etc. can also be undertaken for assessing the contributions of multiple world class performance enhancement programs towards accruing overall organizational competencies. Pramod et al. (2006; 2006; 2007) have suggested a Maintenance Quality Function Deployment (MQFD) model to demonstrate the synergic effects of TPM and QFD principles. Similarly Thomas and Lewis (2007) have also advocated for an integrated TPM-Six-Sigma strategy for Small and Medium Enterprises (SMEs). Similar efforts like this need to be made to practically demonstrate the achievements made through implementation of TQM and TPM practices with other related lean manufacturing initiatives.