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Process Techno - Innovation Using TQM in Developing Countries Empirical Study of Deming Prize Winners

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Abstract

Techno-innovation has been competitive edge for most manufacturing companies. Rapid advancement in technology-innovation geared-up with global mega-competition has resulted in unprecedented economic growth where TQM has played major role. Despite slow economic growth in developing countries caused by incapability to develop their own technology, failure to make wise decision in adopting competent technology, and inability to properly utilize adopted technologies; tremendous developments are seen in some. Examples can be Indian companies that won the prestigious Deming Prize and Japan Quality Medal after adopting necessary technologies from Japan under TQM. We have addressed process techno-innovation by 4M (Man, Machine, Method, Material) and 1E (working condition-corporate culture) approach. Results indicate that TQM affects process techno-innovation by primary effect on human resource and working condition/corporate culture. Three stage gates vis-à-vis: process understanding, process improvement and technology learning, and process techno-innovation are the mechanisms through which TQM promotes process techno-innovation in developing countries.

Keywords: developing countries; process; techno-innovation; TQM; corporate culture.

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1. Introduction

Industry growth and technological change interact to create alternative environments with varying levels of dynamism and complexity requiring realignment of operations strategy. Along with quality, cost, delivery, and flexibility; innovation is another competitive priority to proactively adapt fitting operations strategy in changing environments (Nair and Boulton, 2008). Process and product innovation are important dimensions in internationalized operations especially in companies where developed and emerging countries are relatively close to one another (Reiner, 2008). Regardless of the effort put by managers of such environments to raise their performance, they still face major challenge as to how to implement such strategic initiatives for the company business excellence. Effective strategy deployment can be assumed as one of good ways to make such initiative successful (Saunders and Mann, 2008). However, despite all effort made in different fields of adapting new strategies and implementation procedures, sustainable development in Industries has become major concern in the last decade both in developed and developing countries. Three performance bottom lines vis-à-vis economic, environmental, and social dimensions are considered in the light of sustainable development in organizations (Isaksson, 2006). It is widely accepted that customer satisfaction is the primary focus in modern business success. Companies must always put the customer needs at the first place. This has resulted in the exercise of value creation. Therefore with the concept of value, customer value has become a source of sustainable competitiveness. In this regard TQM has become the platform for market potential realization and synergistic in facilitating efficient management of processes for value creation and delivery in the highly dynamic and competitive market (Mele, 2007). TQM has become one of the most successful practices in helping companies enhance competitiveness and prosperity through innovation and ensuring sustainable growth. In another dimension, although there is strong relationship between TQM and market orientation in the perspective of customer satisfaction, TQM is found to have strong and positive impact on organizational performance (Mehmet and Lenny, 2006). Similarly, it is indicated that the impact of TQM on financial issues are the outcomes of the strong and direct impact of TQM on non-financial issues (Mehmet. et. al., 2006). However, many companies have failed in an attempt to imitate TQM in the 'Japanese way' as they have limited themselves to product quality than the overall TQM culture; one reason being giving up on using proper TQM consultants (Klaus, 2007). In an attempt to evolving business excellence, TQM is found to have very strong cultural and behavioral features in priming and feeding innovative processes (Mele and Colurcio, 2005). Although TQM seems a bit off the art as it has morphed itself into other forms like lean production and six-sigma (Dahlgaard and Su Mi, 2002) many companies still adopt and implement TQM and its diffusion is increasing globally (Osayawe and McAndrew, 2005).

1.1 Management

The practices of TQM differ from country to country and from company to company. Some example companies implement TQM philosophy under the influence of positive results of functioning quality management systems based on ISO standards (Bugdol, 2005). In New Zealand for example, firms with higher level of workplace autonomy, using performance standards, teams, and group problem solving are more likely to have adopted TQM, and that indicates larger firms can adopt TQM easily than smaller firms (Haar, 2008). In Malaysia, there is difference in TQM practices between large and small companies with little emphasis on supplier quality management for both (Quek and Sha'ri, 2003). In Singapore and Australia, TQM was found to correlate leadership and people management to innovation performance, while customer focus and process management are linked with quality performance (Feng, et. al., 2006). Although these practices have the basic lessons of TQM, they still lack the fundamental grounds of TQM promotion. Indian and Thailand companies; however, have followed the 'Japanese way' in their TQM bid by employing vast leadership and technical assistance from Japanese Union of Scientists and Engineers (JUSE) and become successful winning the prestigious Deming Prize and Japan Quality Medal.

1.2 Processes and Products

In light of global success for companies, innovative process is one of the most important functions. But this is also least understood function by many companies. It is important because it is the source of new market. It is the function that gives the company competitive edge over others through unique value of innovation. Besides, it is

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responsible for revenues and business profits that company can achieve financially. However, new process/product development is least understood and practiced by many companies as they hardly install it as organizational function. Even, some companies assign single person to take care of the whole new process/product development unit. However, if TQM is appropriately managed; it supports the company in achieving excellence, through continuous creation of real stakeholder values'. But, in order to achieve business excellence and stakeholder value, TQM importance can be utilized in synergizing development of strategic dimension and company dimension for business excellence and stakeholder value creation (Mele and Colurcio, 2005). Despite the case, the whole meaning of new process/product development begins with the search of market opportunity that the company can operate. This originates with the identification of market needs and ends with successful installation of the process or launch of the product. In this regard, TQM is widely playing major role in helping companies solve complicated business and operational problems. As a result, one of TQM's widely use is becoming in new process/product development. A number of companies in India have shown great improvement in their new process/product development programs through TQM. They have enjoyed improved performance and achieved global leadership through selected processes/products thanks to their TQM programs.

1.3 Technology and Innovation

In periods of relatively steady and systematic evolution of a company, technology management is influential to integrate the elements of the operation strategy (Nair and Boulton, 2008). However, in dynamic market environment sustainable quality management system is useful. Sustainable quality management in this context considers sustainable corporate value, implementing sustainable quality tools, and implementing sustainable quality techniques which TQM consists all of the three (Svensson, 2006). Osayawe and McAndrew (2005) indicated that the need to outlive, surpass, and outsmart competitors, the rapidly changing business environment has driven both employees and companies to continuously search for new ideas, new processes, new products and services, and new strategies. Most successful companies have foster innovation in order to adapt, survive and grow in such challenging environment, which is the key element of many modern management initiatives and practices. According to Reiner (2008), although there is potential market attraction and cost advantage in emerging economies, the low knowledge made investors cautious on the fear how the business journey will end. However, Fasil and Osada (2009) have found that TQM can be used to easily understand and adapt the best practices achieved by companies of advanced countries to enhance innovation capabilities and ensure sustainable growth. In their TQM promotion model, Fasil and Osada (2009) have defined TQM to be promoted phase by phase namely: pre-TQM, Introduction, Promotion, Expansion, and Consolidation, in emerging economies. Strategic management by policy (SMBP) is a methodology that must be followed by corporate or business management to create systematic and consistent process for integrating strategic planning and management by policy (MBP) - to determine appropriate strategies and policies corresponding to them. Adoption of TQM should consider revisiting company quality system to encompass full utilization of TQM tools as a means of solving company problems. This can only be achieved if TQM philosophy is adopted fully by top management and becomes embedded in company policies (El-Kafafi, 2006). The adoption and implementation of TQM practices should however go beyond the short time solutions to address in creating sustainable business values, tools, and techniques (Svensson, 2006). Innovation management on the other hand requires companies to master tools and techniques that are suitable for creating, fostering and diffusing knowledge that generate customer value (Mele and Colurcio, 2005). Meanwhile, the concern is that manufacturing capabilities do not always match competitive strategy in dynamic and unpredictable environments to sustain competitive advantage (Nair and Boulton, 2008). However, Knowledge and Quality Management movements are closely linked by common competitive advantage through the application of processes. This helps companies to get closer to the customer and better understand the needs and wants (Stewart and Waddell, 2008).

2. Research Framework

2.1 Research Background

In modern global economics, manufacturing companies in developing countries are facing serious challenges from domestic and international market competitions. Such

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reason is that their limited potential in adopting efficient and effective technologies, and poor technology management. Unless proper techno - innovation capabilities are fostered by the developing countries, it is unlikely to see these companies show any sort of progress in the dynamically changing global economics. If such a potential is not ensured in these companies, the domestic economy of these countries will be taken away by cross-boundary companies. Hence, this paper will address systematic process techno - innovation to help developing countries foster their competitiveness using TQM.

2.2 Objectives

The main objective of this study is to empirically study the possibility of success for process techno - innovation using TQM in developing countries to enhance competitiveness and sustainable growth. Based on lessons learned from successful companies, model will be developed to show roadmap of process techno - innovation using TQM for developing countries.

2.3 Research Methodology

The research methodology includes literature search and interview focused empirical assessment of Deming Prize and Japan Quality Medal winner Indian companies which are successful in adopting necessary technologies and enhance their innovative potentials using TQM. Deming Application and Japan Quality guidelines are used to understand the TQM framework.

2.4 Research questions

Despite the fact that TQM and Innovation are advocated to support sustainable growth, Singh and Smith (2004) and other researchers have argue that insufficient statistical evidence is available to indicate the relationship between TQM and Innovation. Meanwhile, reports of Deming Prize and Japan Quality Medal winners from India indicate TQM has significant contribution to the innovation capabilities. Hence, in this research three main research questions are raised for study. These are

1. Does TQM have impact on process techno-innovation?
2. How does it influence techno-innovation capabilities?
3. How is TQM used in the process techno-innovation
4. How can developing countries use TQM for their process techno-innovation

2.5 Hypothesis

Hypothesis - 1

TQM has positive influence on process techno-innovation

Hypothesis - 2

TQM can be used by developing countries for the purpose of process techno-innovation

3. Results of Empirical Study

In this research 8 Indian companies, winners of the prestigious Deming Application Prize and Japan Quality Medal are empirically studied. The process techno - innovation often begins with a challenge or a problem. From the study, it is observed that in process techno-innovation TQM mainly focus on human resource development and process (Method) innovation. However, TQM is also used in innovative new technology (Materials and Machine) development programs. Gapp (2004) stated that "the acquisition of new knowledge is important than sophisticated techniques for the development which the results of this study also confirms. Moreover, this research has identified the way how these continuous learning behaviors have been developed by the companies to develop innovative and sustainable processes. As Gloet and Terziovski (2004) described the process of innovation depends heavily on knowledge and its management regarding the human capital. This management needs consistency especially when dealing with product and process innovations. For the purpose of analysis, we have attempted the process techno-innovation through the 4M (Method, Machine, Material, and Man) and 1E (working environment-in this case corporate culture). The details are as follows.

3.1 Method Innovation

Methods (processes) innovation is found the beginning of the innovation. From the empirical study, it is observed that TQM has first affected the process (method)

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innovation. As is shown in Table-1 process (method) innovation has affected the companies in multitude aspects. TQM has affected the companies in different fashion but all resulting in better performance. These influences can be exemplified by process (method) modification and up-gradation, system improvement, and quality control. From this influence; considerable financial gains, high quality products, better productivity performance, easy detection of defect sources, and high customer satisfaction were seen. Table-2 shows how TQM is used in the respective companies to achieve the results mentioned in table-1 with regards to the process (method) innovation and the associated effects. TQM tools such as benchmarking, supplier consultancy, daily management, lean production, TPM, and others were at the heart of the strategic approaches.

3.2 Machine Innovation

Machines are at the heart of any industrial process whether complex or simple. Developing countries often depend on advanced countries for the acquisition of machines. The companies studied had challenges of fitting adopted technology to the old process and training people to use these machines. However, TQM was used to properly adopt and use the technology and to develop new ideas to update and modify these technologies to include more pervasive functions required by management to fit customer requirements, Table-1. TQM is used to rejuvenate their machines to satisfy requirements. As is for process (method) innovation, machine innovation is also observed in different companies. While companies have used TQM to modify and up-grade their machines, it is also observed TQM is used to customize and standardize machines. This innovation gives the machines a totally different performance and purpose than they were originally made for. As a result of machine innovation, companies have enjoyed better financial gains, improved system performance, better quality products, increased productivity, better and reliable machines, improved safety conditions, better expertise in machine development and management, better raw material utilization, and higher customer satisfaction. Different TQM tools have been used by different companies, Table-2.

3.3 Material Innovation

Material innovation is found as third component of the process techno-innovation. Companies have used TQM in their pursuit of search for new materials or up-gradation of their materials. Table-1 shows the techno-innovation done on materials and the effects of the techno-innovation in business performance with respect to outputs and outcomes. In table-2 it is displayed how TQM is used in the material innovation.

SNo	Company name	Focus of Innovation	Process/ Equipment	Process/Technology Problem	Techno-innovation using TQM	Effect of techno-innovation
						Output/Outcome
1	Indo-Gulf	Method/ Process	Ammonia plant	High energy consumption	Modification and Up-gradation	24million Rs/year saving, reduced CO_2 emission, reduced steam consumption/Better heat regenerating system, financial gain through carbon credit
			Urea plant	High steam consumption	Modification and Up-gradation	High quality urea, 40.95million Rs/year saving/Better process heat utilization, improved process
2	Rane TRW steering system Ltd.	Method/ Process	Valve assembly	Missing thrust washer	Defect reduction	Reduced rejection/Customer satisfaction
			Seal assembly prototype development	Misplacement of seal	Error correction	Easy and early detection of wrong seal assembly

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3	M&M Farm equipment	Method/ Process	Tractor assembly (H-2 Model)	Assembly misalignment	System improvement	Assembly quality improved, zero defect achieved/Design drawing updated, assembly system improved
4	Sundram Brake lining Ltd.	Method/ Process	Passenger car finishing cell	Low productivity, high defect	Layout improvement	Productivity increased by 424%, required floor space reduced by 50%,line scrap reduced from 10,000PPM to Zero, production lead time reduced from 6.28 to 1.54 days/Easy to operate and safe process
1	Indo-Gulf	Machine	Gas turbine	Low power generation	Modification and Up-gradation	1.5MW power gain, 16.6million Rs/annum saving/Reliability, ease, safety, in-house experts, and capacity
2	SRF Ltd.	Machine	Reiter	Machine incapability	Modification and Up-gradation	Yarn tenacity improved from 8.96 to 9.17, denier variation improved from 11.3 to 7.8 Std. deviation/In-house experts, capacity improved, proactive projects in other areas initiated
3	TATA steel	Machine	Vertical mould caster	High rate breakout, failure in machine hydraulics and turret	Modification and Up-gradation	98% in Blister and 67%in Sliver defect reduction/High customer satisfaction
		Machine	RH Multi functional burner	Lance chock and vacuum problem	Modification and Up-gradation	Process C_{pk} improved from 0.2 to 2.22, mean carbon content improved from 26ppm to 15.8ppm
4	Rane engine valve Ltd.	Machine	Standardization	High investment cost	Customization and standardization of conventional machines	542.7million Rs. saving, reduction of lead time/Better performance, in-house machine development capability improved
5	Rane TRW steering system Ltd.	Machine	Cam ring internal grinder	Capacity	De-bottlenecking	Production capacity doubled
6	Sundram Brake lining Ltd.	Machine	Drilling machine	Wrong drilled hole location due to loosening drill head	Locking mechanism	Error eliminated, quality product /Reduced scrap rate, machine breakdown due to loosing head removed
1	TATA steel	Material	Coal washer	Poor coal floatation	Development of new efficient froth	5-7% improvement in clean coal yield, reduction of 12% ash content and 5% clean coal moisture, approximately 5000tone/annum clean coal

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						recovery
		Material	Super ductile rebar	Poor material chemistry	Enhance the ultimate tensile strength to yield ratio (UTS/YS)	UTS/YS > 1.20/ Society satisfaction, safety
2	Mahidra and Mahindra	Material	Transmission aggregate	Strength and cost	Chemistry (carbon-nitrating) and process (shot-pinning)	High strength transmission, low cost, new model tractor/ Enhanced image, new business
3	Indo-Gulf	Material	Urea coating	Value loss due to leaching, volatility, or de-nitrification	Development of Neem oil for urea coating	New value added product, multi purpose urea/ Customer satisfaction, initiation for other new value adding materials

Table 1. Method, Machine, and Material Innovation using TQM

SNo	**Company name**	**Focus of Innovation**	**Process/ Equipment**	**Process/ Technology Problem**	**Techno-innovation using TQM**	**How TQM is used**
						TQM tools (Applied to)
1	Indo-Gulf	Method/ Process	Ammonia plant	High energy consumption	Modification and Up-gradation	Benchmarking (Performance comparison)
						Supplier consultancy (Identify possible reason)
			Urea plant	High steam consumption		Preliminary study (Improvement possibility)
						Kaizen (Improvement implementation)
2	Rane TRW steering system Ltd.	Method/ Process	Valve assembly	Missing thrust washer	Defect reduction	Poka yoke (Identify alternative solutions)
			Seal assembly prototype development	Misplacement of seal	Error correction	Daily management (Identify productivity and quality problems)
						TPM (Effective equipment maintenance improvement)
3	M&M Farm equipment	Method/ Process	Tractor assembly (H-2 Model)	Assembly misalignment	System improvement	Observation (Preliminary assessment)
						Cause & effect diagram (Root cause analysis)
						Sample testing (Confirm probable root cause)
						Confirmation check (Effectiveness of action)
						Standardization (System improvement)
						Critique (Challenge design specification)
	Sundram Brake	Method/P	Passenger car finishing cell	Low productivity,	Layout	Lean (Floor space management and line scrap

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4	lining Ltd.	rocess		high defect	improvement	reduction)
						TPM (Productivity improvement and lead time reduction)
1	Indo-Gulf	Machine	Gas turbine	Low power generation	Modification and Up-gradation	Brainstorming (Machine understanding)
						Cross functional team (Feasibility study of alternatives)
						In-house experiment (Ratify technical feasibility)
						Kaizen by phase (Improvement implementation)
2	SRF Ltd.	Machine	Reiter	Machine incapability	Modification and Up-gradation	Benchmarking (Technology and cost comparison)
						Process decision program chart (Understand and control the improvement plan)
						Technology mapping (Identify improvement areas)
						Product characteristic study (Match with new technology conditions)
						Kaizen (Ensure product-technology harmony)
3	TATA steel	Machine	Vertical mould caster	High rate breakout, failure in machine hydraulics and turret	Modification and Up-gradation	Data collection (Process understanding)
						Data analysis (Metallographic examination)
						Literature survey (Technology understanding)
		Machine	RH Multi functional burner	Lance chock and vacuum problem		Technical validation (Determine improvement factors)
						Investment analysis (Choose better technology options)
						Kaizen (Technology improvement)
4	Rane engine valve Ltd.	Machine	Standardizatio n	High investment cost	Customization and standardization of conventional machines	Customer focus (Technology & cost determination)
						Technology focus (Customization & standardization)
						Leadership (Spread QCC in all sections)
						Functional forum (Kaizen

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						deployment)
5	Rane TRW steering system Ltd.	Machine	Cam ring internal grinder	Capacity	De-bottlenecking	Cross functional team (Introduction of SOP)
						Daily management (Identify process bottleneck)
						Poka Yoke (Identify alternative solutions)
						TPM (Ensure machine availability)
6	Sundram Brake lining Ltd.	Machine	Drilling machine	Wrong drilled hole location due to loosening drill head	Locking mechanism	Lean (Reduce scrap rate from operation)
						TPM (Avoid frequent breakdown)
1	TATA steel	Material	Coal washer	Poor coal floatation	Development of new efficient froth	Define problem (Identify basic technology status)
						Characterization (Identify improvement features)
						Laboratory test (Performance check of alternatives)
						ANOVA (Confirmation of results)
						Kaizen (Improvement of new material)
		Material	Super ductile rebar	Poor material chemistry	Enhance the ultimate tensile strength to yield ratio (UTS/YS)	Market research (Identify alternative material)
						Theoretical and experimental data (Draw cause-and-effect relationships of factors)
						Preliminary study (Draw first hand solutions)
						Regression analysis (Understand relationship between factors)
						Kaizen (Optimize material property)
2	Mahindra and Mahindra	Material	Transmission aggregate	Strength and cost	Chemistry (carbon-nitrating) and process (shot-pinning)	Customer survey (Collect customer voice)
						Must be quality (Address basic customer need)
						Attractive quality (Address comparative advantage)
						QFD (Address customer voice in design)
						CAE & DFMEA (Design change & reliability validation)
						Lab & field test (Confirmation of results)
						Contact with research

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3	Indo-Gulf	Material	Urea coating	Value loss due to leaching, volatility, or de-nitrification	Development of Neem oil for urea coating	institute (To understand Neem oil technology)
						Product platform (Identify alternative technologies)
						R & D (Confirmation of technology Vs base product effectiveness)
						Infrastructure (Development & production)

Table 2. Application of TQM for Method, Machine, and Material Innovation

3.4 Human Resource Development Process

The studied companies had difficulty in that the human resource often do not follow and practice the business strategy in everyday operation. Moreover, the learning behavior was very limited creating wide gap of knowledge and ability among employees. To solve this integrated approach to knowledge management is used to maximize innovation performance that lead to competitive advantage. This result agrees with the finding of Gloet and Terziovski, (2004). However, our study extends the result to three best practices vis-à-vis: capability development and human need consideration, unleashing the creative potentials of employees, and ensuring employee participation in the TQM approach.

3.4.1 Capability Development and Human Need Consideration

The study indicated that the companies have addressed their human resource development process in two perspectives: capability development and addressing the human need. In this two perspectives, four quadrant approach (HRM Matrix) was followed. In the case of capability development the four quadrants will span four capability states: beginner, skilled, expert, and master. Each quadrant depicts specific capability level of the employee or manager. The assessment is continuous and especially when there is job rotation, or promotion through the Plan-Do-Check-Act (PDCA) Cycle. Along with the skill development matrix, employee need management matrix was also used. This matrix addresses four basic need hierarchies: experiencing, learning, contributing, and growing. The context is rapid competency growth ahead of market. Two way approach: executive competency enhancement and operator skill enhancement were the focus of TQM program for process techno-innovation. The approaches are distinctive defining the requirements for each group of employees. The executive program dealing with strategy matters while the operators program dealing with technical capabilities.

3.4.2 Unleashing the Creative Potential of Employees

Other approach of TQM with regards to human resource is to unleash the creative potential of employees. This was part of the employee involvement program to tap the talents employees. As Gapp (2004) put it change is not the progress of scientific invention, rather it is a development over time from the basic lessons learned from emergencies, interruptions, and alternations that occur. Thus, unleashing the creative potential of employees was one important issue in the process techno-innovation. The talent unleashing process is designed in a formal structure by which the company can appreciate the contribution of individuals, employees can learn from the achievements of others, and contributors can feel their validity in the company.

3.4.3 Ensuring Employee Participation

Fundamental issue often pinpointed with TQM regarding to human resource management is ensuring the employee participation in process techno-innovation. The realization of this is not easy for many companies. But, the TQM philosophy of collectivism and respect for everyone has led companies to develop a proactive human resource management system called the family type management system. This system addresses the employee, the employee's family, the local community, and the society in the management philosophy. As the family, the local community, and society has a lot to do with the general

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behavior of the employee and company, the emphasis must be extended long enough to address all of them. This TQM philosophy has resulted in seamless working environment because of mutual trust between management and employees, ensured employee participation, employee dedication to support community through innovative efforts of working methods, machines, and materials in their company.

3.5 Working Environment/Corporate Culture

One of the most integration units between TQM and process techno-innovation is the working environment (corporate culture). Unlike the hard working environment (environmental factors), TQM influences process techno-innovation capabilities of a company by instituting conducive working environment (soft) in to the organizational structure. This process synchronizes the hard elements of the process techno-innovation (man, method, machine, and material) to the overall company requirements. Table-3 shows how the working environment (corporate culture) has affected the process techno-innovation

Sno.	Factor	Company	Philosophy	TQM focus	
				Applied to	Target
1	Policy	TATA Steel	ASPIRE	Integration of all improvement initiatives	System integration
		M&M,FES	Corporate constitution	Working environment for development and participation	Company conduct building
		SRF Ltd.	Corporate citizenship	Social consciousness on environment and business	Social value
		Sundram brake lining	TVS way	Family and elder focus to deploy company vision	Continuity and understanding
		Krishna Maruti Ltd.	Family style management	Manage employee, family, and local society together	Collectivism
2	Evaluation and Reward	TATA Steel	4 student model	Evaluate achievement based on target and process	Distinctive status management
		Indo Gulf Ltd.	Think Thank	Unleash employee creative potential and award the best ones	Self explanation and assessment
		Krishna Maruti Ltd.	Cost Saving Award	Saving share based on suggestion's contribution	Valuation and clarity
		SRF Ltd.	Man of the month	Acknowledging, recognizing, and celebrating for contribution	Distinction and reward
		Sundram brake lining	Founders day	Non-leave taker and service awards	Recognition
3	Autonomy	Indo Gulf	Self-assuredness	People stand-up to situation	Independence
		SRF Ltd.	Process based organization	Process based work flow, decision making at point of action, involve people cut across traditional function to customer voice	Facilitate and foster learning capability
		Sundram brake lining	Autonomous maintenance	Maintenance of machines by employees	Versatility
4	Safety	Indo Gulf	Safety work permit	Protect employee health, safety, and ergonomic	Risk management

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				problems	
		Sundram brake lining	Greening SBL	Use of recycled water, reduce asbestos, and safe working place	Green concept
5	Communication	Rane engine valve Ltd.	Functional forum	Horizontal deployment of kaizen	Dissemination of knowledge
		Krishna Maruti Ltd.	Communication e-nagare	Connectivity with vendors and customers (Extranet)	Information sharing
		Rane TRW steering sys	Online deployment	Single database on intranet for policy management	Easy access to data source
		Indo Gulf	"Aditya Disha"	Group-wide corporate intranet for sharing information and knowledge	Easy communication
		SRF Ltd.	Interact board	Shop-floor boards for writing employee views	Sharing views
		Sundram brake lining	Transparent communication	Office automation, internet, intranet, e-mail, ERP, CAE, and E-commerce	Transparency

Table 3. Effect of working condition/Corporate culture on innovation

4. Analysis and Discussion

The essence of process innovation for developing economies is necessary for global competency. Fasil and Osada (2009) indicated that TQM is fundamental to innovation and sustainable growth in developing countries. Similarly, in this research the potential of TQM to process techno-innovation was clearly seen to be effective.

4.1 Overall relationship of the five factors

From this study we have learnt that TQM affects the five factors in a network like. The achievements in one factor are reflected in another factor. Conditions that influence one factor also cause revelation in the other factor. Especially, corporate culture and human resource factors are predominantly influential to the process techno-innovation. Three pillars are fundamental in the relationship vis-à-vis: human resource, process & technology, and corporate culture (working condition). See figure-1 & table-4.

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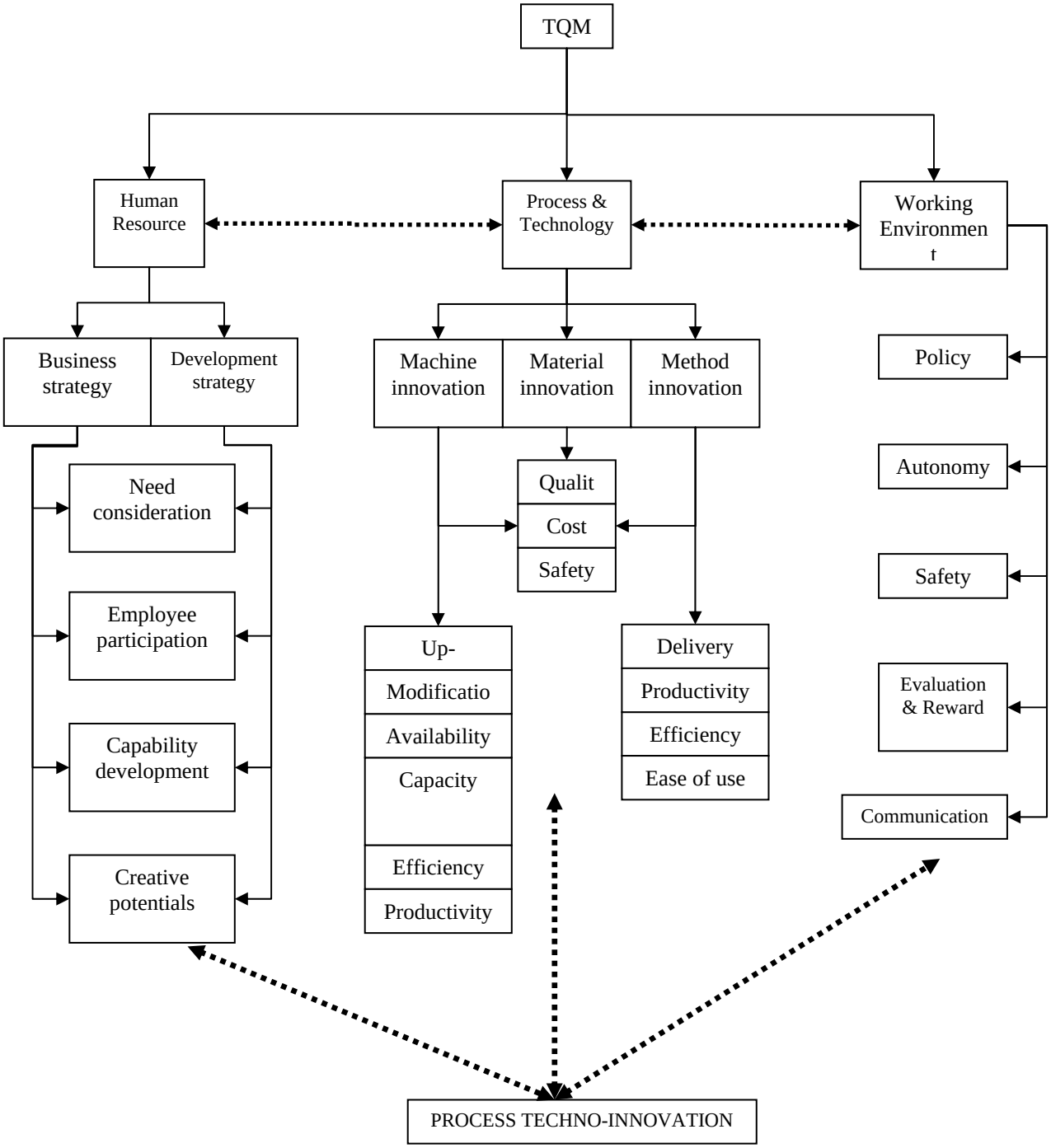

Figure1. Three pillars of process techno-innovation using TQM.

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	Man	Machine	Material	Method	Working condition
Man	Communication, learning, skill, morale, development,	Up-grading, modifying, reliability, customizing, standardizing, availability, safety,	Improve properties, innovate new material, reduce waste, cost reduction	Productivity, ease, efficiency, safety, cost reduction, delivery, quality,	Discipline, loyal, respect, cooperative, supportive, lawful, honest
Machine	Productivity, skill, knowledge, safety, satisfaction, morale	Productivity, capacity, cost efficiency, delivery, quality		Productivity, ease, safety, efficiency, quality, capacity,	Safety, ease, suitability,
Material	Knowledge, morale, satisfaction	Productivity, quality, efficiency		New skills, variety, efficiency	
Method	Ease, safety, productivity, skill, knowledge, satisfaction, morale	Definition, conception, understanding, productivity maintainability, design	Understanding, characterization, design,	Efficiency, safety, ease, productivity, quality, cost efficiency	Versatility, safety, ease, efficiency,
Working condition	Safety, morale, communication, clarity, value, ease, transparency, versatility, recognition,	Safety, maintainability, understanding, availability, productivity,	Innovation, attention, consideration, learning	Ease, efficiency, productivity, safety, simplicity,	Harmony, speed, efficiency, trust, legitimacy, ease, communication

Table 4. Cross relation of man, method, machine, material, and working condition/corporate culture

4.2 Human Resource

The use of TQM to the human resource in skill development has shown dramatic change in capability development for the process techno-innovation. PDCA conducted on continual improvement of skill has helped companies to see further on limitations and alternative deployment of policies. Skill index measured on the companies indicated that annually constructive employee transformations were results of TQM based approaches. Two main factors in this area are found to be human resource and business strategy matching and the human resource development strategy.

4.2.1 Human Resource and Business Strategy

In the context of TQM implementation to the revelation of employee participation in the company business excellence, the following things are found important. The company vision with respect to human resource development must sight the "Need for Human resource development" with mission "To create competent and good people for the organization and society." For the success of this vision and mission HR strategy formulation with respect to HR context need to be given priority. The strategy can be designed to address different aspects of the business as shown in Figure - 2**.** Meanwhile, the HR activities can be vast and intensive addressing wide range of personal and capability development. Moreover, with regards to developing committed employees, clear definition of the human concept is found important. This emanates from the fact that for a company the first and foremost assets are the people. It is important to select good people with good academia. But, more than qualification is commitment. People are trained to be given authority, autonomy, and space with in which they can work and also can make mistakes. Hence, it is important to give them the freedom to make decisions. Under this framework TQM can be adopted to human resource development.

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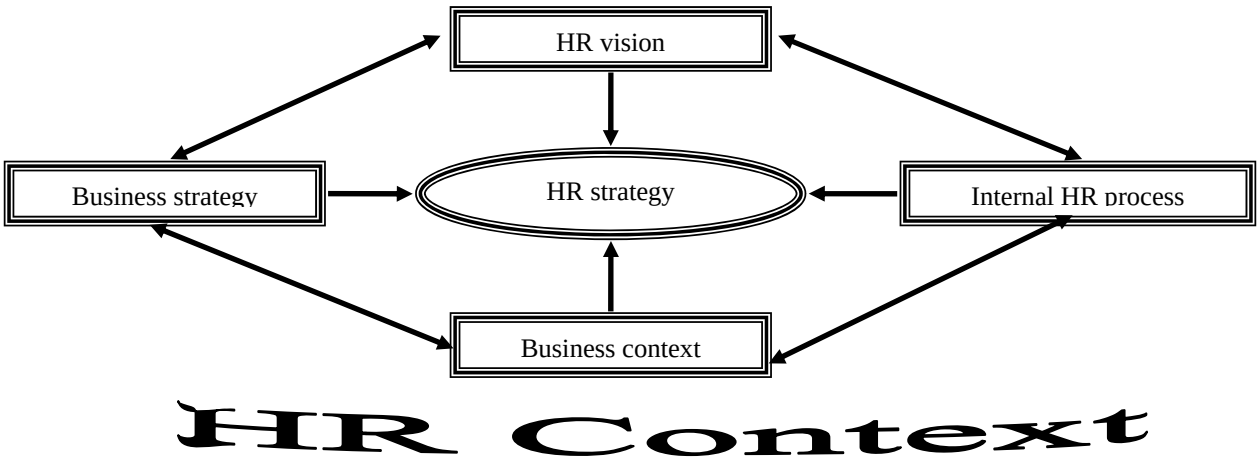

Figura.2. Fundamental Aspects of Human Resource Management

4.2.2 Human Resource Development Strategy

However, despite the fact that TQM is applicable and has been addressed as a means towards business excellence, the context of business excellence remains open as the business incorporates different functional department which are unique to one another. This calls a question that what is the level of TQM applicability in the different departments and its contribution in promoting innovation in those departments? This issue needs to be addressed in the context of TQM applicability and its contribution to innovation. In our research we have found that TQM in the context of human resource embraces large but simply interconnected sections. These sections are very important and must be addressed in the human resource development strategy for the purpose of process techno-innovation. These sections are (Figure-3):

1. TQM Philosophy
2. TQM Infrastructure (Plan and Do)
3. Performance Measures (Check)
4. Counter Measures (Act)

These four components should be framed based on the breadth and depth of the TQM program with respect to the human resource. However, realistic span of TQM applicability should be done by management when dealing such efforts. Meanwhile, the ideal span of those components with respect to this study is modeled here under figure-3.

4.3 Process techno-innovation

Our study indicates that process techno-innovation is used enhance resource utilization and develop competency. The reason being developing countries relies primarily on process. Then can only think about technology innovation. This is due to the fact that they often do not possess high technology to engage themselves in high-tech or product innovations. Moreover, management philosophies in developing countries are so traditional that processes are less optimally managed. From the companies studied for this research, three main stages are identified in process techno-innovation using TQM. These are key land marks in process techno-innovation. The main aim of these innovation processes is increasing productivity and profitability through method, machine, and material innovation. Three process techno-innovation stage gates are: process understanding, process improvement and technology learning, and process techno-innovation. The detail is described here under. See figure-4.

4.3.1 Process understanding

In all of the companies studied process techno-innovation begins with the process understanding. Quite often

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employees and management wander which way to begin. The problem is that as everybody is busy with the daily task which gives them little chance to think of major change. On the other hand intense competition and dynamic change in customer requirement pressurizes the system to change. In such very complex environment with still less trained employees and traditional management system TQM is found to help companies resolve their problems easily. Simple TQM tools such as 5S, poka yoke, suggestion scheme, daily routine management, and others have given companies the edge to address the long term objectives in their daily work. This stage results in good understanding of process and recommends useful measures to process improvement.

4.3.2 Process improvement and technology learning

The next stage is where employees and management develop the capability of process improvement and technology learning. Rigorous tasks conducted during the process understanding starts to pay off with better process performance and improvement. Matured management practices and skilled employees start to grow. Knowledge becomes an asset in many groups. This company wide knowledge dissemination builds the ground for the major process techno-innovation.

4.3.3 Process techno-innovation

The third stage is the process techno-innovation. At this stage the company comes up with distinctive procedures or methodologies of modifying, updating, or creation of new ideas for process technology innovation. TQM as a system integrates the created knowledge in individuals or groups to business strategies and objectives. At this stage companies become aggressive in improvement programs creation of additional knowledge. Development of proprietary technologies becomes a reality of aggressive TQM in the process techno-innovation.

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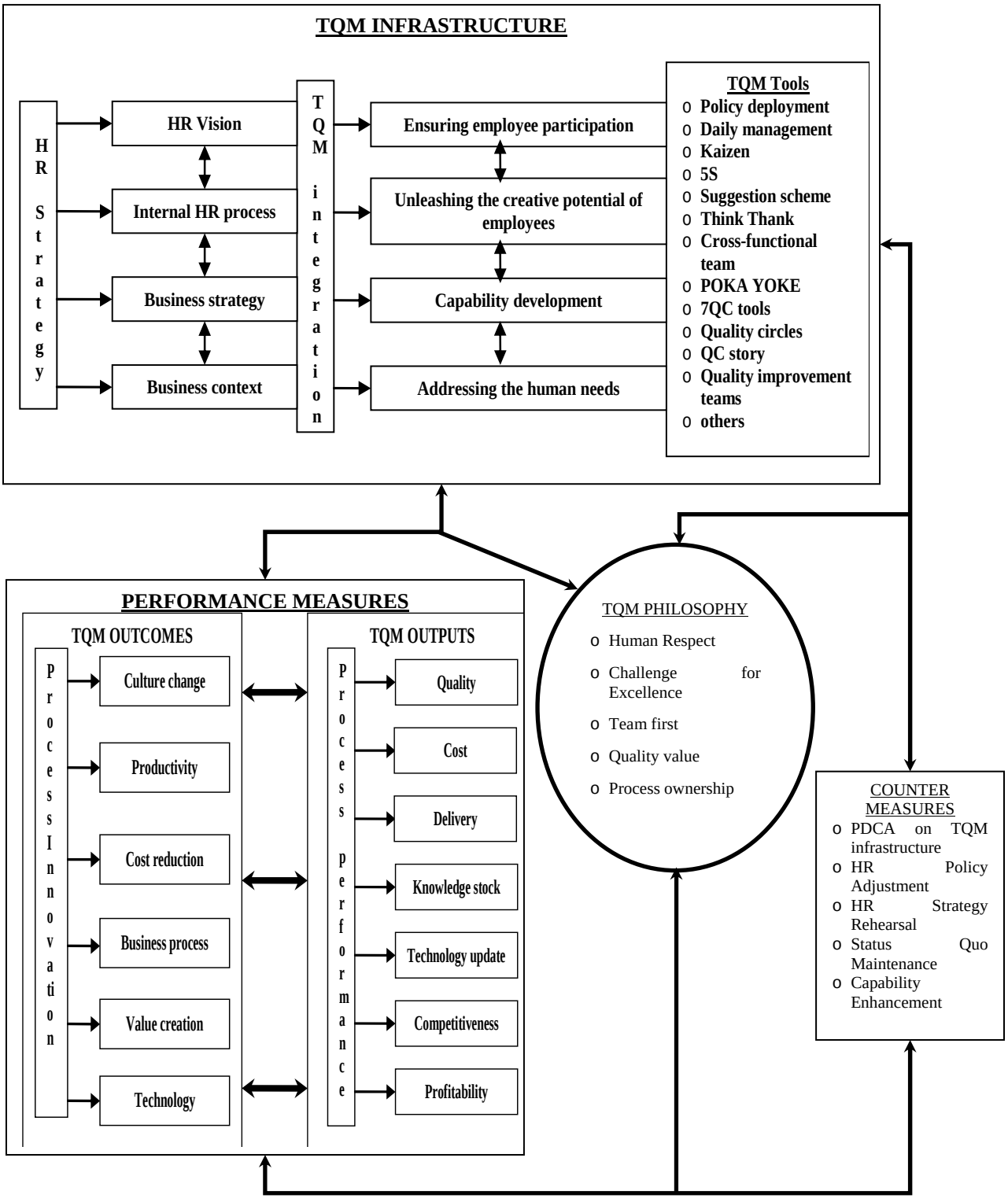

Fig.-3: Human resource development strategy model

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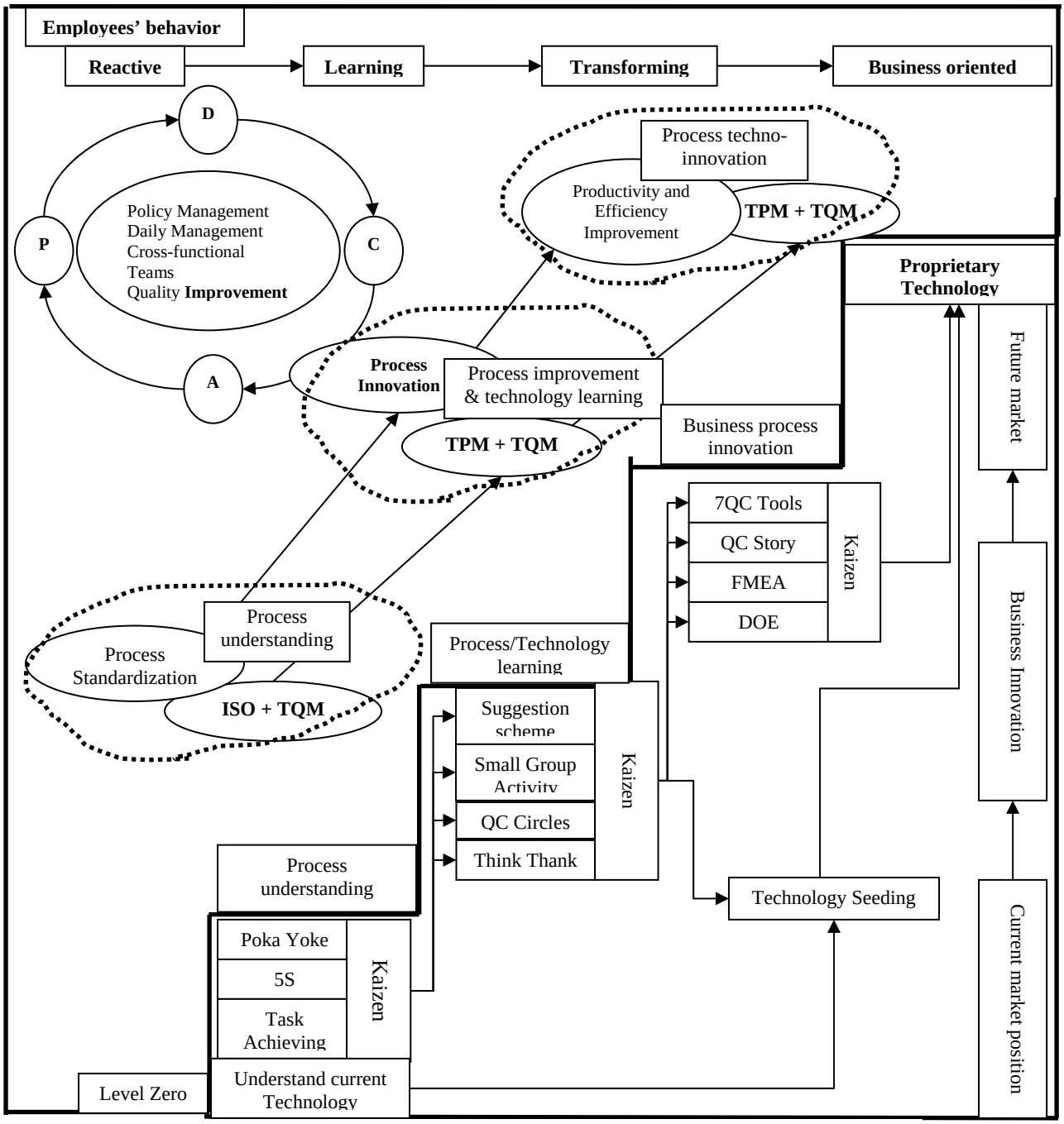

Fig.4 Mechanism for Process Techno-innovation using TQM

Conclusion

From this study it is observed that TQM is influential management tool for process techno-innovation in developing countries. The role of TQM in process techno-innovation is creation, accumulation, and integration of knowledge to development of proprietary technology. Key factors are 4M (man, method, machine, material) and 1E (corporate culture/soft working environment). This is achieved through effective TQM organizational activities

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such as small group activities, quality control circles, and cross functional teams. The reason for TQM to be successful is, first TQM's potential to bring culture change in the company. This happens due to process orientation approach of TQM and systematic management of processes to synergize change and innovation through kaizen and participation. Second is TQM's potential to proactively identify root-causes of problems through quality control for the purpose of technology development. This is achieved through tools such as problem solving, QC story, and kaizen for the purpose of knowledge sharing. This makes TQM to act as a catalyst for the development of proprietary technology. Hence, based on this study it is concluded that unlike huge investment made on R&D by companies of advanced countries and huge investment on new technology, developing countries must focus on human resource development (knowledge stocking) and creating favorable working conditions (corporate culture) in the face of innovation. TQM approach is very helpful for the purpose of coordinating, harmonizing, synergizing, and integrating fragmented achievement over the wide span of the company to a common strategic objective. The TQM application mechanism follows a three stage-gate vis-à-vis: process understanding, process improvement & technology learning, process techno-innovation strategy to foster innovation capabilities. This approach has helped the companies studied to develop from poor performance level to the possession of own proprietary technology with limited investment in R&D. However, it must be remembered that process understanding and process improvement programs are the key areas that must be the primary focus of process techno-innovation using TQM. Meanwhile, the necessary conditions are; first focus on human resource for knowledge creation and stocking, ensure participation, and forming strong process techno-innovation grounds. Second is creation of conducive working environment/corporate culture to foster transparency, clarity objectives, togetherness, safety, and autonomy in the workforce so that contribution towards creativity will be enhanced. Therefore, the focus on human resource and working conditions will generate creative potentials in the process techno-innovation (Method, Machine, and Material). Meanwhile, the detail study to how much TQM affects the organizational change is a topic to be studied further.

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