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The Combination of Soft System and Quality Function Deployment Methodologies in the Design and Development of the Comprehensive Model for World Class Manufacturing Processes

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Abstract
The present paper attempts to design and develop a comprehensive model based on which the manufacturing processes can be promoted toward a world-class manufacturing level. In this paper, it is believed that the Soft System Methodologies (SSM) can be utilized in a synthesized fashion to attain the world class manufacturing status and the Quality Function Deployment (QFD) to analyze and assess customer needs and requirements and to design production processes used for the achievement of high quality products. It is believed that such a combination can lead to the successful design of a model of key success criteria for the purpose of achieving the above mentioned goal. To achieve the above mentioned goal, the SSM and QFD Methodologies are combined to establish the major components influencing manufacturing processes in the form of a model consisting of 12 components (strategy, system, organization, work process, value, personnel, culture, quality, price, speed, flexibility, and customer services).

Key words: World class manufacturing; Soft system methodology; Quality function deployment; Modeling; critical success factors; Production process design

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INTRODUCTION
The needs and developments of today's human being global participation. For participation we should be aware of its terms and conditions, and to be considered as a manufacturer in the world, we should know the requirements and factors affecting it. So the concept of World Class Manufacturing (WCM) should be understood well. Moreover, to change the present situation of traditional manufacturing processes, world-class manufacturing criteria should be determined and learned.

To determine these criteria, a model must be designed and implemented, which doing so, in turn depends on determining and choosing an appropriate methodology to achieve the set goals (improving manufacturing processes to the position of a world class manufacturer). Based on literature, soft systems methodology (SSM) was proposed to determine the factors affecting the achievement of WCM. Paying attention to quality at the organization level is among factors effective in achieving WCM. To promote the quality of manufacturing processes, Quality Function Deployment (QFD) methodology was selected. In this methodology, customer needs are determined first, and then the need to technical characteristics of the product

and technical characteristics of the product are changed into Manufacturing process and the Manufacturing process into a product which will eventually be marketed.

Considering the fact that development of sciences depends on synthesizing and combining the previous methods, to strengthen and use the strengths of both selected methodologies (QFD, SSM) simultaneously and fix up their weaknesses, both SSM and the QFD methodologies were synthesized with each other. Based on this synthesized and in order to design a model that can promote manufacturing processes to a WCM level model, the key success criteria model (which use a hierarchical analysis technique to determine preferred factors) was designed. To evaluate these models, in addition to the feedback mechanism in the models, the face validation techniques (taken from the experts), Accepted Theory and Conservation Theory were proposed to determine the validity of synthesis methodology according to its hard and soft characteristics.

PHILOSOPHY, GOALS AND MODEL-BASED METHODS

The primary technique of Quality Management to help the regular transition process of customer demands is that of Quality function Deployment (QFD) which regularly relates customers' demands and needs to features of products or services (Sharifzade, 2000).

This method can determine the consumers' needs and demands in the area of design and transform them into features of parts and manufacturing operations. Therefore it can be used to design and develop manufacturing processes tailored to consumers' needs.

QFD can be used to create a product in accordance with customer demands at World Class Manufacturing levels.

In fact, there is a research gaps in the area of attempts to provide a model for manufacturing processes to have access to WCM status. This study has designed a comprehensive model of World Class Manufacturing processes.

The designed model indicates how a traditional manufacturing process could be improved to WCM through ten steps. On the other hand, while improving manufacturing processes, key success criteria model determines what key aspects (success factors) should be considered in the operation sequence and stages.

To design a model which can promote manufacturing processes to a world-class status, an efficient and useful methodology is needed. The concept of world-class manufacturing is related to complexities and the different dimensions of organization, and domestic, foreign and environmental variables according to the competitive aspects must be considered together. Theoretically, systems thinking is a reliable approach to identify complex phenomena. In this approach, through the conscious recognition of the organization as a system one can become aware of the complexity of the organization (Rezayian, 1998; Sadeghi, 2005). Therefore, the systems thinking pattern used in this paper is based on soft system approach (Checkland & Scholes, 1999; Abooei, Ardekani *et al.*, 2000). In the process of systems thinking, hard and soft problems and systems are being hadled.

Soft System Methodology (SSM), which is a structural approach for clarifying targets in the complex and dynamic problem solving tasks, explain the facts in solving these tasks and can be used to deal with soft problems (Checkland & Scholes, 1999; Bustard & Wilkie, 1999; Shehata & Bowen, 2000; Hong *et al.*, 2003).

As Quality Function Deployment methodology is focused on understanding the customer needs, it tries to create a framework to improve sensitivity to quality in all processes and to organize the process of manufacturing operations in such a way that lead to delivery of better quality products to customers (Crow, 2002). This methodology was used simultaneously with other ones, so that the resulting synthesized methodology (SSM-Q) can include the strengths of both methodologies and fix up their weaknesses.

In this study, for the purpose of the development of a comprehensive model of World Class Manufacturing processes, the main components of the conceptual model and key factors of success were extracted, and the proposed model with twelve components was developed.

Main components of the selected model are mainly based on ideas presented by Burcher, Stevens and Blanchard regarding features of world-class manufacturer organizations (Burcher & Stevens, 1996; Farish, 1995; Shunta, 1995), while the selected elements in the matrix of product planning, product design, process design and process planning (QFD1 to QFD4) can be derived from various literature reviews and expert opinions, and according to the system viewpoint they include market, manufacturing and distribution factors influencing manufacturing processes to achieve World Class Manufacturing level.

Among the validation methods of conceptual models, taking into account the hard and soft characteristics of selected methodology, the face validation methods (based on expert opinions), Accepted Theory and Conservation Theory were used to validate the model (Illgen & Gledhill, 2001; Fleishman, *et al.*, 2003; Pala, *et al*., 1999; Van der, *et al.*, 2001; Hicks & Earl, 2001; U.S. Environmental Protection Agency, 2005; Brock-Nannestad, 2000; Balci, 1997; Welsh, *et al.*, 1992).

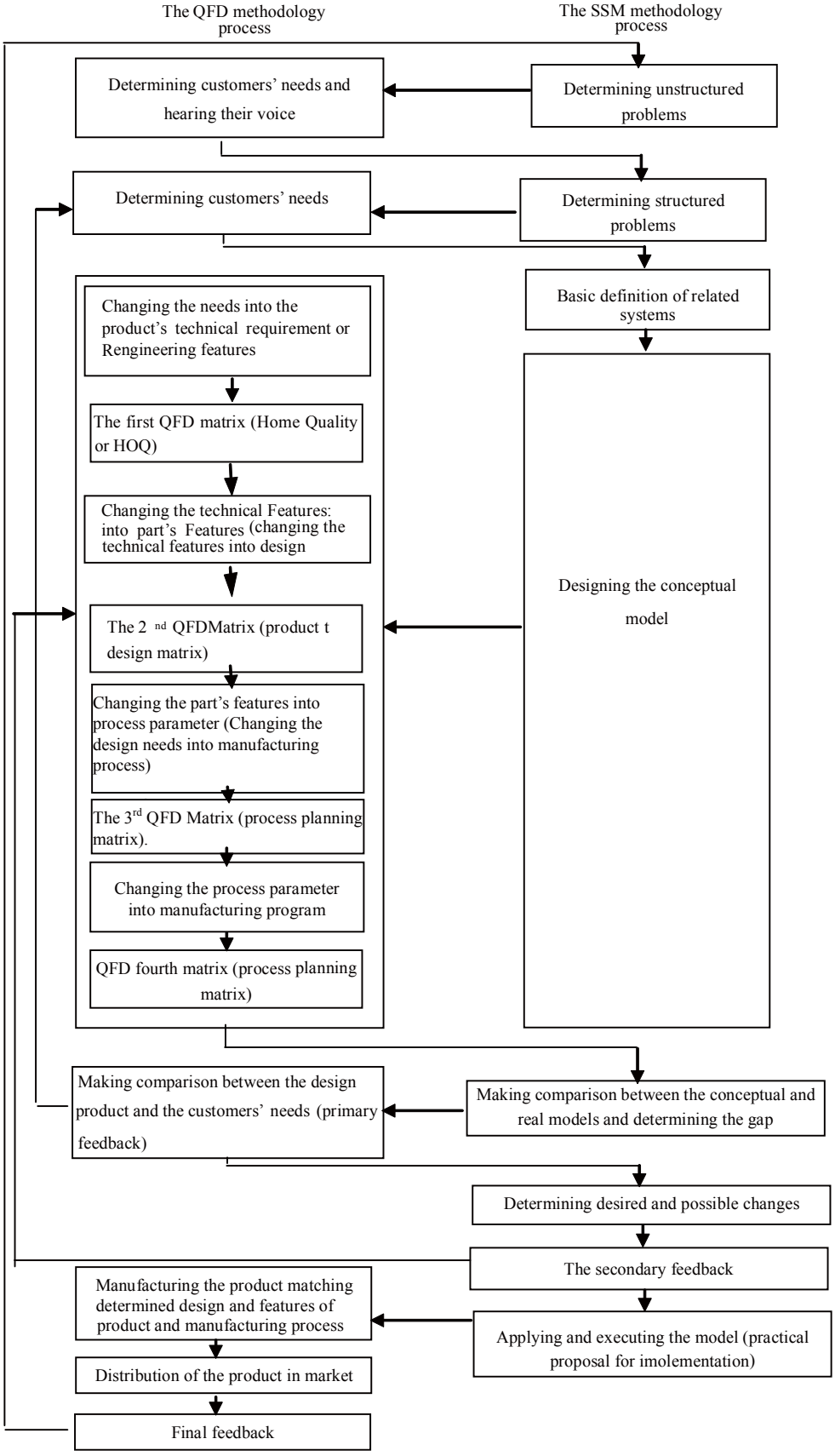

Figure 1
SSM Methodology and QFD Methodology Processes

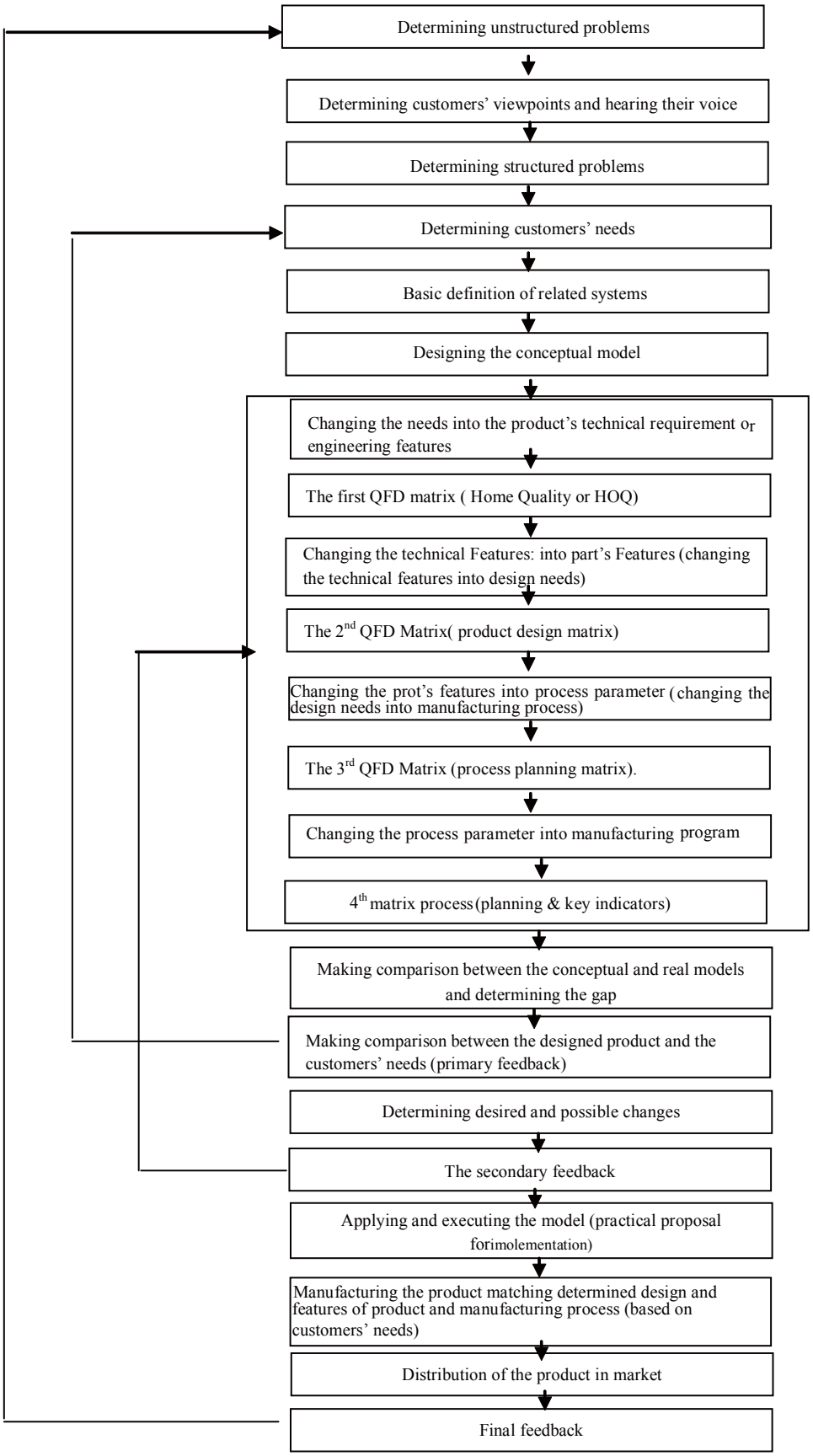

Figure 2
The SSM-Q Synthesized

COMBINING SOFT SYSTEM METHODOLOGY AND QUALITY FUNCTION DEPLOYMENT

In this study, for the development and design of a comprehensive model that can promote manufacturing processes to WCM level, as illustrated in Figure 2, a methodology is suggested that includes different steps (Figure1) in which two approaches of Soft Systems Methodology (SSM) and Quality Function Deployment (QFD) have been connected together.

New theories always are created from "combining" previous separate concepts and thoughts. Fundamentally, development and delivering of new ideas and knowledge is based on combining other previous methods, or combining and reorganizing previous methods and methodologies (Novali, 1995). By definition, the word synthesis is synonymous with words like combination, organization, linking, compilation, and matching (Hornby & Sally, 2004). In this study synthesis is used as synonymous with relating and organizing.

According to Prof. CheckLand, methodology should be somewhere between "philosophy" and "technique"; A philosophy is a general guide for action. On the other hand, a clear operational plan that provides a specific outcome is a "technique". A methodology is less accurate than a technique, but it is a more stable guide for action in

comparison with "philosophy". While a technique tells us about the "how" and a philosophy about the "why", a methodology tells us about both components of "how" and "why" (Checkland & Scholes, 1999).

In this research, the proposed synthesized methodology is designed in such a way that by Soft System Methodology (SSM) answers the "why" and can be used as a philosophy and general guide to improve the current situation to an ideal situation. Using QFD methodology which is a technique, we can answer the "how" and provide a program that can help us achieve the world Class Manufacturing level.

Soft System Methodology (SSM) approach is in line with the necessity of using existing methodologies in systems thinking approach and QFD to provide practical solutions to expand the quality, determine customer needs and ultimately manufacture the final product which will fit the required level of quality.

FEATURES OF SSM AND QFD METHODOLOGIES AND THE SYNTHESIZED METHODOLOGY

Based on existing literature and theoretical studies, in summary we can illustrate some of the important characteristics and features associated with soft systems methodologies (SSM) and Quality Function Deployment (QFD) and the synthesized methodology (SSM-Q) in Figure 1.

IMPLEMENTING THE SYNTHESIZED METHODOLOGY TO ACHIEVE WORLD CLASS MANUFACTURING STATUS

The key issue identified in this article is the lack of a comprehensive model to enhance World Class Manufacturing (WCM) processes. By synthesis methodology, a model is presented in this study that, regardless the given variable examples in the model, can be used to provide a framework (methodology) by which the proposed variables and factors of achieving success in reaching the position of World Class Manufacturing can be determined with The emphasis on manufacturing process and relative importance of each.

By definition, World Class Manufacturing matches with the highest level of performance in the world in terms of external and internal key factors. External key factors include quality, price, speed, flexibility and customer demands. Internal key factors include key values and shared goals, strategy, human resources, culture, system, structure and manufacturing process (Burcher & Stevens, 1996; Farish, 1995; Shunta, 1995). The synthesis methodology designed in this study is based on systems thinking and takes all such factors into account.

By definition, World Class Manufacturing also requires attention to concepts like Total Quality Management (TQM), Total Quality Control (TQC), quality assurance, lean production, Total Productive Maintenance (TPM), just in time (JIT) production cost deployment, KAIZEN, understanding methods and structure of production in Japan (Gunasekaram, 2000). The synthesized methodology in its process contains concepts and capacity to take into account many of the above indicators as well. One of the key elements of success in achieving WCM is paying attention to indicators such as quality, customer and process (Ali Askari, 2004). To manufacture products according to customer needs at the World Class Manufacturing level, QFD can be used. If QFD is implemented through the method presented in this study, achieving to these indicators would be in reach.

Among key indicators of success in achieving WCM are quality and structure (Ali Askari, 2004). QFD methodology is primarily based on quality. SSM methodology, which is basically a methodology based on process, uses structure to move toward the desired system (Davis, 2002). Therefore, considering the possibility of synthesizing these two methodologies, quality and structure indicators can be determined and taken into account.

Designing the model was based on an objective achieving (WCM). The objective determines needs; and to respond to these needs, the synthesis methodology was designed. The model has been designed in a way that if you intend to achieve the objective you should put the QFD methodology in a new framework (WCM status). Thus to achieve this objective such as the fore going

synthesized methodology should be used.

System creation activities can be done in several ways, including the traditional and structured life cycle and design and analysis of systems (Rezaeian, 1998; Sadeghi, 2005). Stages of creating and developing systems can include goal determination, feasibility evaluation, the status quo reviewing, status quo analysis, designing optimal situation, implementation, operation, maintenance and improvement (Cutts, 2002). The synthesis methodology in this research includes these steps.

Performance and functional characteristics of SSM provides a guide for promotion from the current position of organizations to an optimal one. QFD is a tool that helps in achieving the desirable status (WCM). As a result, recognizing the status quo is possible by SSM and designing an optimal position of WCM by QFD.

Using QFD as a tool of SSM, we can promote the status quo to an optimal one.

Considering the different aspects needed to achieve WCM and its related complications, and given that each of these methodologies (QFD, SSM) individually have the capability to be combined, to reinforce strengths and eliminate weaknesses of each of them, in this paper QFD methodology was integrated with SSM as one of its tools so that the resulting synthesized methodology, can be used to design optimal conditions by QFD matrices. Some important aspects of WCM can be embedded in the model this way.

Considering the real-world conditions and various influential factors on the manufacturing processes including soft and hard problems, the synthesized methodology and capability to respond to such issues has some complications, which calls for more researcher's'attention.

In the synthesized model, indicators of achieving WCM has been designed, defined and applied using QFD matrices.

The WCM status looks for the best and most important factors determining success. To achieve this status, concepts like TQM are essential. In TQM, critical success factors are determined in support of the organization missions and the key organization performance criteria (Pike & Barnes, 1998). Total quality management (TQM) focuses on three main issues: focusing on customer, process improvement and emphasizing universal participation (Tenner & DeToro, 1997). Customer-oriented approaches includes understanding customer's needs and listening to their voice and universal participation includes listening to the voice of organizations' employees, and improving the process can be considered equivalent to the process voice (Sadeghi, 2005). Implementation method of total quality management (TQM) is QFD technique. Implementation method determines the customer and his or her needs and the way their needs should be taken into designe criteria (Pike & Barnes, 1998). The synthesized methodology involves TQM principles and its implementation method (QFD). Thus it can be expected that through implementation of it alongside providing other prerequisites, the WCM status will be achieved.

Table 1
Features of QFD, SSM and Synthesized Methodologies

Methodologies / Criteria	Soft System Methodologies (SSM)	Quality Function Methodology (QFD)	Synthesis Methodology SSM-Q
Objectives	Improvement, paying attention tothe customers' viewpoints and needs	Improvement, paying attention tothe customers' viewpoints and needs	Improvement, paying attention tothe customers' viewpoints and needs
Function	can beusedtoachieveworld class manufacturing status	can be usedfor Quality Function Deployment	A frameworkfordesigning and extendingthe production processmodelto accessWCM-statuswithregard toWCM productionstandardsincludingqualityrequirementsdefinedby thecustomers andtransforming it into the desiredproduct
Designed for	Unstructured and soft problems	Structured and hard problems	Both Unstructured and soft problems and Structured and hard problems
Focuses on	Organizational goals	Expanding quality and customer satisfaction	Organizational goals, quality and customer satisfaction
Focus area	Organizational structure and processes	product quality	Both structure and product quality
Focuson beneficiaries	All beneficiaries	Customers and developers	All beneficiaries including customers and developers
Engineering needs	Need to deduce	Need to deducing, Managing, tracking and ranking	Need to deducing, Managing, tracking and ranking
Tool	Specific tool not available	Specific tool available (quality home)	QFD as a tool in the process of SSM and SSM being the system requirements and design are created.
System design	Unable to create a complete system and to express how to build the system; new system design constraints	Able to create a complete system and to express how to build the system; can provide new system	Able to create a complete system and to express how to build the system; no new system design constraints; can provide new system

Using methods of validating conceptual models and their compliance with the topic, the validity of synthesized methodology and the designed model for achieving world class manufacturing status were confirmed. Among such validation methods, face validity (based on expert opinions), accepted theory and the conservation theory were used for this purpose (Illgen & Gledhill, 2001; Fleishman *et al.*, 2003; Pala *et al.*, 1999; Van der *et al.*, 2001; Hicks & Earl, 2001; U.S. Environmental Protection Agency, 2005; Brock-Nannestad, 2000; Balci, 1997; Welsh *et al.*, 1992).

COMPREHENSIVE MODEL OF WORLD CLASS MANUFACTURING PROCESSES

According to the mission determined (World Class Manufacturing) and based on synthesis methodology, the model of key criteria for successfully achieving WCM status was designed as illustrated in Figure 3. This model is essentially based on one of the techniques of multiple-criteria decision making model (Analytical Hierarchy Process) (Qodsipur, 2006; Darabi, 1993), integrated multiple criteria decision model for evaluating investment feasibility of Advanced Manufacturing Systems (Jiang & Wicks, 2002), integrated strategic model to access WCM (Ali Askari, 2004), or characteristics and features of the Manufacturing processes. The results of such models include determining key indicators of success to achieve WCM status, and determining rank and importance of each factor compared to other factors.

As manufacturing process planning entails manufacturing system design that can be used to achieve world class manufacturing levels, in this research the above mentioned model was designed in the fourth stage of preparing QFD matrices (QFD4). The relationship of factors obtained from this model (the key criteria for successfully achieving the position of world class manufacturing) with the manufacturing process was determined using QFD matrices and by paired comparisons as illustrated in Figure 5 and Figure 4.

Stages of designing the model according to the synthesis methodology process as illustrated in Figure 6 contains the followings:

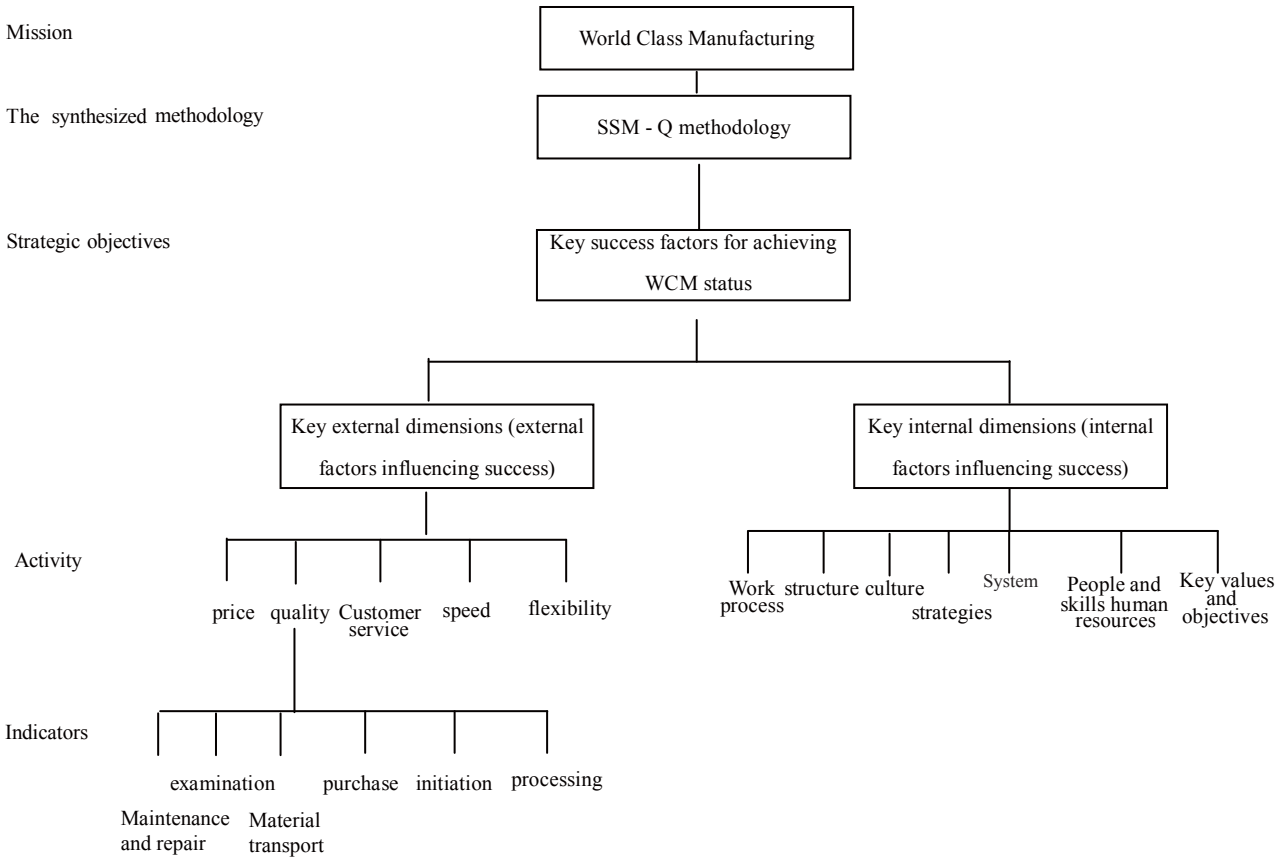

Figure 3
The Conceptual Model of Key Success Factors of Manufacturing Processes to Achieve WCM Status

Key process requirement (process planning) / Process stages	Provision	Manufacturing	packing	Sending	Distributiig and delivering	Total (net weight)	Relative weight (%)
strategy							
system							
structure							
Work process							
Key values and objectives							
People and skills (human resources)							
culture							
quality							
price							
speed							
flexibility							
Customer service							
importance							

Figure 4
Planning Process Matrix (Manufacturing Planning) in World Class Manufacturing Status (QFD4)

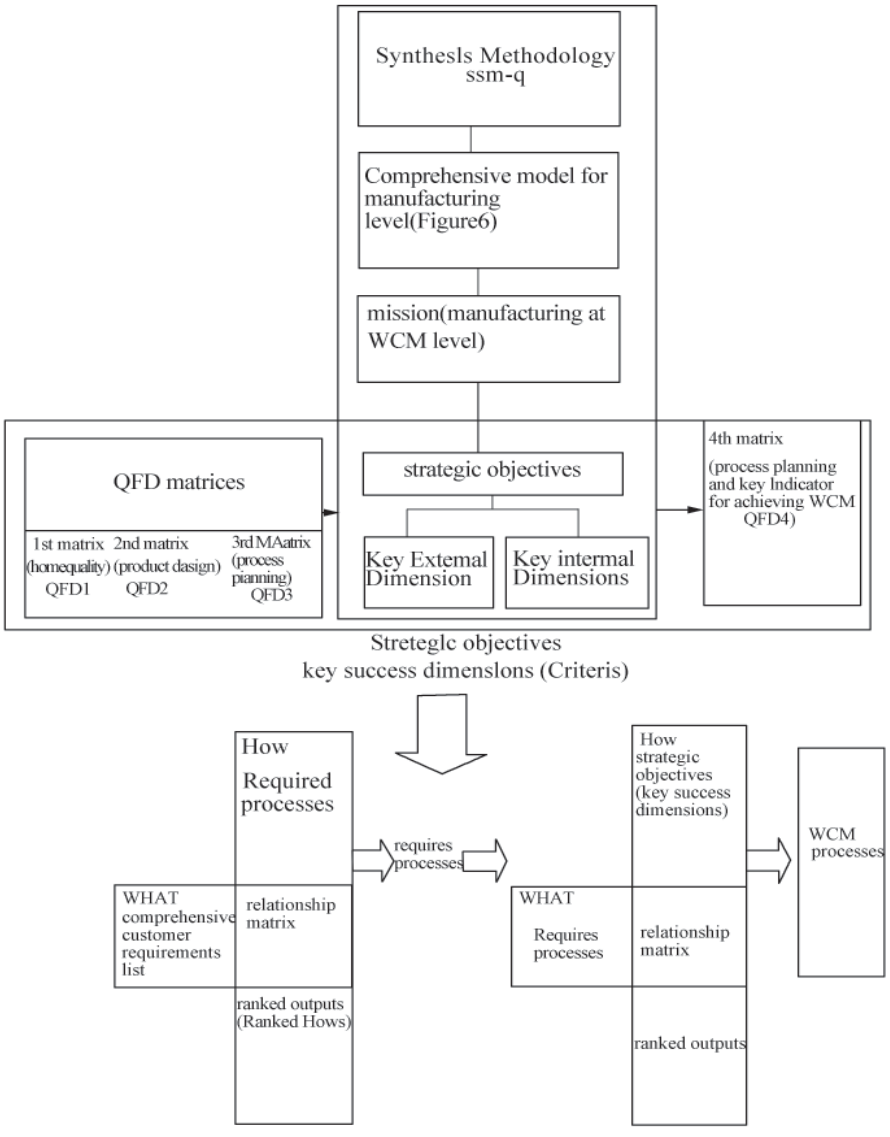

Figure 5
The Model of Changing Customers' Quality Requirements into Strategic Objectives

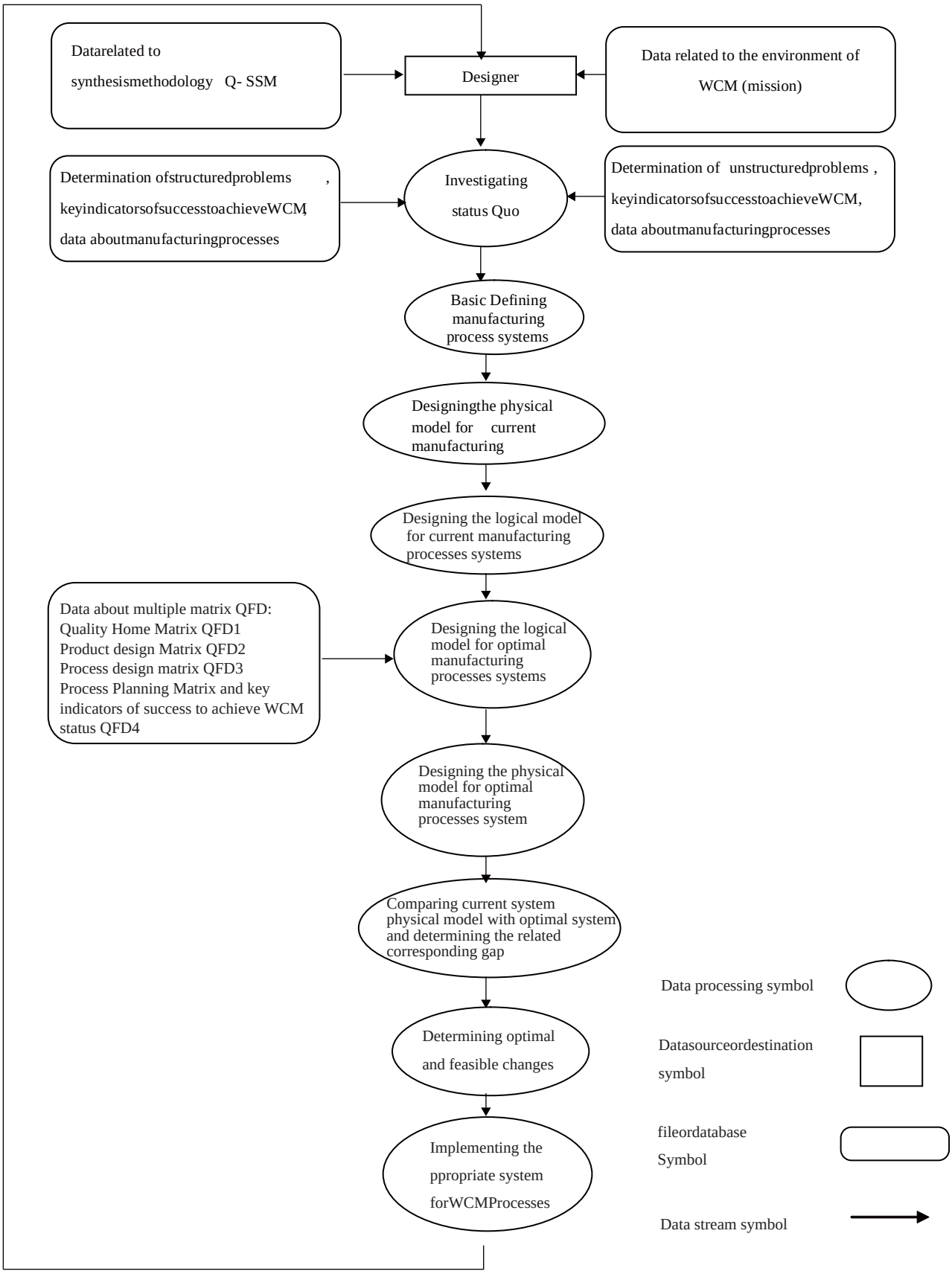

Figure 6
Physical Data Flow Diagram Designed Model (Ideal System) Using the Synthesis Methodology

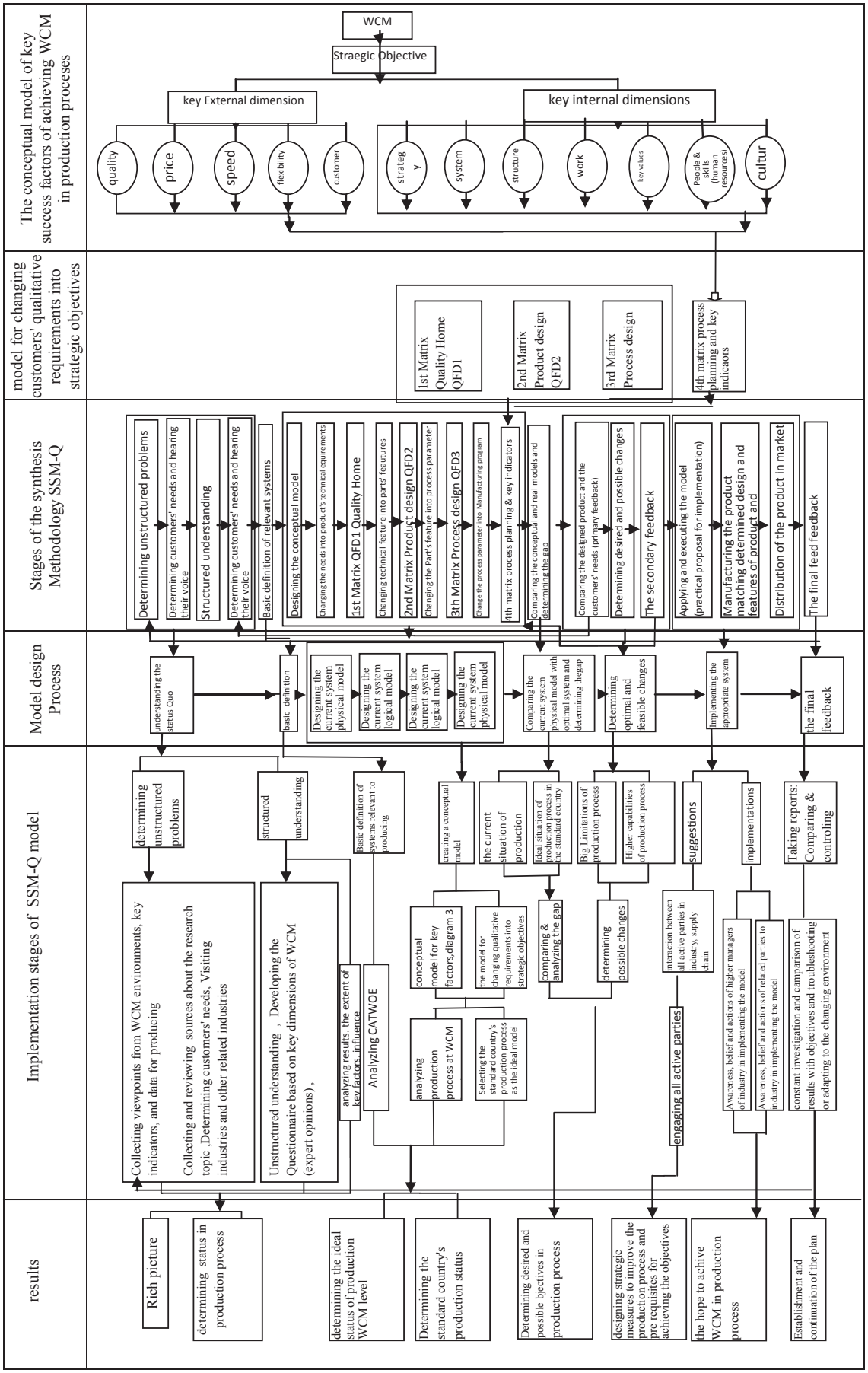

Figure (7). The administrative model of SSM-Q for World Class Manufacturing processes
* CATWOE:Customer, Actors, Transformation, Worldview, Owners, Environmental
**Rich Picture : Pictures of the Status quo seems Industry

- Understanding the status quo (determining the structured and unstructured problems)
- Defining the associated systems
- Designing the current system physical model
- Designing the current system logical model
- Designing the optimal system logical model
- Designing the optimal system physical model
- Comparing the current system physical model with optimal system and determining the related corresponding gap
- Determining optimal and feasible changes
- Implementing the appropriate system
- Final feedback

Figure 7 shows SSM-Q model for administrative processes of world-class manufacturing.

HOW TO DESIGN THE MODEL FOR KEY SUCCESS CRITERIA

As in Figure 3, in the presented model from top to bottom, first mission is set (global manufacturing). In the next level a number of strategic objectives should be developed to achieve this position (To determine a process that can promote the location of manufacturing processes to reach that level, customer needs become strategic objectives through a matrix of QFD (Figure 5)). Strategic goals in this research include key success criteria for World Class Manufacturing. At the lower level, to achieve the above objective, decisions must be made. As results of investigation, the decisions that are repeated in the system are deemed as necessary activities (the activities are steps that are being to key by organizations to achieve strategic goals). Repeated decisions to achieve world-class manufacturing include key internal and external dimensions affecting success (critical activities). following the same method we can develop the model to the level of performance measurement indicators including measurement criteria used to help assess the effectiveness of the organization's activities based on strategic objectives. Relationship between these items is determined through the Analytical Hierarchy Process (AHP) technique (Jiang & Wicks, 2002).

DISCUSSION AND INTERPRETATION

Because studying phenomena should be done using the scientific understanding methods (Delaware, 1997) and designing a model should be with a system thinking approach (Abooei Ardekani, *et al.*, 2000) and based on a scientific system (methodology), in this study initially SSM (Checkland & Scholes, 1999) and QFD methodologies (Dytoro, 1997; Sadeghi, 2005; Davis, 2002; Pike & Barnes, 1998) were selected. Next, these methodologies were synthesized into a methodology for the first time (Novali, 1995; Amiri, 2003; Hornby, 2004), so that the synthesized methodology has the characteristics of a methodology proposed by Prof. CheckLand and includes most of the strengths and eliminates weaknesses of SSM and QFD methodologies which was previously used separately. Among these characteristics are: a framework for designing a model to achieve WCM, creating a system, addressing hard and soft problems simultaneously, and paying attention to customer needs, quality and structure (Farsijany, 2005; Ali Ahmadi, 2003; Ali Askari, 2004). In order to achieve the specified mission (WCM), the synthesized methodology was designed to design manufacturing processes and develop models needed to achieve WCM.

Exploring different models individually makes clear that each specifies some dimensions to achieve success in WCM based on their own points of view. Collecting specifications contained in the above mentioned models and integrating the similarities,general key success criteria - mainly based on comments of Burcher & Stevens and Blanchard regarding the characteristics of a WCM organization (Burcher & Stevens, 1996) - were determined to achieve WCM using AHP approach and expert opinions. All steps of scientific research are included in synthesized methodology. All designed models have features of scientific knowledge such as being testable, empirical, selective, criticizable, and replicable (Novali, 1995). Moreover, models have special dynamics so that there is the possibility of compromise and reform especially in their effective parameters. Based on the selective characteristics, no claim is made here as to inclusion of all effective factors in achieving WCM and only aspects that can be executed in a reasonable time period have been considered. However we can acknowledge that in determining the causes, a system point of view has been used in a way that the market, manufacturing and distribution factors that can affect manufacturing processes to achieve WCM, are covered. It appears that the proposed methodology and models have the characteristic of generalizing in industrial, commercial and service activities to determine how to achieve WCM status.

Designed models are based on stages of development of systems (Cutts, 2002), methods used in systems' life cycle (Sadeghi, 2005), an integrated multiple criteria decision model for evaluating investment feasibility of advanced Manufacturing Systems (Jiang & Wicks, 2002), an integrated strategic model to access the WCM (Ali Askari, 2004), AHP Technique (Saaty, 1980; Ghodsi Pour, 2006; Darabi, 1993; Esfahani, 1991) and manufacturing processes features.

Integrated multiple criteria decision model was designed to assess the investment feasibility of advanced manufacturing systems with the aim of providing a model for decision-making and evaluating and justifying investment projects.

In this research, the model of key success factors to

achieve WCM is designed based on the above mentioned model. This model results in determining indicators, activities, and strategic objectives to achieve WCM. AHP was used to determine the relationship between the items discussed and solutions suggested for achieving WCM. Moreover, the coefficient of importance (weight) and the priority of each key factor relative to other factors was determined by the same model.

AHP is a model of rating factors with weight (value) which has the ability to find inconsistencies inherent in the decision making process. In this model a wide range of issues has been used to make decisions (Saaty, 1980). In this study the model was used in several cases including determining customer needs and prioritizing them (Rezaeian, 1998) and determining the effect of and comparing key dimensions of success in achieving WCM status.

CONCLUSION

In today's competitive world being aware of current standards to achieve World Class Manufacturing is essential. Nowadays organizations must promote their current position to WCM; otherwise, it would be difficult or even impossible for them to survive.

Because the proposed method in this paper for achieving WCM has not yet been fully used in related research,s attempt the next step is to try to use it for cases such a Persian hand made carpet within designed models.

In this article the following models were designed, developed and used:

- The synthesis methodology SSM-Q
- The model of key success criteria for achieving World Class Manufacturing status
- The inclusive model of World Class Manufacturing processes
- The administrative model of SSM-Q for World Class Manufacturing processes
- Developing four Quality Feature Deployment matrices (QFD)
- SSM methodology used to achieve WCM status
- QFD methodology used for designing the process of manufacturing operations to achieve better quality products matching customer demands and Quality Feature Deployment
- Validation techniques for validating conceptual models, including techniques of: face validity (obtained from the experts), Accepted Theory, and Conservation Theory, which were used for determining the validity of synthesis methodology and other models
- Analytical Hierarchy Process technique which is used for: determining the priority of key success criteria necessary for changing customer quality requirements into strategic objectives and determining the necessary strategy; prioritizing needs, and allocating resources to activities affecting success

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