Customer Responsive Manufacturing System With Response Assessment & Enhancement

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Abstract
In a market where rapid changes in demand, product design, and volumes are now common and where the requirement of a production operation to be reliable in terms of quality and delivery performance. It is now a base-level expectation with an appropriate set of response capabilities. This paper describes the analysis of customer responsive manufacturing system with various tools and subsystems. It presents the different sources of disturbances which are caused by the manufacturing responsiveness and examines key issues which are associated with assessing, measuring and improving the manufacturing responsiveness, and considers the role of flexible decision making and control strategies in this context.

Keywords
Customer Responsiveness, Manufacturing Systems, Assessment & Enhancement

I. Introduction

In 20th century, mass production system was introduced but being very inflexible it is not responsive to changing customer demand. Later, Toyota production system or Just-In-Time (JIT) system was developed to produce right products in the right amount at the right time. Thereafter, concept of Lean manufacturing evolved from Toyota production system to strive for improvement to eliminate all non-value added activities. In 21st century, due to high fluctuating demand and change of product design, a new kind of manufacturing system developed called Agile manufacturing. Another technique called, Quick response manufacturing focuses on reducing the lead time for all tasks resulting in improved quality, lower cost, & quick response. Furthermore, a new methodology called Legrile manufacturing system is generated which makes an eco friendly production environment [1, 6].

Whether lean manufacturing, agile manufacturing, or legrile manufacturing, companies must be able to react and respond quickly to predict and improve their overall performance in fast changing and uncertain customer demand. In other words, the manufacturing system must be customer responsive to operate in steady-state mode. This in turn necessitates analysis of customer responsive manufacturing system. In particular, it is important to be able to assess and improve the manufacturing responsiveness.

Responsiveness is the ability of a production system to respond to disturbances (originating inside or outside the manufacturing organization) which impact upon production goals. There are certain drivers which are essential for customer responsive manufacturing system such as [4-5]:

- Work place organization
- Uninterrupted flow
- Error-free processing
- Insignificant change-over

This paper reviews the tools and subsystems of responsiveness by analyzing the responsiveness in a production context. Methods for assessing and measuring the responsiveness of a production operation are introduced and work seeking to improve the responsiveness through cooperative control and decision making strategy are described.

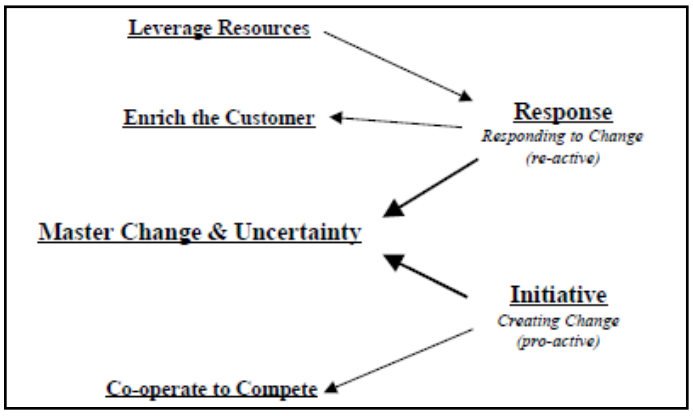

Fig. 1: Contributors to Responsiveness

II. Variables Affecting Future Corporations

Responsive manufacturing requires a blend of technological, organizational, and human resources to adapt to the fast and unpredictable changes in the way of product development. The major forces influencing today's manufacturing environment are global competition, shortened product life cycle, increasing requirements for quality & reliability, increase of fast paced & complex technology [2].

The following are the critical variables affecting the future responsiveness-

1. Product development & extensive customer service
2. Building brand image & marketing innovation
3. Influence over distribution channel
4. Targeting unexplored segments
5. Maintaining the firm's reputation
6. Providing products with many features
7. Premium product quality
8. Operating efficiency/ cost management
9. Pricing below competitors & Accurate market forecast
10. Managing supply sources
11. Process innovation & product cost reduction
12. Serving special market segments
13. Being first to enter into market
14. Manufacturing services & broad product range
15. Maintaining high point of sale inventory level

III. Developments in Manufacturing Technology

Although the idea of virtual organizations is not newly proposed, recent developments in information and responsiveness relate to the ability of manufacturing systems to make a rapid response to predictable and unpredictable changes. The "Responsive Manufacturing Enterprise", the enterprise that is designed to achieve balance between stability under conditions of uncertainty and responsiveness to change. This critical balance of enterprise response ensures enterprise success in coping with disturbances in its environment through its adaptability [1-2].

To achieve this, the enterprise has to excel in integrating its technological, organizational & human resources and develop manufacturing technology as seen in fig. 2.

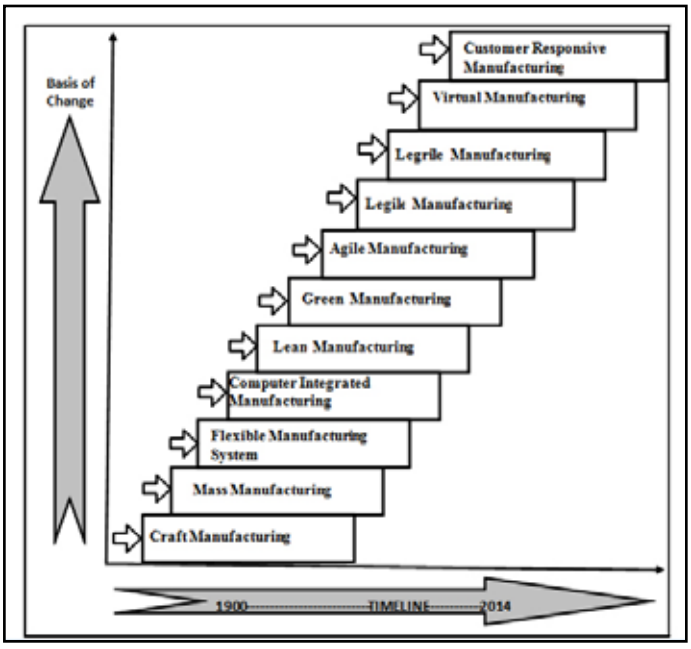

Fig. 2: Developments in Manufacturing Technology

IV. Tools of Customer Responsive Manufacturing

Tools of customer responsive manufacturing system with their respective attributes are as follows [4-5, 9]:

A. Lean Manufacturing System

1. Eliminates non-value added activities
2. Improves production efficiency
3. Minimum waste & minimum inventory
4. Just-in-time delivery
5. Workers teams spirit
6. Worker involvement
7. Flexible production systems
8. Continuous improvement

B. Agile Manufacturing

1. Customized products
2. Short market life expected
3. Produce to order
4. High information content
5. Continuing relationship
6. Pricing by customer value

C. Theory of Constraint

1. Improves lead time & on time delivery of product
2. Improves & maintain responsiveness of system for changing customer requirements
3. Works on single priority system
4. Improves the availability of the system
5. Identifies the constraint & exploit through focusing mechanism

D. Quick Response Manufacturing (QRM)

1. Enhanced customer service
2. Faster response to demand
3. Reduced inventory with higher quality
4. Efficient responsiveness
5. Reduced Lead time
6. Integrated production system
7. Improved Team work & planning
8. Increased Turnover per employee per area per available machine hour

E. Lead Time Optimization

1. Reduced lead time & enhanced quality level
2. Elimination of waste in operation
3. Cycle time reduction
4. Inventory storage shortens
5. Reduction in material handling & transportation time

F. Information Technology in Responsive Manufacturing

1. e – Manufacturing
2. Agent technologies
3. Artificial intelligence in manufacturing

G. Cloud Based Manufacturing

1. Rapid elasticity
2. Reduced time to market
3. Reduced cost
4. Improved information sharing
5. Improved resource reuse
6. Improved machine utilization
7. Pooled manufacturing resources
8. Enhanced computing environment

H. Cellular Manufacturing

1. Improvement in process balancing
2. Increased productivity through reorganized manufacturing floor
3. Reduction in WIP inventory
4. Eliminates overproduction
5. Cost saving and operation control

I. Flexible Manufacturing System

1. Increased variety of parts and reduction of direct labor
2. Improves machine utilization and response to engineering changes
3. Reduced inventory, due to the planning and programming precision
4. Faster, lower-cost changes from one part to another which will improve capital utilization
5. Improves responsiveness & operation control

J. Sustainable Manufacturing

1. Systematically identify and evaluate cleaner (less polluting, less toxic, and less wasteful) production opportunities and facilitate their implementation.
2. Improves recyclability and energy efficiency
3. Reduction in hazardous waste in operation
4. Provides social sustainability
5. An environmentally and economically positive outcome

H. Supply Chain Management

1. Organizational Flexibility
2. Mass customization manufacturing strategy
3. Intra–and inter-organizational communication
4. Better inventory management
5. Inter-organizational relationship
6. Effective outsourcing
7. Smooth supply chain coordination

While implementing the above tools, there would be some common outcomes achieved after execution. These outcomes are as follows:

- Management style
- Development of the system
- Voice of the customer
- Tools, techniques, and information technology
- Results and benefits
- Optimization of system
- Employee management
- Product and process development
- Flexibility & agility
- Ecofriendly environment

V. Subsystems of Customer Responsive Manufacturing

To effectively manage the responsive manufacturing metrics (Inventory, operating metrics, and manufacturing cycle time), above mentioned responsiveness tools are used. These tools can be applied on a set of subsystems for further process execution [1, 4].

The process execution involves audit of all operational, support and administrative activities that contribute to products & services provided to the customer.

Generally the following subsystems are assigned:

1. Manufacturing process control
2. Manufacturing capability
3. Inventory management
4. Quality management
5. Management commitment
6. Business & Industry knowledge
7. Compliance of purchased materials
8. Order-entry process & Cost control
9. Customer service
10. Labor relations
11. Compliance with government regulations
12. Document control process
13. Facility management
14. Distribution process control
15. Product warranty, Reliability, & Technical support

These subsystems can be analyzed separately with a suitable auditing tool. This process will lead to improved product quality and services.

Although various subsystem listed above contributes towards customer responsive manufacturing, yet their contribution can not be assumed equal. Weight of one subsystem may be more than others. To determine their relative weightage, AHP (Analytical Hierarchy Process) technique to be used.

VI. Analysis of Customer Responsive Manufacturing

Like any other strategic initiative, Customer Responsive Manufacturing requires a high level of planning and preparation. The first step is to establish the scope and objectives for the process. The next step is the development of the performance metrics to measure the conformance to the requirements of process. And finally, a checklist to be developed of the required actions, tools, resources, timing, and support to deploy the strategy [1].

During this phase of process, an objectives matrix to be developed to assist in quantifying the objectives. Before moving forward, the checklist to be filled to ensure all process data is available [1].

OBJECTIVES MATRIX					
Objective	By When?	By How Much?	Expected ROI	Metrics	Data Sources
Improve quality level					
Improve deliveries					
Reduce lead time					
Reduce supply base					
Faster response					

Fig. 3: Objectives Matrix

PREPARATION OF CHECKLIST				
Required	Actions	Tools	Resources	Timing
What				
When				
Confirmed				
What				
When				
Confirmed				
What				
When				
Confirmed				

Fig. 4: Preparation of Checklist

VII. Disturbances Affecting the Responsiveness

A disturbance is a change (internal or external) affecting the performance of a production system, which is either outside its control or has not been planned. The principal aim of responsiveness assessment method is to provide an indication as to how greatly a production operation is affected by internal/ external disturbances. Disturbances often place additional pressure on production [4], [11].

The responsiveness assessment and measurement procedure aims to evaluate its ability to handle non-steady-state conditions and to decide appropriate strategy for improving its responsiveness. To help identify & describe disturbances, a classification of common disturbance sources is described as follows:

A. Upstream disturbances

1. Material quality problem, supplier production problem, material delivery delay, material property variation, incorrect deliveries

B. Internal Disturbances

1. Information, control and decision making
   - Control system failure, operator error, recording error,

material ordering error

2. Production equipment and labour
- Machine breakdown, variation in machine performance, unavailability of labour

3. Material handling and flow
- Blockages, handling equipment failure

C. Downstream disturbances
- Rush orders, change to orders, quantity variations, demand variation, forecasting error, finished goods delivery delay, poor stock monitoring

VIII. Assessing, Measuring & Improving The Responsiveness

A. Assessing Responsiveness
In order to be able to specify appropriate ways to improve responsiveness, it is important to identify – for a particular disturbance – the different response capabilities required by a production operation. Figure-5 outlines the response capabilities identified in this research [3-4].

A suitable combination of the qualities is critical for effectively responding to a disturbance which alters the normal operating pattern of the plant. A simple quantification methodology has been developed for assessing both (a) the extent of available response capabilities and (b) the level to which these are currently exploited.

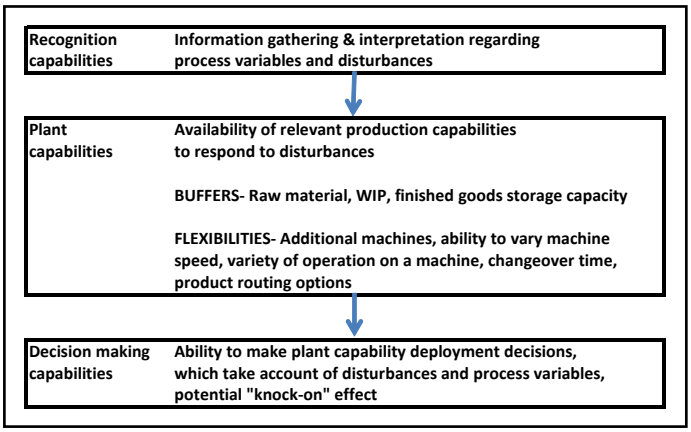

Fig. 5: Contributors to Production Responsiveness

An auditing tool has been developed – which enables an objective assessment to be made of both the impact of different operational disturbances and the response capabilities available for dealing with those disturbances.

The basic audit process is outlined in fig. 6 which indicates that a typical audit proceeds as a series of short interviews for determining disturbances (response issues) & plant information followed by a workshop in which these disturbances are assessed and prioritized and the current capabilities available for dealing with them [3].

The audit provides following outcome:
- A structured and collective view of the plants ability to handle important response issues
- Prioritization of response issues
- For key response issues, the audit identifies whether benefits can be achieved by exploitation of existing facilities or infrastructural improvements are required
- Identifies target improvement area

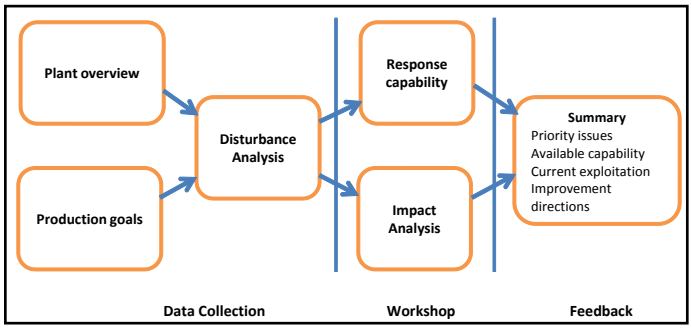

Fig. 6: Production Responsiveness Audit Process

B. Measuring Responsiveness
The following are the key areas of measurement that are essential for achieving and maintaining consistent improvement throughout the entire manufacturing arena [8]:

1. Completeness of production processing
2. Yield that is defect and error free
3. Zero set up and/ change over
4. The total skills of the work force
5. Operation for mistake proofing
6. Mixed model capability
7. Waste elimination activity
8. Reducing material handling activity
9. Speed to market for product delivery

C. Improving Responsiveness
Improving Responsiveness Through Co-operative Control and Decision Making Strategies: The improved production response can often be achieved without infrastructural change. This research has investigated a class of decision making and control strategies based on the co-operative interaction. These strategies have two key features compared to conventional approach (Fig-7) [3].

1. A more localized rather than centralized deployment of processing for decision making
2. An interactive rather command approach to information exchange

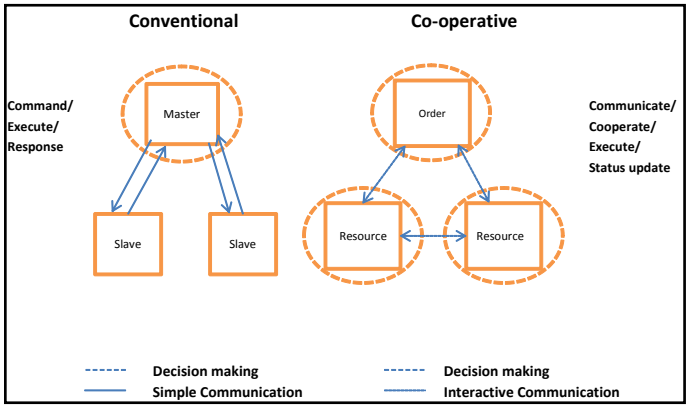

Fig. 7: Conventional Vs Co-operative Interaction between Process Elements

The key benefits of this approach are an increased ability to exploit dynamic shop-floor data in decision making and a more flexible & robust approach to the allocation of tasks in scheduling, manufacturing execution and process optimization.

In such a strategy individual production resources would not be assigned tasks, but rather would negotiate to determine the role they play in processing an order. These interactive solution procedures are stable and converge to an acceptable solution within a specified time period.

IX. Furure Research Areas in Responsive Manufacturing

The following research areas are mentioned wherein further research can be done to assess and improve the responsiveness of a manufacturing system [2-6-7-10]:

1. Analysis of Subsystems of Customer Responsive Manufacturing through AHP Technique
2. An Intelligent Environment For Total Product Development
3. Finding a Paradigm for an Uncertain World of Responsive Manufacturing
4. Customer Responsive Pickup and Delivery System
5. The Technological Imperatives of Customer Responsive Manufacturing

X. Conclusion

The manufacturing system must be able to react and respond quickly to predict and improve their overall manufacturing system performance in fast-changing and uncertain global market. Various tools and subsystems of customer responsive manufacturing are described and analysed. The analysis recommends the application of objective matrix and preparation of check list which leads to enhanced responsiveness. This paper concludes that co-operative control and decision making strategy can be effectively used to improve the responsiveness of a customer responsiveness manufacturing system. The various future research areas for responsive manufacturing are also mentioned.

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