



Manufacturing Flexibility and Agility: A Distinctive Comparison

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Both flexibility and agility are requisite for the successful operation of organization. From manufacturing perspective, there is still confusion of using, implementing and understanding of both concepts. This paper addresses the issue of both in a coherent manner and examined the comparison from manufacturing point of view. It has been learnt that there is a difference of 'engineer to order' and 'innovate to order', responsiveness, business network and level of organizational resources. This has been concluded with similarity and differences and stated that forecasting and adaptability are similar key indicators.

Keywords: Agility, Flexibility, Manufacturing

1. Introduction

To perform at world class stature has been an ongoing target for entrepreneurs, industrialists and management personals. In the distant past the economies of scale dominated the industries. The production at mass scale and full utilization of resources considered to be the way of sustaining in the business. Although the cost of production was remarkably low but this manufacturing style resulted very inflexible plants, factories and organizations. The plants congested with raw material, work in process and bulky inventories were very difficult to reconfigure.

The disability of those organizations to accommodate the uncertain changes in customer demands ignited the need for flexibility. Uncertain demands and variety of products required by customers forced the organizations to take a shift towards flexible manufacturing. Flexibility in manufacturing efficiently accommodates the expected changes in customer demands. Fluctuating demands and variety of products are entertained by flexibility in a reasonable way. In medium volume a variety of product mixes are effectively produced.

Although flexibility deals expected changes very well but unexpected changes in customer demands are beyond the scope of flexibility. In this situation organization need not only flexible but very responsive and easily reconfigurable system. Literature suggests that agility is the answer of both expected and unexpected changes. Further we explore what are the commonalities and the differences both flexibility and agility have.

2. Flexibility

The concept of flexibility emerged in 1970's as a result of over specializations in operational areas.

Although a vast literature is available on this subject ambiguity in defining the flexibility still exists [1]. This ambiguity of the concept restrains its effective management [2]. Ten to fifteen years ago the concept of quality was much like the concept of flexibility, difficult to accept yesterday, vital to competitiveness today. Flexibility is still being explored so it has different meaning to different people [3]. Endnilson [4] put effort to make the understanding of flexibility, agility and responsiveness. Among the causes of unclearness the perception of system and perception of customers towards flexibility play significant role.

2.1 Defining Flexibility

The manufacturing flexibility in the context of firm is defined in literature alongwith the general definitions which emerged in other disciplines as well.

Correa [5] defined flexibility as an interface between system and external environmental changes. According to this interpretation of flexibility it acts as a filter and absorber against external disturbance which possibly can cause disorder in the system.

The flexibility is an ability of a system to maintain its equilibrium and dynamic efficiency [6]. This interpretation talks about internal control and ability to preserve the state of system in presence of changes. Thus flexibility is taken as potential of adaptation to external changes.

Newman et al. [7] defined flexibility as primary tool to cope with uncertain conditions. Slack [8] and Mandelbaum [9] considered the flexibility as general change adoptability.

- Action flexibility
- State flexibility

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Taking action in front of change or shifting from one type of business to another in minimum cost and time is action flexibility whereas ability to continue working in changing operative conditions is termed as state flexibility.

2.2 Need for Flexibility

Vast literature is focused on the reasons behind the need of flexibility. Correa [5] enlisted two major drivers of flexibility.

- Environmental uncertainties
- Products and processes variability

The uncertain changes both from within the system and from outside the system requires flexibility to deal with. When it is required to offer variety of products by carrying out different processes the flexibility is much essential.

An analysis of nature of changes confronted by manufacturing system is necessary to assess the flexibility of the system [10]. Miller et al. [11] coined the term 'flexibility driven by customer' because they thought the customer as the origin of need of flexibility. The factors which promote flexibility are comprising of training, compensation, employee empowerment and team work [12].

The conditions which require flexibility found in literature can be summarized in list below.

- Demand uncertainty
- Shorter life cycles of products
- Shorter life cycles of technologies
- Wider product range
- Customization
- Instant deliveries

2.3 Types of Flexibility

Slack further categorized the flexibility as under.

- Volume Flexibility
- Product Flexibility
- Mix Flexibility
- Delivery Flexibility

In manufacturing context the volume flexibility is characteristics of the process by which process moulds itself according to the volume of demand so that a range of demand quantity can be compensated. Volume flexibility is much needed in high uncertainty and low variety.

The ease of system to produce new product frequently on frequent demands of customers is considered as product flexibility. Mix flexibility is the

ability of process to handle variety of product mixes. Delivery flexibility copes with high uncertainty and low variety as well as low uncertainty and high variety.

2.4 Dimensions of Flexibility

Flexibility has two aspects that are dynamic and static. Former is measured on longer period of time and later measure over shorter time period [13].

- Range flexibility
- Response flexibility

Slack [13] suggested in his research that the range flexibility of a process is assessed by the range of changes it can accommodate e.g. how many batches or how many product mixes can be entertained at any point in time. On the other hand, how quickly the process responds to change and neutralize it is referred as response flexibility. The plants which are MRP based have greater range flexibility whereas the plants managed by JIT have greater response flexibility [14]. In either of the case the focus is at resource level not at system level.

2.5 Broader View of Flexibility

There is no confusion between flexibility and agility until flexibility is discussed and explored at process level i.e. volume flexibility, mix flexibility etc. Confusion of differentiating starts when we further explore the broader types of flexibility.

Buzacott [10] and Gerwin [15] separately distinguished resource flexibility from production system flexibility. Look at the classification of flexibility by Gupta [34]. Machine flexibility, cell flexibility, plant flexibility and corporate flexibility.

By presenting Honda case study Mair [16] distinguished the level of flexibility.

- Micro level
- Factory level
- Corporation level

Micro level covers the workers and machine flexibility whereas corporation level demands the networking between factories that practice flexibility.

Many other authors have discussed the flexibility at higher level of organization i.e. strategic level in contrast with the flexibility level discussed by Slack [8]. The strategic flexibility emerged at first in 1984. The ability of an organization to adapt extensive and fast occurring changes in the vague environment is termed as strategic flexibility [17]. A number of internal and external modes can be employed to achieve strategic flexibility [18].

3. Agility

About two decades ago the agile manufacturing emerged as a solution to ever changing economic environment and global competitiveness [19]. In early 1980s the quest of greater flexibility was at peak and concept of elimination of waste, less inventories and high quality was dominant so a term lean manufacturing or lean production got popularity among industrialists [20].

Industry leaders started trying to develop a prototype of successful manufacturing enterprise of 21st century in 1990s. Although many manufacturers were struggling for lean production at that time and at this time as well. In 1991 Agile Manufacturing Enterprise Forum (AMEF) was formed in affiliation with Iacocca Institute of Lehigh University as result of findings of report of “21st Century Manufacturing Enterprise Strategy” by the collective effort of 150 industry executives [21-23].

3.1 Defining Agility

A great deal of literature is available on the novel concept of agility. Different authors and practitioners have understood and defined agility in different ways. To Goldman et al. [24] agility is dynamic, growth oriented and change embracing. Agility is ability to manufacture and market a wide range of products with minimum cost, less time and with high quality [25].

By utilization of managerial and manufacturing tools taking advantage of changes of environments and moulding those changes for your benefits are the central concepts of agility [26]. Sharifi and Zhang [27] argued that the agility is concerned with ability of an organization to cope with unexpected changes, ability to survive in threats and ability to get advantages of the changes by converting them into opportunities.

3.2 Scope of Agility

The difference between flexibility and agility remains unclear till the time we roam about the definitions and basic interpretations. Both the flexibility and agility talk of change and suggest ways to tackle the change so the confusion of differentiating persists. To bring ultimate clarity one need to explore the agility in detail.

Agility is multi facet manufacturing system in which its sub systems posses varying degree of agility and different dimensions [28]. To make the organization agile the research is focused on bringing agility in major nine areas of organizations. For an organization to be agile nine core areas must possess agility [29]. Furthermore, are of production planning was focused by Ashraf et al. [30]. Those areas of concern are briefly

described here to figure out the vastness of the scope and applicability of agility.

- Design of product and processes
- Process planning
- Production scheduling, planning and control
- Design of facility and location
- Material handling systems
- Information system
- Supply chain
- Human factors
- Business practices and processes

Early design of components and manufacturing system is very important to achieve agility [31]. Agile design of products and systems is not limited to few varieties of products to be manufactured. The design must be such that which can accommodate any sort of product. A design rule which reduces manufacturing lead time is developed by Lee [31]. Cheng et al. [32] developed new approach which employs artificial intelligence in agile design of manufacturing.

Process planning is focused in the similar way as design of product and system is focused. It is very much essential to know how a component will be manufactured. Manufacturing software is of great help regarding process planning. Designing of assembly line and its critical issues are investigated alongwith classification like U shape, straight and serial arrangements [33]. But this software does not accommodate the necessities of an open system particularly speedily changing environments. For agile manufacturing Gupta et al. [34] presented a generative process planning approach.

Two of the nine core areas are discussed briefly here one can refer to Luis, Nagi [29] for further reading. The way of treating all these areas by the advocates of agile manufacturing is totally different from the way the proponents of flexibility approach these areas. Agility focuses all these areas in context of extreme uncertain changes of business environment whereas the flexibility remains in the context of expected and minor changes in manufacturing environment. Furthermore agility insists on constructing networks among organizations to develop virtual organizations, the characteristic which is lacked by flexibility.

Many scholars contrasted agile with lean and propagated that both are two different names of the same thing, actually they are not. Lean is in fact a collection techniques employed at operational level for effective and productive use of resources. Whereas the agility is a comprehensive strategy dedicated to be successful in unpredictable environment [35]. On the

other hand many scholars argued the similarity of agile manufacturing system and flexible manufacturing system on bases of adaptability. The FMS is a reactive approach whereas agile manufacturing system (AMS) follows proactive approach.

4. Agility and Flexibility: A Decisive Comparison

Through previous reading it is discovered how the agility and flexibility approach the manufacturing system. Application areas of both concepts are discussed however there is need to minutely analyse both concepts in a hope that both can be differentiated clearly. There is no doubt about the fact that both the agility and flexibility are evolving as competitive priorities [36].

However on basis of previous discussion flexibility and agility can be distinguished on their differences in following measures.

4.1 Diversity of Product Creation

Flexibility follows the strategy of *Engineer-to-Order* in which new products are made by a little modification in the designs that are already available. The variety in demand is accomplished by just incorporating the flexibility in manufacturing system. However customization competence lies beyond this and that requires quick and efficient designing of new products with existing competencies and enhance competencies where needed. This is termed as *Innovate-to-Order*.

The future organization need to work in this environment. This requires responsiveness, the need flexibility cannot fulfill alone. Agility comprising of variety and responsiveness is answer to the future competitive environment.

Product Variety	Agility	Flexibility
Engineer-to- Order	×	√
Innovate-to-Order	√	×

Figure 1. Comparison based on product variety

4.2 Intensity of Changes Faced

The way we define both the agility and flexibility by that one comes to know that both address the changing environment. One can question what sort of change or

intensity of change both can cope with? Answer lies in predictable and unpredictable nature of change.

The focus of flexibility is to manage the predictable change by preset and predetermined strategies e.g. production of new (one of the available products) product mix with changed batch size.

Agility neutralises unpredictable changes by employing innovative responses as well as predetermined strategies e.g. production of completely new (Not available in products family) product.

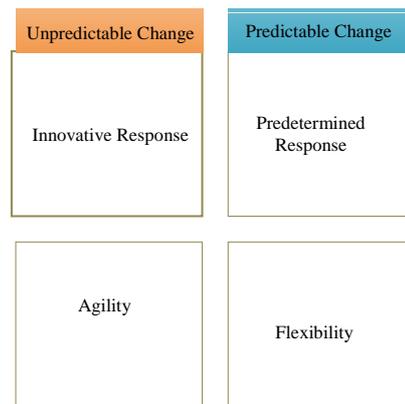


Figure 2. Comparison based on nature of change and nature of response.

4.3 Individual Vs Group of Systems

Both flexibility and agility can be distinguished on the bases of the system they focus on. Flexibility is primarily focused on individual system or even a process e.g. manufacturing system. At individual system level agility and flexibility are hard to differentiate.

Agility being broader in scope addresses the group of systems in which are all constituent systems are interconnected and ready to confront high rate of change whereas in contrast to agility, flexibility can cope with smaller magnitude of change [36]. Focus of agility at group of systems facilitates the existence of virtual organizations.

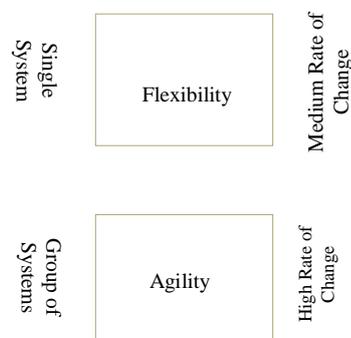


Figure 3. Comparison based on system.

4.4 Constituent Elements

Constituents of each make it different from each other. Literature suggests that flexibility is more concerned with the equipment and process flexibility. The agility is primarily focused on structure and relationship. As mentioned earlier the agility is dedicated to the unplanned changes, so to be agile predetermined strategies are no more workable. Those changes can be countered only by mature structure and strong relationship among the group of systems.



Figure 4. Comparison based on constituents.

4.5 Variety and Responsiveness

In a broader sense flexibility has its emphasis on variety specifically at process and resource level. Flexibility copes well when medium variety is required. Agility, on the other hand, focuses on swiftness of response against any uncertain change. Responding to the change quickly with smaller cost and less effort differentiates agility from flexibility.

4.6 Level of Application

In any manufacturing environment the level at which both flexibility and agility are applied is one of the bases on which one can differentiate.

In literature as well as in industries the flexibility is found at process, sub process and resource level thus facilitating the flexibility at lower level of organization. At business network, organization and collaborated system level agility is required where we need more responsiveness.

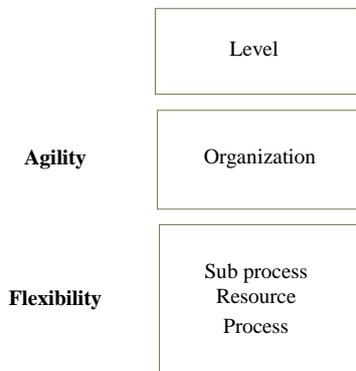


Figure 5. Comparison based on level.

Agility and flexibility differ in many traits. Organizations need both, agility and flexibility, in order to survive in ever changing competitive environment so coexistence of both is inevitable. To coexist in one organization it is very logical for both to have commonalities. A great deal of explored literature is summarized in Figure 6 in order to give a detailed analysis of similar and dissimilar characteristics of agility and flexibility.

Similarities and Differences	Agility	Flexibility
Copes with unexpected changes	√	×
Ability to be profitable tomorrow	√	×
Is applicable at strategic level	√	×
Emphasis on system	√	×
Is a proactive approach	√	×
Focuses directly on customers	√	×
Is applicable at design stage	√	×
Copes only with expected changes	×	√
Ability to be profitable today	×	√
Is applicable at process level	×	√
Emphasis on resources	×	√
Is a reactive approach	×	√
Focuses indirectly on customers	×	√
Is applicable on execution stage	×	√
Focuses on changes in customer demands	√	√
Enables to be profitable in uncertainties	√	√
Takes input from forecasting	√	√
Has potential of adaptability	√	

Figure 6. Comprehensive comparison.

As mentioned earlier, for an organization to become agile at higher level flexibility is needed at lower level i.e. process level. So agility and flexibility go hand in hand with different scope and application level. Figure 7 demonstrates the concept.

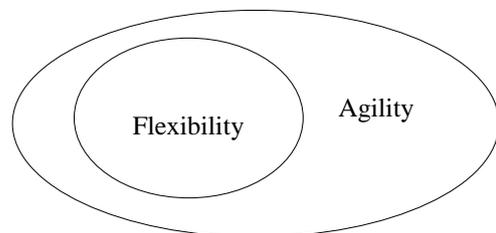


Figure 7. Flexibility as subset of agility.

5. Conclusion

It has been found that distinction exists among two concepts in their “level” of application. Furthermore nature of change faced by each and nature of response produced by each are also distinctive attributes. If flexibility is considered as subset of agility, then there are hardly any differences but differences exist when treating them exclusively. It is also observed that agility and flexibility are not conflicting to each other. For an organisation to become agile at strategic and business network level it must be flexible at process level. Therefore, both concepts are harmonizing rather than mutually exclusive.

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