Development of Rescheduling Framework to Overcome the Different Source of the Disruptions in the make to Order Supply Chain with the Reverse Flow of after-sales Service

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Abstract—Supply chain management is a stratagem, which produces the product with right quality, appropriate quantity, in right time and it deliver the exact order quantity to the right person. However, the uncertainty in the real time manufacturing system is unavoidable. Handling of the post disruption and selecting the suitable rescheduling strategies to overcome the disruption are challengeable task. The current paper deals the framework development to manage disruption from the various entities in the house hold goods manufacturing system. Machine breaks down, supply delay, entry of returned goods, rush orders, supply failure, order postponement, order preponement, order cancellation and the entry of the rework are considered as disruption. The objective of the frame work is to meet the delivery schedule under disruption. Key performance indicator for each disruption and monitoring them from each entities are discussed. This systematic frame work escorts to conduct case study by incorporating popular rescheduling strategies.

Keywords---Disruption, Framework, Supply Chain, Rescheduling

I. INTRODUCTION

In today’s competitive business environment demands a well coordinated supply chain activities for fulfilling the customer request. Technology development and globalization are considered as important factors in the modern business. However, there is a challenge exists to get the customer and keep them with the business network. Supplier and customer are the business entities, which are away from the company wall. These entities are treated as the source of uncertainty and disruption. Therefore, the supply chain should be more sensitive and react when the uncertainties arises. It is designed to meet the business objectives under the disruption and uncertainties. After-sales service is a strategic tool to promote the customer, to buy the goods. A well configured after-sales service network in the supply chain helps to retain customer and offer competitive advantage to the business (Gaiardelli, Saccani and Songini, 2007; Kurata and Nam, 2010). The performance measure of the supply chain is more important to assess the manufacturing system to meet the business goal (Rao, Rao and Munaswamy, 2008). Gunasekaran, Patel and McGaughey, (2004) developed a framework to measure the performance of the supply chain. This framework provides performance activities (plan, source, make and deliver) for strategic, tactical, operational levels of management. Supply chain council, (2011) introduced a supply chain operational reference model for measuring performance of the supply chain. The activities are classified into plan, source, make, deliver, return and enable. The council also provided the performance measures including perfect order fulfill, order fulfillment cycle time, flexibility, adaptability, value-at-risk and total cost to serve. Ganonkar and Viswanadham (2004) categorized the events, which reduce the efficiecy of the supply chain into deviation, disruption and disaster. Deviation is an event which causes instability on the manufacturing system. An event, which compels the manufacturing system to reschedule partially or completely, is called disruption. Disaster is referred to an event which induces partial or complete shutdown in the manufacturing system. Real time manufacturing system is always connected with un expected events, uncertainty and disruption. Among these events, the uncertainty due to disruption is widely reported in the literatures (Rahmani and Heydari,2004; Petrovic and Duenas 2006; Qi, and and Yu,2006). Behdani et al (2012) classified the disruption in to pre disruption and post disruption. Pre disruption can be predicted before affecting the manufacturing system where as post disruption cannot be predicted but it will be handled by triggering suitable disruption management activities. Adhitya, Sriniwasan and Karimi,(2009) discussed activities of post disruption management system. Monitoring the key performance indicator, identification of the route cause, selection of suitable rectification activity, rescheduling and coordination are considered as impairment activities of the post disruption management system. Rescheduling is a strategy to manage the disruption from sourcing, manufacturing and delivering the products (Vieira, Herrmann and Lin, 2003). Rao and Janardhana (2014) conducted a comprehensive literature review on the effect of rescheduling on operating performance of the supply chain under
disruption. Mahamani, Rao and Pandurangadu (2006) developed a framework map the supply chain activities for the volume driven manufacturing system. Rescheduling activities in the manufacturing supply chain is reported in the literature review and presented in the section 2. The current paper deals the framework development for disruption management system in house hold goods manufacturing supply chain with reverse flow of after-sales service system. Structure of the paper includes the literature review of the rescheduling activity in supply chain, description of case study, frame work development to handle the different disruption, and summary.

II. LITERATURE REVIEW

Adhitya, Srinivasan and Karimi (2007) proposed a heuristic based rescheduling to recover the disruption from the refinery supply chain. They presented a couple of case studies with single source of disruption. Result of the investigation shows that, the proposed heuristics performed better against the disruption. Ali and Nakade (2014) presented a stochastic programming approach to mitigate the disruption in multi product-multi agent supply chain. They considered several disruption scenarios in this study. They evaluated total cost to optimize the supply chain network. Bansal et al. (2005) developed an on line decision support system for managing disruption in refinery supply chain. They presented a case study under multiple source disruption scenarios. Results of this study points out that, the proposed approach is efficient in handling the multiple disruption. Amaro and Barbosa (2008) demonstrated a continuous time mathematical formulation to absorb the disruption in the pharmaceutical supply chain. The entities of the supply chain are supply, production and distribution. Transportation task, storage and the state of the material are considered as disruption. Mixed integer liner programming and branch and bound procedure are used to optimize the supply chain. Heinecke et al. (2012) studied the effect of disruption on the manufacturing supply chain performance. Transport delay is treated as a disruption and, weighted sum and cost function approaches are used to measure the disruption. Numerical investigation discloses that, the proposed approaches are captured the impact of the transport delay effectively. Wasuari and Tanratpatkul (2005) investigated effect of the rescheduling on the apparel supply chain. The challenge of the apparel supply chain is shorter life cycle, hence shorter lead time to be maintained across the supply chain. Descrete event simulation is applied for evaluating the performance. Analysis of the result indicates that, the low frequency rescheduling with high schedule stability yield better performance. Adhitya, Srinivasan and Karimi (2007) developed a model based rescheduling framework to overcome the disruption in the refinery supply chain. Function of the disruption management system includes operation graph and rectification graph. Operation graph is identifying the consequence of disruption where as the rectification graph captures the possible option to avoid the disruption. It is found from the investigation, the proposed approach overcome the short coming from the heuristics. The literature survey discloses that, the manufacturing system with entry of returned goods for after-sales service is not received the attention from the researchers. An attempt has been made to develop a frame work to handle disruption by the rescheduling strategies and the products are delivered within promised date under different disruption scenario.

III. DESCRIPTION OF SUPPLY CHAIN

House hold goods manufacturing firm is considered for this investigation. It is a make to order manufacturing system configured with after-sales service network. Goods are manufactured in two parallel machines with the functioning of eight hour per day basis. Three different varieties of the products are produced. Each product has different manufacturing cycle time. Setup time to change one product in to another product is one hour. Each product has 4 suppliers with different lead times. Average production capacity per day per machine is 650 units. Capacity of warehouse is 24,000 units. This manufacturing system faces the disruption from supplier, customer and manufacturing. Rescheduling interval for the manufacturing is 3 weeks. The manufacturing system faces at least three disruptions per rescheduling interval. Machine break down, supplier delay, entry of returned goods for after-sales service and rush order from the customer are the disruptions which are occurring frequently and affect the delivery performance. Order cancellation, order pre phone, order post phone, supply failure and job rework are rarely occurring in the manufacturing system. Supplier, manufacturer, retailer and customer are the entities of the manufacturing system. The objective of this paper is to develop framework to manage the order to delivery time under the disruption from the various entities. It is seen from the disruption category, customer and supplier are the major source of the disruption. Unfortunately these entities are beyond the wall of the industry. For solving this problem, a supply chain network is created to focus the order to delivery time under disruption. These disruptions are difficult predict in advance and not easy to control them before affecting the manufacturing system. This supply chain system requires much attention on the operation level management than strategic and tactical level. Therefore, rescheduling strategy is a right choice to achieve goal under the disruption from the sourcing, manufacturing and delivering. Adhitya, Srinivasan and Karimi (2007) developed a systematic approach to handle the post disruption with appropriate rescheduling strategy. The activity of the approach includes monitoring key performance indicator, root cause for the disruption, identifying rectification strategies, selection of the optimal strategies and rescheduling. A similar attempt has been made to develop a frame work to handle the house hold good manufacturing system with after sales service. The structure of the proposed supply chain is shown in Figure 1. Ozlen and Azizoglu (2009) attempted to reschedule the already assigned job in the parallel machine system. Branch and bound algorithm is used to evaluate the performance of the scheduling. They incorporated powerful reduction and bounding mechanisms to improve the efficiency. Azizoglu and Alagöz (2005) aimed to solve the rescheduling issue in identical parallel machine system under machine in availability. Total flow time and schedule stability are evaluated by using polynomial time algorithm. They observed the considerable improvement in the schedule performance under disruption. Arnaout and Rabadi attempted
to reschedule the previously scheduled jobs in unrelated parallel machine environment. Different rate of machine break down and delay are considered as a disruption. Schedule deviation and makespan are evacuated as performance measures. Computational analysis discloses that, the proposed rescheduling more efficient than other rescheduling methods reported in the literatures.

Disruption from the Entities in the Supply Chain

Disruption from the Manufacturing System

Machine break down is an important disruption occurring in the manufacturing system. This will be monitored with a key performance indicator is called average production capacity per hour. Root cause analysis for this disruption suggests to strengthen the preventive maintenance system. First step of the frame work propose the rescheduling is necessary or not. Appropriate rescheduling strategy is identified with the minimal order to delivery time. There is a sub system, which recommends the over time schedule, if the goods are not produced before the due date. The disruption due to the machine break down is illustrated in the Figure 2.

Disruption due to the Supplier Delay

Delay in arrival of the raw material is considered as a disruption from the supplier entity, which cause significant uncertainty to deliver the product in time. Key performance indicator for this disruption is order to delivery time of the raw materials. If it goes beyond limit of the time, the system gets alert and estimate the delay time by collaborating with the supplier. Rectification system checks the inventory status with reference to the delay time. If it is a longer time, the initial schedule will continued until zero stock. Over the period of time the corresponding product is removed and proposed a reschedule with the other two products. After inspection and packaging the products are sent to the customer through the retailers. Disruption management system to deal the supply delay is exposed in the Figure 3

Disruption due to the Returned Goods through After-sales Service Network

The proposed supply chain is configured with an after-sales service network for processing the returned goods from the customer. Key performance indicator of this disruption is monitored by the retailer, who is closely related to the customer. Root cause for this disruption is the spare parts complaint and alignment problem. Frame work suggests the retailer, to collect returned goods which are in the warranty period. The returned goods need to be processed within the shorter duration. A well directed system gives priority to these goods for manufacturing, strict quality check and meets the delivery schedule. Disruption handling for the entry of the returned goods is presented in the Figure 4.

Disruption due to the Rush Orders

Rush order is an unpredictable disruption with shorter delivery time. Urgent order maximizes the revenue, if it is handled successfully. It will cause delay to all other orders, if it is not managed carefully. Order entry rate is a key performance indicator, which is monitored by the retailer. The rescheduling activity is proposed to meet the due date. The frame work recommends the strict quality check to avoid the rework. Activities to absorb the disruption due to rush order are shown in Figure 5.

Disruption due to the Supply Failure of the Raw Materials

This kind of disruption is occurs, if the raw material of a particular product is stock out or unexpected transport strike. An element of the frame work monitors the key performance indicator (order to delivery time) of the each raw material. If raw material is not received within the time, the flow up link interacts with the supplier and estimate approximate delay time. Stock available with inventory is used for regular production. If the inventory is reached the zero stock, the corresponding product is removed from the schedule. Rescheduling is made based on the delay time. Series of activities to be carried out to conquer the disruption is disclosed in the Figure 6.

Disruption due to the Order Postponement

It is a disruption, motivated by the customer entity. The key performance indicator for this disruption is the extension of order to delivery time. The major consequence of this disruption is the instability in production schedule. This disruption can be rectified by postponing the particular order. Right shift rescheduling is a right choice to overcome the disruption and meet the due date. The frame work to overcome the disruption due to order postponement is shown in Figure 7.

Disruption due to the Order Preponement

Order propone is an uncertainty from the customer entity. Reduction in order to delivery time is the indication of the disruption. Arrival of rush order from the customer's customer, cause order preponement and leads to the schedule change. Reschedule is prepared by giving priority to the preponed orders in order to meet revised due date. Left shift rescheduling is a suitable rectification strategy to meet the delivery schedule. If the prephone jobs are unable to meet to the due date, the frame work suggest go for the over time schedule. Activities and decision making for handling the order preponement disruption is shown in Figure 8.

Disruption due to the Order Canceling

Order cancel is a kind of the uncertainty, which is occurred rarely. The information about the order cancel is received at the retailer entry. Reduction in the number of ongoing order is the indication of this uncertainty. Disaster in the manufacturing system and reduction in sales at customer entity can induce this kind of disruption. Reduction in ongoing order reduces the stability of the production schedule and the machine utilization. Rescheduling is made by removing the canceled order from the existing schedule. Left shift rescheduling is an appropriate strategy to meet delivery schedule. The activities involved to manage the order cancellation are illustrated in the frame work, which is shown in Figure 9.
Disruption due to the Entry of the Rework

Rework on the previously finished job, increases the manufacturing cycle time. Number rejection is a key performance indicator for this disruption. Deviation from the Specification of order and specification of the manufactured product, leads to rejection in inspection. This uncertainty can be overcome by strengthening the information system within the firm. Re-entry of the rejected jobs increases the order to delivery time. The proposed rescheduling strategy should meet the delivery schedule of the existing jobs and re-entrant jobs. The frame work to deal the rework disruption is presented in the Figure.10.

IV. SUMMARY

The current paper deals the development of disruption management system to handle the uncertainty from the supply, manufacturing and customer. Key performance indicator for each disruption and monitoring them from each entities are discussed. Strengthening the weak links for each disruption explained. Most frequent disruptions faced by the household goods manufacturing company are reported in the present work. This systematic frame work gives a lead to conduct case study by incorporating popular rescheduling strategies.

REFERENCES

Figure 1: Household Goods Manufacturing Supply Chain

Figure 2: Disruption Management Systems for Machine Breakdown

Figure 3: Disruption due to Supplier Delay

Figure 4: Disruption due to Returned Goods through after Sales Service Network
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Figure 9: Disruption due to Order Cancelling

Figure 10: Disruption Due to the Entry of Rework