is a function of order backlog and production time, there is some delay in production time influencing the actual production level, so the actual production has been modified using 'Production Adjustment Time' variable. In practical situations, production level cannot easily be changed in real time based on the variations in orders, so the 'production adjustment time' can be defined as a random variable. It is reasonable to assume that production adjustment time is lower in AM-based systems compared to traditional manufacturing systems due to lower tooling and higher automation level.

Figure 6. Stock and Flow diagram for retailer's ordering procedure (Modified from [34]).

Figure 7 provides a comparison of the retailer's inventory level in both traditional and AM systems.

![Retailer Inventory graph]

Figure 7. The trend of retailer's inventory over time in both AM and traditional systems (stronger pipeline effect in traditional manufacturing)

As shown, the oscillation in retailer's inventory level is less in AM based system compared to traditional system. This oscillation is due to the delay in receiving orders that the retailer has placed. This oscillation is known as pipeline effect in supply chain systems. Therefore, in the current configuration under study, the pipeline effect is stronger in traditional supply chain than AM based supply chain which may result in maintaining higher inventory levels by the manufacturer.

7. CONCLUSION

This paper has briefly traced the transformative effects of additive manufacturing on traditional supply chains. The changes that AM brings to the production systems as well as the resulting business models have been discussed. The potential for using simulation techniques at different decision making levels have been presented. Two examples of agent based simulation and system dynamics have been provided to illustrate how the performance and structure of supply chain may change as a result of AM technology.

Nevertheless, simulation models have their own limitations. Future directions for research include developing new hybrid techniques (e.g. simulation based optimization) to optimize the performance of the system considering different sources of uncertainty. Feeding real world data to the models would improve the accuracy of the results and provide baseline for evaluation. The purpose of analyses provided in this paper was to just study the trend not the exact values of performance indicators (lead time and inventory level). However, simulation models can be extended to provide more accurate information on the system performance and evaluate different policies.

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