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Improving Just-in-Time manufacturing operations by using Internet of Things based solutions

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Abstract

Just in time (JIT) manufacturing is one of the main methodologies used to enhance manufacturers' competitiveness through inventory and lead time reduction. However implementing JIT has some challenges, e.g. lack of required information sharing or communication between stakeholders, insufficient sound action or planning system etc. Internet of Things (IoT) technology has the potential to be used for acquiring data and information in real time to facilitate dynamic JIT manufacturing. This paper presents a research on using IoT based solution to enhance JIT manufacturing. The general challenges of JIT implementation are identified first, then an IoT based solution is proposed to address the JIT challenges in a selected case study. A framework to support the proposed IoT solution is developed and its implementation steps are suggested.

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Keywords: Production Scheduling; Dynamic Scheduling; Real-time resource status monitoring; Just-in-Time manufacturing; Internet of Things; IoT; RFID

1. Introduction

Just-In-Time operations are widely implemented in manufacturing business with the main objectives to control the timeliness of the production and delivery of products while maintaining or improving the quality of products [1]. JIT requires manufacturers to handle tasks within very small time spans and it has big impact on production scheduling.

The developed sensors and wireless network technologies have raised the possibility of incorporating Internet of Things (IoT) technologies into manufacturing process [2]. IoT can link physical elements in manufacturing process, such as materials, work in progress (WIP), finished products, labour, machine, tooling etc., and capture their status & performance so as to support production scheduling. However, how to use that addition information to help production scheduling remains as an on-going research question. This paper presents a work of developing an IoT based framework to enhance JIT manufacturing through addressing specific challenges in scheduling process. The work has the following objectives:

- To identify specific challenges of scheduling process in the JIT manufacturing environment
- To design an IoT based solution for tackling the identified challenges for a selected case study
- To establish a dynamic production planning framework based on the designed IoT based solution

The paper starts with reviewing related research, it is followed by identifying the challenges of scheduling process in JIT manufacturing to bring out the requirement of the framework. After that, through a selected case scenario, an IoT solution based framework to address the identified challenges has been established. At the end, implementation plan for the established framework has been suggested.

Nomenclature

IoT	Internet of Things
JIT	Just In Time
ERP	Enterprise Resource Planning

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MES	Manufacturing Execution System
MRP	Material Requirements Planning
BOM	Bill of Materials
DB	Database
RFID	Radio Frequency Identification
WIP	Work In Progress

2. Relevant research of IoT applications in production scheduling

Guo et al. developed a system with remote monitoring and production scheduling functions in a distributed manufacturing environment based on RFID and cloud technology [3]. The system meets the requirements for decision making in very short time with good extensibility and scalability. A framework is created to collect real-time production status of machines and operators in order to monitor manufacturing progress in labor-intensive plants and their suppliers. The collected information from plants is used for remote monitoring at different levels to support decision makings in manufacturing scheduling. Zhang et al. established an architecture to realise real-time scheduling and re-scheduling through RFID technology and multi-agent design [4]. The architecture is connected to MRP II to get order information, while the machine agent is designed to manage and process the real-time data collected through RFID devices to meaningful information (real-time status of the machine) used in scheduling process. The information generated by machine agent is used for assigning tasks to machines by process. Zhong et al. considered another manufacturing planning and scheduling model in an IoT-enabled (RFID) shop floor environment [5]. The model is based on a two-level solution (manufacturing planning and scheduling). The RFID devices in the model are not only used for monitoring the production progress and machine/operator status, but also for delivering the job information to operators.

Geerts et al. demonstrated a way to establish an IoT based supply chain model, which shows the advantages like strong visibility, interoperability and practicality [6]. Chen et al. proposed an RFID-based framework for real-time management of production operations. The framework allows enterprises to integrate RFID-based solutions into their information technology infrastructure and manufacturing environment [7]. Poon et al. developed an RFID-based decision support system to monitor the status of manufacturing facilities in a shop floor in real-time [8]. Ngai et al. developed an RFID-based system for monitoring and tracing aircraft repairable items in an aircraft engineering company [9]. Wang et al. used RFID and Internet technologies for monitoring and control of production systems within a manufacturing company. They developed a system with remote connection feature, which can monitor manufacturing progress in distributed environment such as supply chain [10].

Despite existing research on frameworks/architectures to collect real-time information from shop floor and generate scheduling solutions based on the collected information, the existing frameworks and architectures don't consider comprehensive manufacturing resources' variability, e.g. tooling, material logistic, one operator for n workstations scenarios etc. Studies have rarely been seen on the applications of IoT technology in dynamic scheduling during the production process while there are changes of customer orders. This paper intends to develop a comprehensive dynamic scheduling framework in JIT manufacturing environment based on IoT technology.

3. Scheduling process in JIT manufacturing

3.1. The challenges of JIT manufacturing

Jadhav J. etc. discussed the main challenges of JIT manufacturing [11]:

- Absence of a sound action or planning system
- Lack of information sharing or communication with stakeholders
- Cross-functional conflict

3.2. General production scheduling process flow

General production scheduling process flow for a manufacturing company based on ERP system for material requirement management is shown in Figure 1.

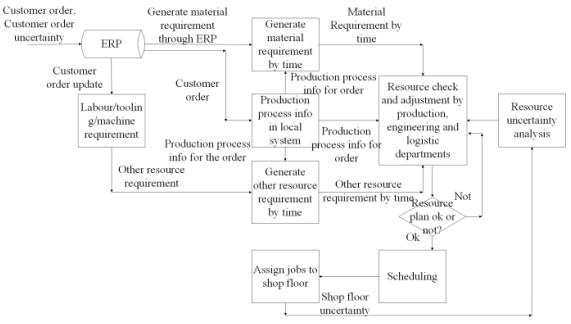

Fig. 1. General scheduling process flow

In figure 1, the responsibility of ERP system is to receive customer order and convert the order to material requirements. The "Labor/tooling/machine requirement" module is to generate resource requirements for the customer orders through local ERP/MES or manually (for manufacturing resources except materials). The "resource requirement by time" module refers to the sub-requirements for each production process with sequential order of process steps. "Production process information" (required resources for each process, standard resource holding time etc.) needs to be broken down to the general resource requirements for each individual process step and time slot. The "Resource check and adjustment" process checks the availability of those required resources in real time during production, and the production schedule is created if the resource plan could meet the production requirements. The broken-down schedules by