Machine Auto Replenishment System

Chuah Soo Aik
Motorola GEMS, Penang
Email: sooaik.chuah@motorola.com

Choong Peng Kiang
AMT
Motorola GEMS, Penang
Email: pengkiang.choong @ motorola.com

Lee Wei Ling
AMT
Motorola GEMS, Penang
Email: weiling.lee@ motorola.com

Abstract

Most front-end machines today can actually provide part usage and run rate of the machine. In order to make sure part are loaded correctly into the machine, part verification system (PVS) are put in place. Integration of these two components becomes possible with the help of RF technology. With the integration of the two components, tracking the inventory inside the machine becomes easy. With the visibility of inventory inside the machine, a closed loop system that allowed the machine to run continues without part shortage is design. Machine Auto Replenishment System (MARS) is a system that integrates these two components.

This paper discusses how this integration was done and how the extended data were use to automate the production process. The feedback gain provides the data for the sub-system to perform piece part auto request. The output of the system combine with the PVS data provides information for shrinkage scrap. The two sub-systems "Auto Request" and "Auto Scrap" is also discuss here. The paper will conclude with some future extension of the system.

Introduction & Overview

Machine Auto Replenishment System (MARS) is a system that was design to track the inventory level in front end machine. Tracking the inventory level in machine allowed us to better manage machine piece part inventory. With the help of MARS, this closed loop system allowed us to run the front-end machine without interruption of piece-part shortage and yet maintain a reasonable inventory level.

Part Verification System (PVS) and Data Acquisition (DAQ) are the two major core components in MARS. With the help of RF scanner, and network DAQ device, data from PVS and DAQ are feed to a remote common database (Oracle Database). By feeding the data into the common database, the integration of the two become simple and possible.

The feedback gain, which is the "Auto Request System", allowed machine continue running without part shortage.

The sub-system, "Auto Scrap" is trigger whenever a replenishment signal detected by the PVS system. The systems will then take the different between the previous load quantity and system calculates output as scrap value.

Objectives & Goal

The initial idea behind MARS is to perform auto request. A lot of time the high inventory in production line is cause by unnecessary inventory buffer. It is believed that with the Just in Time (JIT) concept it will help in reduce the inventory level.

The goal behind MARS is to create a system that will minimize inventory level and yet maximize machine utilization by avoiding down time cause by piece part shortage.

The MARS Closed Loop System Design

The open loop system of a DAQ is as shown in figure-1. The output of the open system DAQ is $Q_{usage}(t_n)$. $Q_{usage}(t_n)$ is the usage of material after time n.

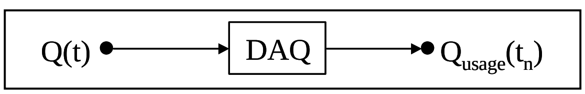


Figure 1

Integrate the information from PVS system on the loaded quantity at load time $Q_{load}(t_n)$ and $Q_{usage}(t_n)$ is the balance material quantity in machine $Q_{bal}(t_n)$. This is as shown in figure-2.

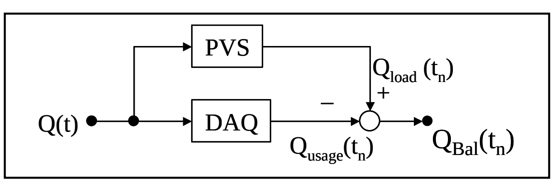


Figure 2

The output from PVS and DAQ is show in figure-3.

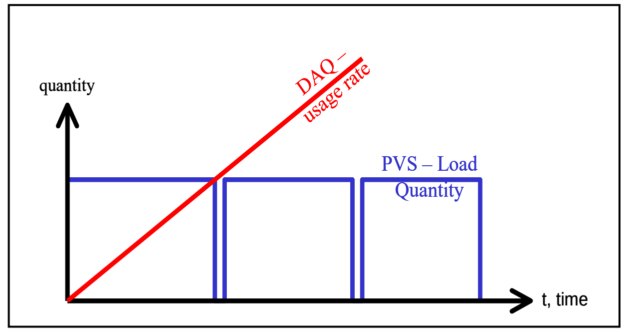


Figure 3

Figure-4 shows the integration of the two signals.

$$Q_{bal}(tn) = Q_{load}(t_n) - Q_{usage}(t_n)$$

Where

$Q_{bal}(t_n)$ - Machine balance Quantity
$Q_{load}(t_n)$ - PVS Load Quantity
$Q_{usage}(t_n)$ - DAQ machine usage

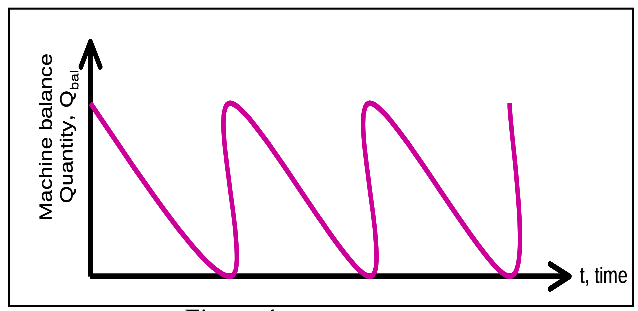


Figure 4

A feedback gain can be obtained to maintain an optimum inventory level in the machine for continues operation. Auto Request System is design to serve this purpose. This is as show in Figure-5.

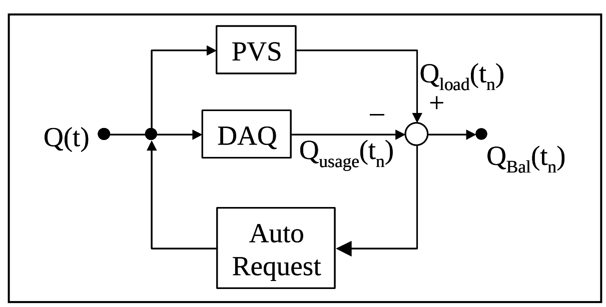


Figure 5

The system was setup with the following boundary condition:

$$Q_{min} = Rate_{mach} * Per_{z\text{-}list} * 2X$$

$$Q_{max} = Rate_{mach} * Per_{z\text{-}list} * X$$

Where

- Q_{min} : Min inventory water mark
- Q_{max} : Max inventory water mark
- $Rate_{mach}$: Machine run rate
- $Per_{z\text{-}list}$: Number of parts place within a board
- X : Parts delivery time

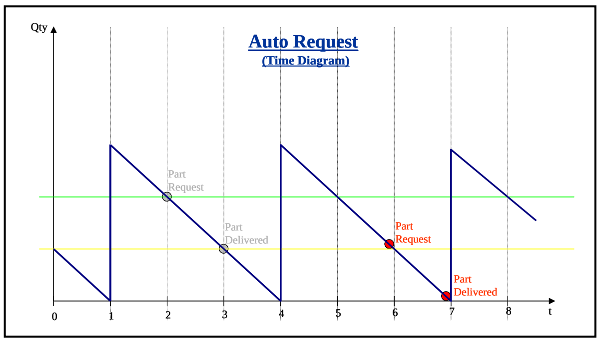


Figure-6

At part replenishment instance, PVS will trigger and sample the inventory level right before part is loaded. This is actually the different between part usage since the last load and the actual quantity load. This value is the shrinkage value, $Q_{Scrap}(t_n)$. This is as shown in Figure-7.

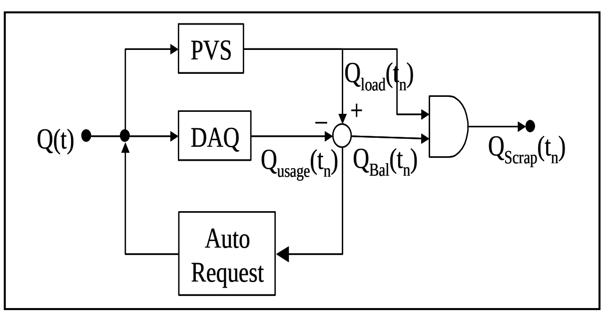


Figure 7

System Integration

Basically the system integration is done using closed loop 3-tier architecture. With the help of mobile RF scanner and Network RS232 communication, data are processes in different remove application server. However, the common databases have provided the link in integrating the two systems. This is as shown in figure-8. With a good table design, the data can be use to enhance and improve production performance. Due to the multi-tier design, additional application can be added on to perform high computation application.

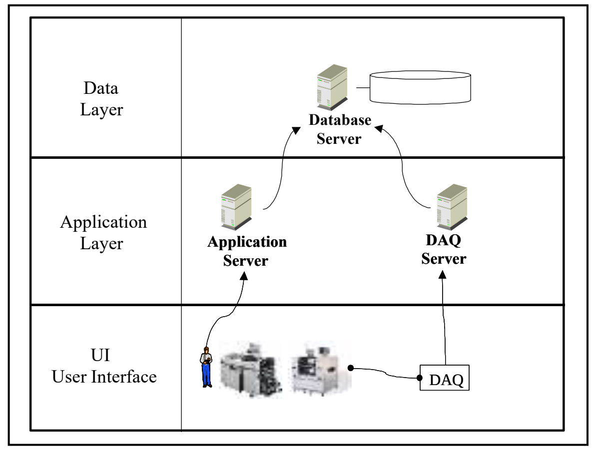
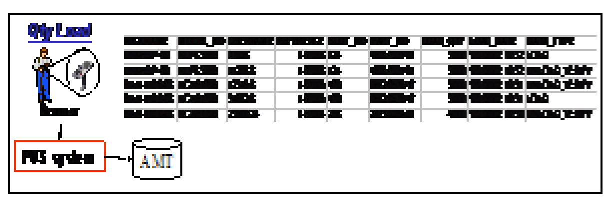


Figure 8

Technical Elements and Module

PVS (Part Verification System)

Part Verification Process is part of a SMT manufacturing process. It is a strategy to ensure correct parts loaded into correct slots of the machine and to prevent the issue of wrong parts. The On Line PVS (Part Verification System) is system where the application program is running at the server. The client is a wireless data terminal device with barcode scanner. The communication between the client and server is linked by the wireless LAN. When doing part loading and replenishment, the operator has to scan the bar-coded machine ID, the model number, slot number and part number.

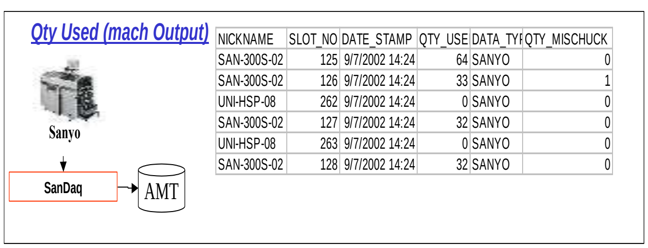


All these data are captured and transmitted to the server for processing. The output messages are returned to the data terminal device for the operator to view. These data is verified against the Z-list database. The Z-list contains the part information of a particular build. If the correct part has been scanned for the particular slot then system will give a short beep and show “Part Verify OK”. If wrong part has been scanned, the system will give long beep and show “Wrong Part”. In addition to the above -mentioned data been scanned, the part quantity has also been scanned. This is to input the system with quantity of the parts that been loaded into the machine.

Machine DAQ (Data Acquisition)

The Sanyo machine does provide information on parts usage and parts reject. But is available at off-line only. Using its own application to upload to the PC. The purpose the Machine DAQ is to acquire the data on-line and automatically at a define time interval. How it has been achieved, will be briefly mentioned as follows.

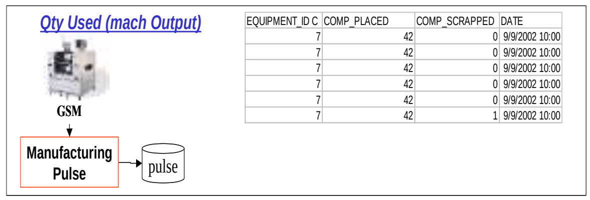
The data of the Sanyo machine has been acquired through the RS232 communication port. Using the machine protocols to call for the required data, example: slot numbers, part usage and part reject (mischuck). A PC has been used as a host computer and connected to each of the Sanyo machines by addressable network devices. The purposed of the addressable network devices are to enable one host computer connected to multiple Sanyo machines. An application has been developed to run at the host computer to control or manage the data acquisition processes. The host computer receives the data in blocks from the machine after the appropriate protocols have been delivered. The computer has also been used to identify and filter the required data. Then formats these data and store them onto the Oracle server.



NICKNAME	SLOT_NO	DATE_STAMP	QTY_USE	DATA_TYI	QTY_MISCHUCK
SAN-300S-02	125	9/7/2002 14:24	64	SANYO	0
SAN-300S-02	126	9/7/2002 14:24	33	SANYO	1
UNI-HSP-08	262	9/7/2002 14:24	0	SANYO	0
SAN-300S-02	127	9/7/2002 14:24	32	SANYO	0
UNI-HSP-08	263	9/7/2002 14:24	0	SANYO	0
SAN-300S-02	128	9/7/2002 14:24	32	SANYO	0

Unlike the Sanyo machine, Universal GSM machine does not provide the serial communication protocols for data acquisition. The way to get online data is by the SECS GEM. Motorola Global Software Group has developed a system called the Manufacturing PULSE. This is a SPC and ET application for SMT equipment. It consists of the main components (SPC and ET) and a set of database that has been acquired through the SECS GEM. The SECS GEM is networked to the factory local area network (LAN). The application and database are operating at the server. These data also consist of slots number, parts usage and parts reject. To save the effort of building a DAQ for this Universal GSM, an interface has been developed to import these data for other application.

Example: Machine Auto Replenishment System.



EQUIPMENT_ID C	COMP_PLACED	COMP_SCRAPPED	DATE
7	42	0	9/9/2002 10:00
7	42	0	9/9/2002 10:00
7	42	0	9/9/2002 10:00
7	42	0	9/9/2002 10:00
7	42	0	9/9/2002 10:00
7	42	1	9/9/2002 10:00

Impacts

Since the implementation of MARS in IDEN line. Inventory had reduced about 50%. This is as shown in the following table.

	WIP Value (USD)
April	**6373**
May	**7269**
June	**5051**
July	**3173**
August	**3005**

No material machine waiting time had reduced about 82% for FE GSM and. This is equivalent to a capacity/opportunity cost of USD525K.
Comparative method is used to analyze the capability of piece part auto request feature. Piece part FE equipment down time is used as the factor. Using the Down Time due to awaiting part as an output response to monitor the significance, one model line is used to study the effectiveness of this project. Normality test is conducted for both data set (21 and 23 for before and after implementation. LSN from Fit Y by X is 34.4) The P-Value found to be 0.0008 indicating there is a significant improvement seen in down time after the Piece Part Project implementation

Reduction from 0.64hour to 0.11hour in Waiting Time for part.

Production DLs parts request waiting time are reduced from average 30minutes to 5mins per request.

Conclusion

MARS was successfully implemented in iDen line in Penang. The result was proven working. The system has shown promising capability in reducing inventory level and yet maintains high machine utilization. In short, it is a workable system concept. Future plans are to implement the MARS at total factories to reduce and control inventory cost. Embed the MARS into Manufacturing PULSE system. Making the system integrate into part of the supply chain.

6.0 Reference

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