CLASSIFICATION		DOCUMENT IDENTIFICATION NO. BNWL-SA-5095	
BATTELLE NORTHWEST BATTELLE MEMORIAL INSTITUTE PACIFIC NORTHWEST LABORATORIES POST OFFICE BOX 999 / RICHLAND, WASHINGTON 99352		COPY AND SERIES NO.	
		DATE MARCH 1975	
TITLE AND AUTHOR A COMPUTER CONTROLLED CARTRIDGE CASE QUALITY ASSURANCE INSPECTION SYSTEM. M. R. COMPTON AND M. D. ERICKSON		CONTRACT ☐ - 1830 ☐ - 1831	PROJECT NO.
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A COMPUTER CONTROLLED CARTRIDGE CASE
QUALITY ASSURANCE INSPECTION SYSTEM

by

M. R. Compton
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INTRODUCTION

An automatic high-speed quality assurance inspection system has been developed by Battelle-Northwest for the U. S. Army's Frankford Arsenal. This fully integrated system automatically inspects small caliber (5.56 mm) cartridge cases on the production line at rates of 1200 cases per minute and rejects cases which do not meet acceptable inspection standards.

At the heart of this inspection system, a special data acquisition and control computer system performs the complete quality assurance chores in real-time response to all process measurements and control conditions of the continuous production line of cartridges. A unique event-driven, real-time executive and an efficient inventory method have been developed to permit real-time data acquisition and control of this inspection system.

Twenty-eight measurement signals are input to the data acquisition subsystem for each cartridge case. These measurement signals come from special electro-optical and eddy current instrumentation which inspect the cartridge cases for diameter, length, wall thickness, metal hardness, surface flaws, and primer-vent presence. The case handling and inspection instrumentation are illustrated in Fig. 1.

REAL-TIME EXECUTIVE

An event-driven, real-time executive was developed for the data acquisition and control of this inspection system for two reasons: (1) there was not a working minicomputer real-time executive available from a computer vendor at the start of this project in 1972; and (2) The designs of the vendors' real-time executives did not permit efficient response to the high speed and asynchronous events which initiate data acquisition and control in this inspection system.

Fig 1,

CARTRIDGE CASE MEASUREMENT EJECT SYSTEM

The Battelle developed executive provides a standard set of multi-tasking capabilities such as:

- (1) start another task for parallel operation
- (2) start another task to perform subtask function
- (3) terminate a task (self and/or another)
- (4) reserve and release a task
- (5) cause a task to wait upon single or multiple conditions in either AND or OR configuration
- (6) return the status of any condition to the task.

In addition, this executive provides the capability for tasks to be initiated directly from interrupt service routines.

For execution efficiency (i.e. low system overhead), this executive uses a fixed priority and fixed size run-time task queue. This was done because the number of tasks is fixed and their priority is predetermined by data acquisition and control objectives.

The interrupt handling subsystem is the fastest and most efficient that can be implemented on the NOVA line of computers. It is also as fast as any available for a third generation minicomputer.

INVENTORY SUBSYSTEM

An inventory subsystem records the status of a cartridge case from the time it enters the inspection system until it leaves. The implemented inventory system is easily accessed and is a software analog of the mechanical movement of the cases in the inspection system as shown in Fig. 2.

This subsystem is a first in - first out endless queue. The units of the queue correspond to each of the 90 case positions in the inspection system. The elements of each unit record the status of the case in that corresponding position. Access is implemented by a moving pointer which indicates the entry position.

Fig 2.

RCMES MEZS 3 CASE STATUS HANDLING ALGORITHM

Each status change or status query position is a fixed number of case positions from the entry point of the inspection system. Thus by using an inspection station bias from the entry station, the status of the case in that station can quickly be accessed.

A signal from the inspection system indicates each time that the cases have been moved ahead one position. This signal is used to operate the inventory subsystem by moving the queue entry pointer.

An electro-optical measurement determines the presence of a case at the entry point to the inspection system. This case present status is essential and is the first information input to the inventory subsystem.

There are 24 stations on this particular manufacturing line which produce cartridge cases. The station origin of each case is communicated to the inventory subsystem by a synchronizing optical encoder on the production line chain. This identification provides inspection status feedback to the manufacturing line concerning each station.

DATA ACQUISITION

There are five measurement stations in the inspection system which determine the diameter, length, wall thickness, surface flaws, and primer vent presence of each cartridge case. The data from each measurement are acquired upon receipt of an interrupt signal from each measurement device indicating that its inspection data are ready as shown in Fig. 3. These measurement instruments use special electro-optical and eddy-current techniques, also developed at Battelle-Northwest. All accept/reject decisions on the case are made in the interrupt service routines as each measurement value is compared with its pre-established acceptable limits. The accept/reject decisions are made immediately on raw data values to maintain real-time control of the inspection system.

Case Diameter and Length

Fourteen case diameter and two case length measurements are made on each case by an electro-optical technique using two

Fig 3.

COMES
ME/S-3

DATA ACQUISITION AND CONTROL SYSTEM

electrically sequenced instruments. The data are digital counts from a photo-diode array indicating incremental measurements from a fixed gauge diameter or length. The 16 digital data values are input to the computer via direct memory access because of the speed and timing inter-relationship of each data value. A data channel transfer complete interrupt indicates the measurement is completed. This data acquisition process is illustrated in Fig. 4.

Deviation from the defined nominal diameter and length are calculated. The accept/reject decisions are based on the magnitude of these deviations. The identity of the unacceptable diameter and length deviations are recorded along with the production station identity. Then all the deviation measurement values and their measurement identifications are input to a queue to await engineering units conversion for data trending.

Case Wall Thickness

A maximum and a minimum case wall thickness are measured at four regions of the case by an eddy current technique. These measurement values are input to the computer as analog signals. A case wall thickness interrupt signal indicates the measurement is completed. The eight analog values are then converted to digital and input to the computer. This data acquisition process is illustrated in Fig. 5. Each data value is compared with its respective maximum and minimum accept limit value to determine each case's accept/reject status. The difference between the maximum and minimum wall thickness at each region is compared with a maximum thickness variation limit value to determine an additional accept/reject condition for each case. Unacceptable thickness measurements are recorded along with the production station identity. Then each case thickness measurement value and its identification are input to a queue to await engineering unit conversion for data trending.

Case Surface Flaw

The surface flaw inspection is done by an electro-optical technique which divides the surface of each case into three zones

FIGURE 2. Schematic of a Typical Transfer and Inspection Wheel

4. Block Diagram of Case Profile Electronics

FIGURE 5. Eddy-Current Thickness Unit

and determines the surface flaw status for each zone. The status of each zone indicates whether or not a surface flaw is present and is input to the computer as a binary value. Thus, for surface flaws, the accept/reject decision is made in the inspection instrument hardware. The identity of the unacceptable flaw zone and the production station identity are recorded.

Vent Hole Monitor

The vent hole monitor uses an electro-optical technique to determine whether or not the primer vent hole exists in the cartridge case. The result of this inspection is input to the computer as a binary value. The production station is identified and recorded for a no-vent hole case.

UNACCEPTABLE CASE REJECT CONTROL

The cartridge cases which do not pass the quality assurance inspection are removed from the production line. There are three reject stations within this inspection system, one at each case transfer wheel. The reject decision is made during data acquisition. Then the "case to be rejected" status is set in the inventory for that case.

Each time the inspection unit moves one case position ahead, the inventory status of the case at each reject station is queried. If the case is to be rejected, the reject mechanism is released by a digital output command; if the case is acceptable, the case is permitted to pass.

CONTROL STATUS, DATA TRENDING, AND DISPLAY

The reject status of each measurement is accumulated and displayed in summary format for inspection department records and for feedback to the cartridge case production operators. The data file where this information is recorded consists of a data field for each measurement station and for each measurement acquired. Each data field contains 24 counters; one for each case production station. This information is displayed in an overall format for all measurement stations and in detailed formats for each measurement station as shown in Figures 6 and 7.

000:4051

REJECT: 12940

OLDFATHER: 12799

DATE: 6

100-115-1761-24 - 100-115-1761-24

FIGURE 6. PROCESS REJECT SUMMARY

<THICKNESS REJECT>

028:1239

LINE	ZONE 1	ZONE 2	ZONE 3	ZONE 4	TOTAL
1					9
2					6
3					9
4					6
5					9
6					6
7					9
8					6
9					9
10					6
11					9
12					6
13					9
14					6
15					9
16					6
17					9
18					6
19					9
20					6
21					9
22					6
23					9
24					6

OUT-OF-RANGE:

FIGURE 7: THICKNESS REJECT SUMMARY

Each qualitative data measurement input to the data trend queue is converted to engineering units and is trended using a running average with the other data values of the same identity for a fixed time period. This trend information is displayed for inspection department records and for feedback to the cartridge case production operators.

The data file for this information consists of a data field for each measurement value being trended. Each data field contains a trend value and number of values in that trend for each of the 24 case production stations. There is a data file for each of eight trend time periods. This trend information is displayed in detailed format for each measurement according to case production station and trend time period as shown in Fig. 8.

INTERNAL CHECKING AND ALARM

The proper operation of this inspection system is continuously checked at 10 positions by the computer subsystem. These checks ascertain that each cartridge was inspected at each inspection station, that unacceptable cases have been removed, and that acceptable cartridge cases have not been removed. Failure at any of these checks are accumulated for automatic alarm condition processing.

<PROFILE TREND

CASE LENGTH

028:1308

LINE	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0

FIG 8 PROFILE TOTAL LENGTH DEVIATION TREND