

Closed Loop
One Piece Flow System

Field of the Invention

5 The present invention relates generally to an improved one piece flow system used in a processing line. More particularly, the improved one piece flow system is used in a dye penetrant inspection line to increase throughput, output quality and to reduce space
10 utilization within a factory floor.

Background of the Invention

 There are various technological developments in the fields of structural crack detection and inspection
15 including use of infrared thermal imaging method, use of hybrid ultrasonic/thermal imaging method or radiography. However, a more common type of crack detection method for use in non-ferromagnetic materials is based on dye penetrant method. The dye penetrant method involves the
20 application of dye to a subject component, typically by dipping or spraying. After sufficient penetration time, the excess dye is removed, dried and a developer is applied. The developer draws the dye from a crack to form a visible indication that becomes visible to an
25 inspector.

In order to improve throughput and to increase the efficient use of production floor space, a typical dye penetrant inspection line is set-up based on batch processing. During inspection stage, pallets comprising a plurality of components are checked batch by batch by an operator for cracks. As a multitude of components arranged in a matrix within a pallet would require manual inspection one at a time during each batch inspection, there is a tendency for the operator to miss out on some defective components. The search for fine cracks within a matrix arrangement of confusingly similar components would increase the miss ratio and is highly undesirable. This is particularly where components with surface breaking defects or cracks present major safety and reliability issues especially those used in the aerospace industry.

The dye penetrant inspection line based on batch processing is furthermore susceptible to delays. Essentially, no pallet may move on to a next station until all components within a pallet are processed. A larger pallet would result in longer processing time at any particular station, thereby increasing the wait time between stations. This reduces throughput as a result of delays along the processing line. Storage space would be additionally required to provide temporary storing whilst

waiting long processing cycle at any processing station and would increase the risk of deterioration if stored over long time. A batch processing system therefore has inherently lower output quality, lower throughput and
5 would require greater space utilization.

As evidenced from the above discussion, it is desirable to provide an alternative to ameliorate one or more of the abovementioned problems.

10 Summary of Invention

In accordance to one aspect of the present invention, there is provided a method for increasing throughput of a one piece flow system used in a
15 processing line comprising the steps of dividing a task time T needed for a singular task A in the processing line with a required throughput T_p per piece to obtain a number of sub-tasks n , that is, n is T / T_p ; and allocating said n sub-tasks to n new stations, each
20 station performs the same task A but at reduced time T_p .

In accordance to another aspect of the present invention, the method further comprises the step of arranging the processing line in a closed loop vertical formation relative to a production floor.

Preferably, the closed loop vertical formation is in rectangular shape.

Preferably, the closed loop vertical formation is in circular shape.

5 In accordance to yet another embodiment of the present invention, the method further comprises the step of arranging the processing line in a double deck formation.

In another aspect of the present invention, there
10 is provided a processing line for use in assembly or inspection line comprising a plurality of tasks with different task time arranged along the processing line in a closed loop vertical formation, wherein each task with a corresponding task time T in the processing line with a
15 throughput of T_p per piece is divided into a number of sub-tasks n , wherein n is T / T_p , such that each sub-task is executed at T_p or less.

Preferably, the closed loop vertical formation is in rectangular shape.

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Brief Description of the Drawings

Fig. 1 shows a perspective view of a preferred embodiment of the present invention.

Preferred Embodiments of the Invention

In accordance to the one piece flow system of the present invention, a task with task time T in a processing line with a required or pre-determined throughput T_p per piece is divided into a number of sub-tasks n , wherein n is T / T_p and wherein $T_p < T$. In the event n is non-integer, n is rounded-up.

The arrangement of the present invention advantageously reduces the task time T needed for a task by allocating the n sub-tasks to n new stations in the processing line, each station performs the same task but at reduced time T_p or less in the event n is rounded-up.

For illustration purposes, it is assumed that the throughput T_p per piece required for a processing line using a one piece flow system is 10 minutes per piece and the task time T required for station α is 30 minutes. In accordance to the one piece flow of the present invention, station α is replaced by 3 stations, each station performs the same task at reduced time T_p of 10 minutes. The reduced task time from T to T_p per station advantageously removes bottleneck at any one processing station to achieve the desired throughput of the processing line.

The number of stations in a processing line will inevitably increase as a result of allocation of

additional stations in order to bring down the task time T at any station in the processing line to T_p .

In accordance to another aspect of the present invention, the processing line is arranged in a formation
5 which would be space efficient when located on a production floor.

Preferably, the processing line is arranged in a closed loop formation relative to a production floor. In a preferred embodiment of the invention, the close loop
10 formation of the processing line is formed as a vertical closed loop formation. More preferably, the vertical closed loop formation takes the form of a double deck as shown in Fig. 1 or multiple decks in the shape of rectangular or square. In particular, Fig. 1 shows a
15 processing line with a series of processing stations 103 containing parts 108 arranged in the double deck formation.

In an alternative embodiment of the invention, the said closed loop formation also includes a planar closed
20 loop arrangement which may take the shape of for example, rectangular, square or circular.

The closed loop arrangement of the present invention is as opposed to a conventional linear and planar arrangement across a production floor which would
25 advantageously increases the efficiency of space

utilization within the factory space. More particularly, the vertical close loop formation of the processing line advantageously utilizes the vertical space of the production floor so that the increased length of the
5 processing line would not increase the utilization of floor space.

The one piece flow system of the present invention may be used in any processing or assembly line. In particular, the one piece flow system of the present
10 invention may be used for a dye penetrant processing line for the inspection of cracks in components. A typical dye penetrant processing line comprises a penetrant task, a dwelling task, a washing task, a drying task and a dye development task. A typical dye penetrant processing line
15 may require, for example, a throughput of 5 minutes per component.

The dye penetrant task includes a station for coating the components under test with dye. The coating may be achieved by dipping or spraying the components
20 under test with dye serially. Typically the process may take about 5 minutes per component. For a processing line with a throughput of 5 minutes per component, the penetrant task time of 5 minutes would satisfy the throughput requirement.

Alternatively, if the throughput required of a processing line is 2 minutes per component, the penetrant task time of 5 minutes is divided into 3 sub-tasks (that is, the number of sub-tasks n are being rounded-up such that each sub-task is 2 minutes or less), each sub-task is assigned a task time of 2 minutes to satisfy the throughput requirement. Each sub-task may be assigned to one processing station in the processing line.

The dye is subsequently infused into the component through a dwelling process. The dwelling process may typically take about 10 minutes per component. In accordance to the present invention, the dwelling process with a task time of 10 minutes is divided into 2 sub-tasks for a processing line requiring a throughput of 5 minutes per component. Each sub-task may be assigned to one processing station in the processing line. The breaking-up of a single task into a series of smaller tasks advantageously allows each smaller task to meet the desired throughput of the processing line and effectively removing bottleneck.

Upon completion of the dwelling process, the components under test are washed to remove excess dye and dirt. The washing process may take about 15 minutes per component. In accordance to the present invention, the washing process with a task time of 15 minutes is divided

into 3 sub-tasks for a processing line requiring a throughput of 5 minutes per component. Each sub-task may be assigned to one processing station in the processing line to achieve the required throughput of 5 minutes per
5 component.

In another alternative embodiment of the invention, if the throughput required of a processing line is 2 minutes per component, the washing process with a task time of 15 minutes is divided into 8 sub-tasks (that is,
10 the number of sub-tasks n are being rounded-up such that each sub-task is 2 minutes or less), each sub-task is assigned a task time of 2 minutes to satisfy the throughput requirement.

Upon completion of the washing process, the
15 components under test are dried. The drying process may take about 15 minutes per component. In accordance to the present invention, the washing process with a task time of 15 minutes is divided into 3 sub-tasks for a processing line requiring a throughput of 5 minutes per
20 component. Each sub-task is assigned to one processing station in the processing line to achieve a required throughput of 5 minutes per component.

In another alternative embodiment of the invention, if the throughput required of a processing line is 2
25 minutes per component, the drying process with a task

time of 15 minutes is divided into 8 sub-tasks (that is, the number of sub-tasks n are being rounded-up), each sub-task is assigned a task time of 2 minutes to satisfy the throughput requirement.

5 The subsequent process carried out in the dye penetrant processing line comprises the dye development process. A developer is used to draw the dye out of the crack onto the surface to form a visible indication that is obvious to the naked eye with the aid of UV light and
10 which may be easily detected by a human inspector.

 In the development process, the developer may be applied to the components under test by for example, spraying. The development time for the chemical reaction between the developer and the dye may take about 15
15 minutes. In accordance to the present invention, the dye development process with a task time of 15 minutes is divided into 3 sub-tasks for a processing line requiring a throughput of 5 minutes per component. Each sub-task is assigned to one processing station in the processing line
20 to achieve a required throughput of 5 minutes per component.

 While the invention has been particularly shown and described with reference to various embodiments, it will be recognized by those skilled in the art that
25 modifications and changes may be made to the present

invention without departing from the spirit and scope
thereof. The scope of the invention should therefore be
determined not with reference to the above description
but with reference to the appended claims along with
5 their full scope of equivalents.

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What is claimed is:

1. A method for increasing throughput of a one piece
5 flow system used in a processing line comprising the step
of:

dividing a task with a corresponding task time T in
the processing line with a throughput T_p per piece into a
number of sub-tasks n , wherein n is T / T_p , such that each
10 sub-task is executed at reduced time T_p or less.

2. The method as claimed in claim 1 further comprises
the step of arranging the processing line in a closed
loop formation.

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3. The method as claimed in claim 2, wherein said
closed loop formation includes a vertical closed loop
formation.

- 20 4. The method as claimed in claim 3, wherein said
vertical closed loop formation includes an arrangement of
double deck or multiple deck formation.

5. The method as claimed in claim 2, wherein said closed loop formation includes a planar closed loop formation.

5 6. A one piece flow based dye penetrant processing line for use in marking surface crack of components under test using the method as claimed in any of claims 1 to 5.

7. The one piece flow based dye penetrant processing
10 line as claimed in claim 6, wherein said processing line further comprises:

a dye penetrant station for coating a layer of dye onto the surface of a component under test;

a dwelling station to allow infusion of said dye
15 into cracks or surface breaking defects;

a washing station for removing excess dye from surface of component under test;

a drying station for removing water and moisture from surface of component under test; and

20 a development station for applying a developer onto surface of the component under test and to allow reaction between said developer and dye penetrant.

8. A processing line for use in assembly or inspection line comprising:

a plurality of tasks with different task time arranged along the processing line in a closed loop formation, wherein each task with a corresponding task time T in the processing line with a throughput of T_p per piece is divided into a number of sub-tasks n , wherein n is T / T_p , such that each sub-task is executed at T_p or less.

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9. The processing line as claimed in claim 8, wherein said closed loop formation includes a vertical closed loop formation.

15 10. The processing line as claimed in claim 9, wherein said closed loop formation includes an arrangement of double deck or multiple deck formation.

11. The processing line as claimed in claim 8, wherein
20 said closed loop formation includes a planar closed loop formation.

12. The processing line as claimed in any of claims 8 to
11, wherein said processing line is a dye penetrant
inspection line for marking surface crack of components
5 under test.

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