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Automated line integration from through hole technology to integrated circuit testing

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Abstract: Through Hole Technology (THT) is a method in electronic printed circuit board (PCB) mounting technology by which components are mounted on the PCB board and it is later sent for Integrated circuit testing (ICT). The in-process material movement is the real culprit for decreased production rates. Here we discuss the various identified reasons for the same and calculated effective possible maximum production rates and improvise the process with the help of an automated material transfer system and validate the same using production simulation software called Tecnomatix. Each of the system i.e. the manual and the automated system was studied, and appropriate corrective decision was taken to improvise the overall productivity.

1. Introduction

In any manufacturing unit, production process and its routing is very much essential to be updated in accordance with the upgrowing demands of the product. Here, two production lines are taken into consideration i.e. THT and ICT. THT line deals with huge amounts of PCBs and the same must be achieved in testing of the PCBs. This testing is being handled by ICT. Currently the manual material handling is leading to huge accumulation of PCBs and that further affects as an implication for slower production rate in THT line. The proposed automated material handling system deals with autonomous entry and exit of PCB bins from station to station thereby reducing lead time and a direct improvement in productivity by effective production process. Highlighted the new built-in platforms and remote controls for factory automation [1], Application of robotic process automation integrating platforms for factory process optimisation [2], Incorporating active energy drives with variable frequency drives is the key to new levels of control and precise automation [3], Advantages of using parallelism with crossover methods for production [4], Coining two major production concepts of capacity planning and time management along with modern computing platforms [5], Critical path analysis for batch production is the key way to improvise productivity [6], Usage of flexible manufacturing systems along with advanced special purpose automated machines for better production [7], Experimental analysis and study about modern controls like model based analysis, intelligent analysis, etc. for factory control and automation [8], Strategic planning and control for effective control in factory operations [9], Self-adaptive factory systems being discussed for advance agility of factory production system [10].



2. Experimental setup

2.1 Layout of THT to ICT line

There are two lines for THT and one line for ICT consisting 4 machines. THT line 1 has three working stations and THT line 2 has four working stations. Material movement takes place from THT line 1 and 2 to the four machines of ICT as per the testing required by the product. Out of these four machines, two are multimode machines and two are fly machines.

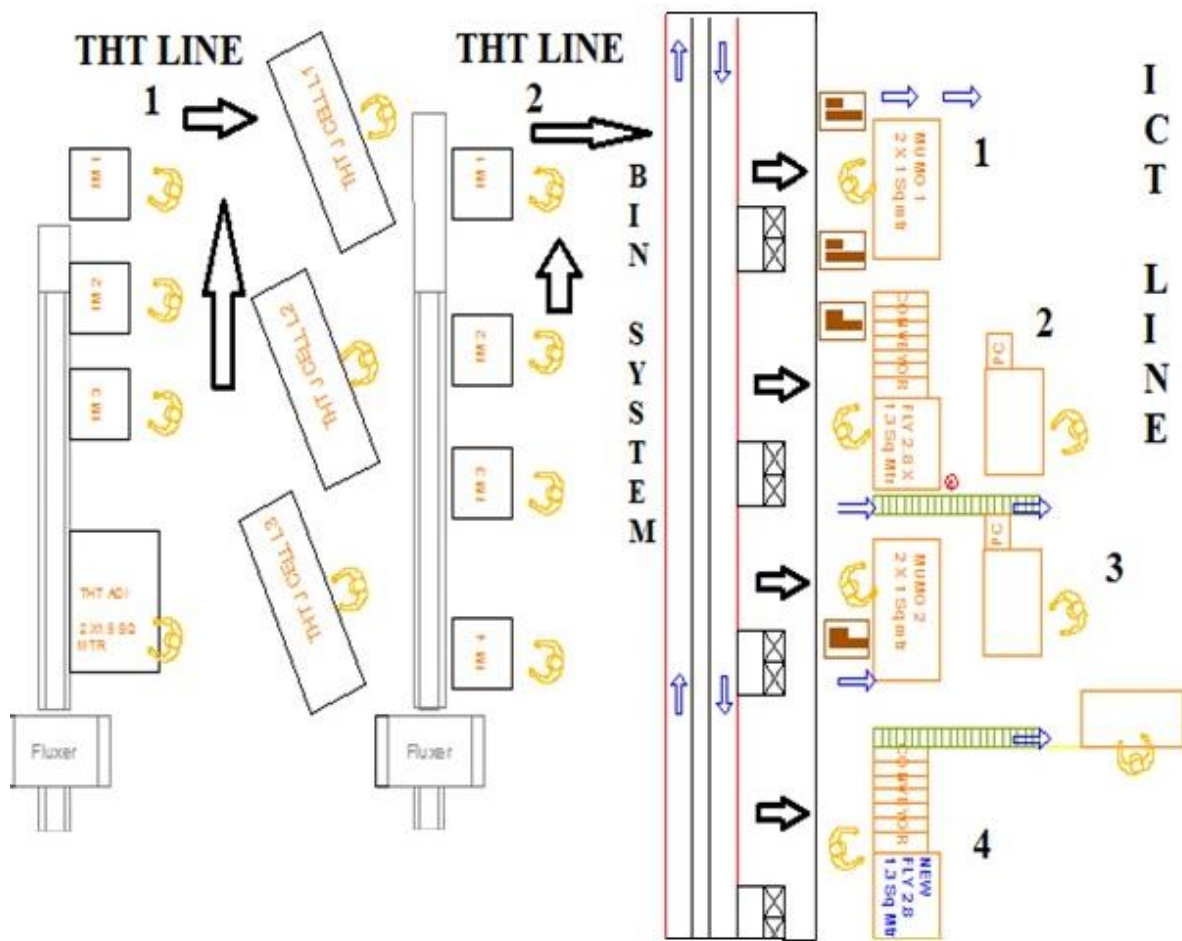


Figure 1. Layout of THT to ICT line



Figure 2. Bin trolley system for material transfer from THT to ICT line

2.2 Simulation using tecnomatix

The above THT line was taken into consideration and the mounting time cycle for each type and batch of PCB was taken into consideration. Similar was done at the ICT end with respect to corresponding PCB testing requirement.

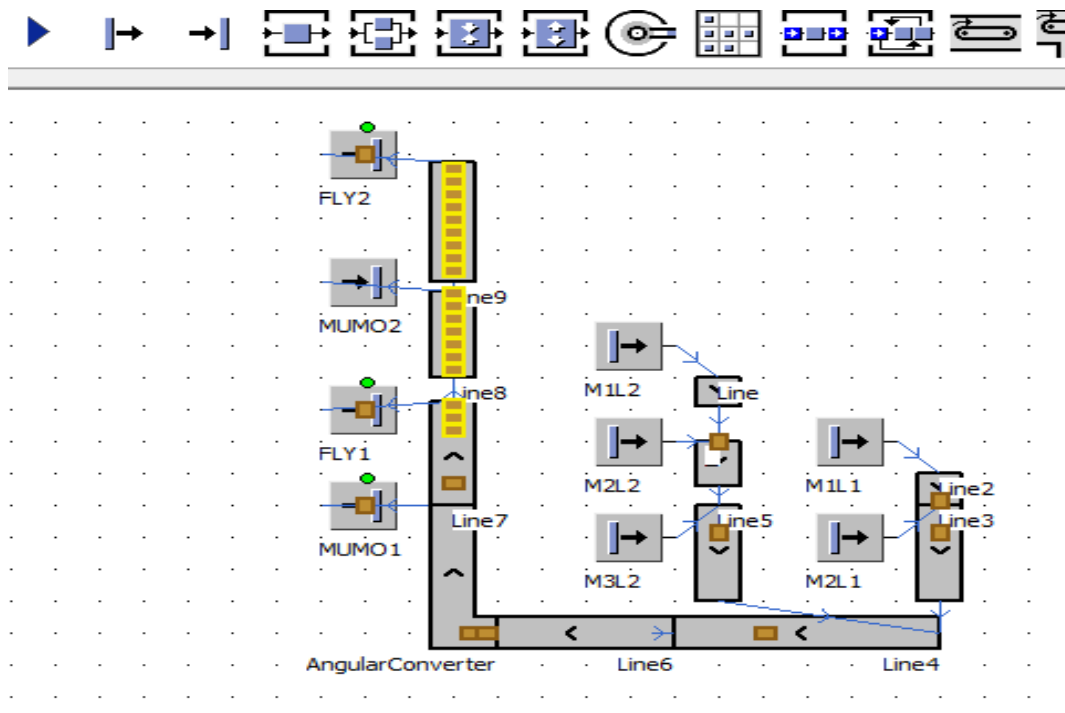


Figure 3. Tecnomatix simulation of automated line from THT to ICT for manual transfer

2.3 Automated material movement from THT to ICT

The transfer of materials from both THT lines to ICT (Integrated Circuit Testing) is done manually which leads to huge accumulation of bins containing PCBs and loss of space. Need for a automated system was required for better movement of PCBs and save floor space. The flowing system was proposed after analysing, designing, modifying, etc, the area and process that was taken into consideration. Movement is achieved by belt & chain conveyor system for horizontal and vertical movement respectively.

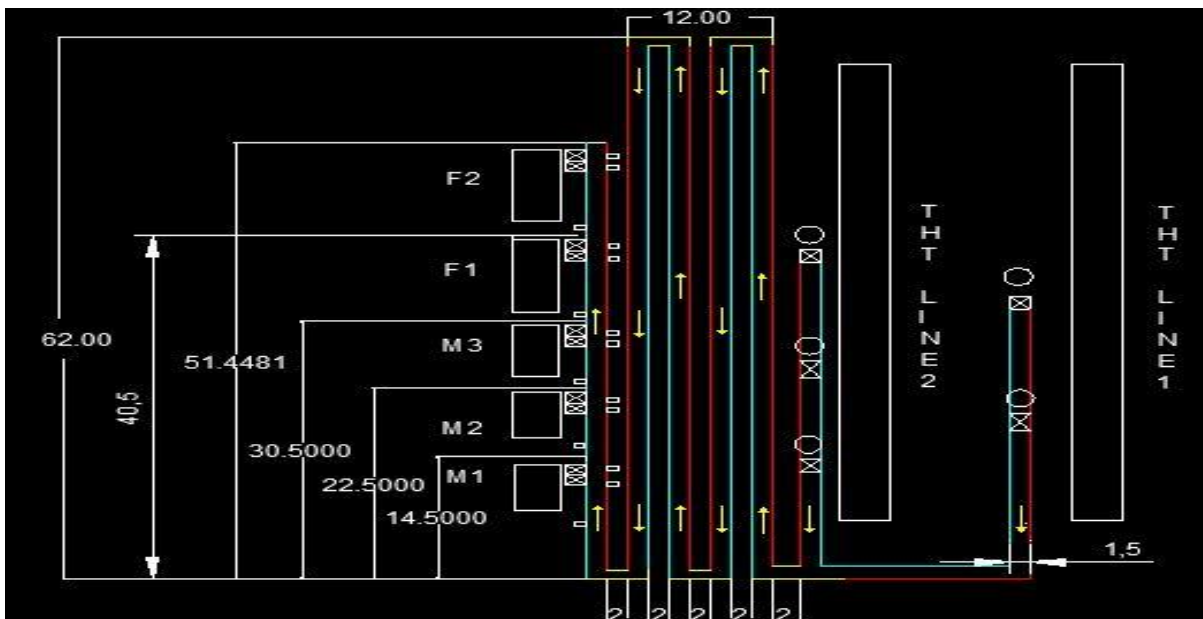


Figure 4. Top view 2D layout of automated material transfer system

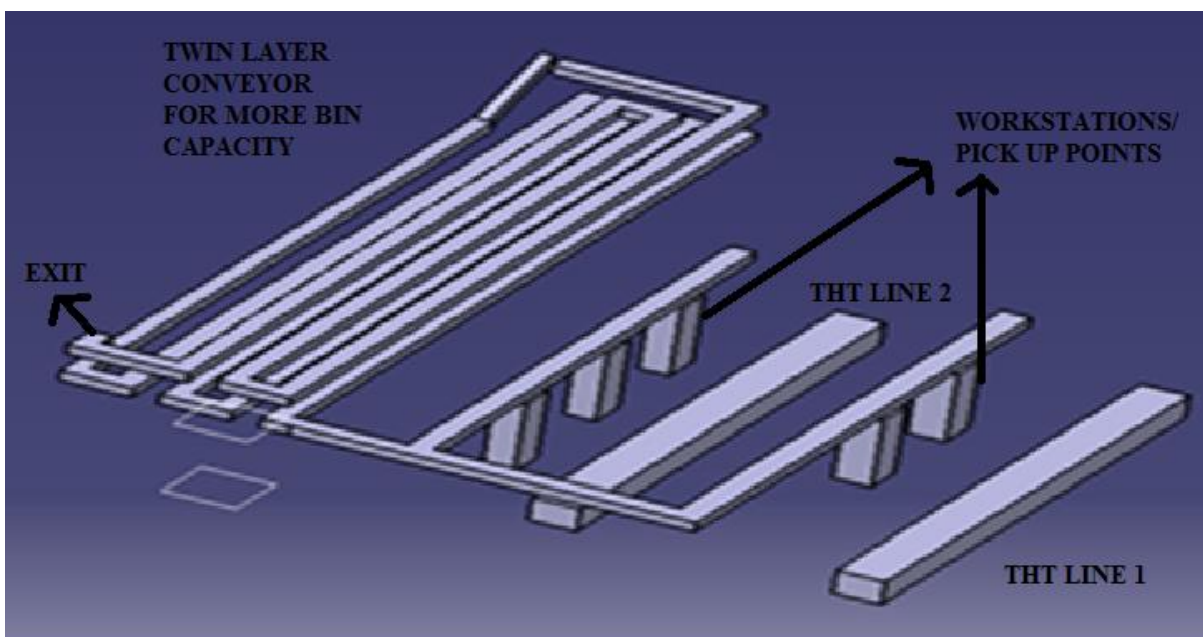


Figure 5. Top view of model of automated material transfer system

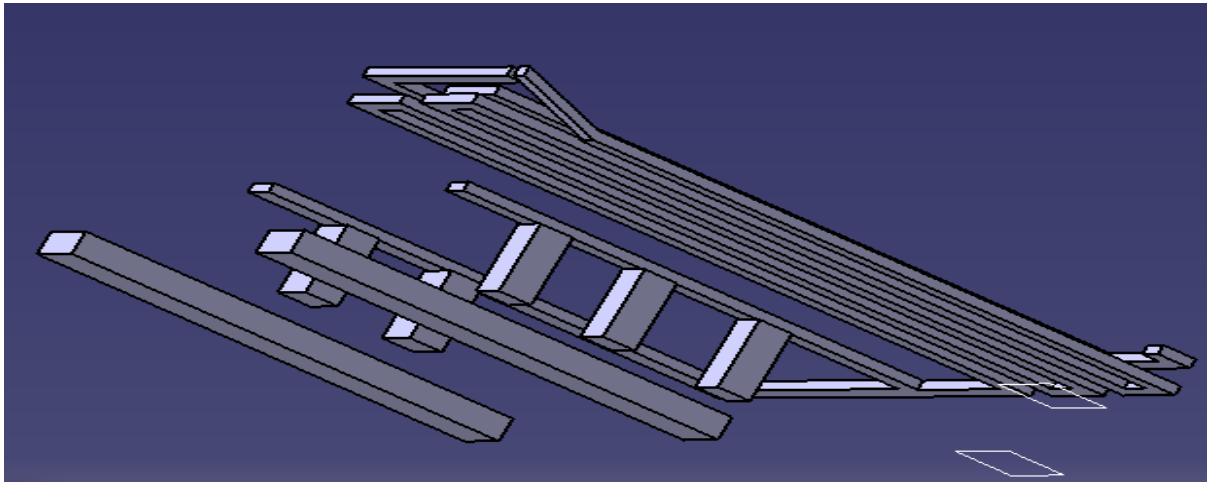


Figure 6. Bottom view model of automated material transfer system

Design Calculations

Minimum overhead distance of conveyor belt : 10 *ft.*

Maximum overhead distance of conveyor belt : 12 *ft.*

Dimension of cassette : 1(*L*) * 0.83(*B*) * 0.15(*H*) *ft.*

Width of conveyor : 1.5 *ft.*

Rack storage dimension : 1.1(*L*) * 1(*B*) * 7.5(*H*) *ft.* --{2.5 *ft.* left for mounting of rack on floor}

Spacing between two conveyor belts : 2 *ft.*

Number of cassettes per rack:

0.15*ft.*(height of cassette) + 0.05*ft.* (clearance between 2 cassettes) = 0.2 *ft.*

Therefore, $7.5/0.2 = 37.5$ cassettes $\sim\sim$ 36 cassettes (rounding off considering additional clearance)

Total rack capacity:

Total no. of racks : 15 (2 on THT Line1 and 3 on THT Line2 and 2 each on each ICT)

Therefore, total capacity of storage : $15 * 36 = 540$

Overhead Conveyor design:

Total considered area for conveyor travel: $62 * 12$ *ft.*

No. of cassettes per line of conveyor :

1 *ft.* + 0.5*ft.* clearance between 2 cassettes = 1.5*ft.*

No. of cassette per line = $62/1.5 = 41.33 \sim\sim$ 40 cassettes (rounding off for additional clearance)

Total no. of lines = 4

Therefore, $4 * 40 = 160$ cassettes

Total capacity of conveyor system:

540 (rack storage) + 160 (conveyor line) = 700 *cassettes*

Drop points at ICT:

(Considering 2 feet gap between each ICT)

(Length of each MUMO machine : 6*ft.*

Length of each FLY machine : 8.4*ft*)

Mumo (ICT)1 : 12 to 14.5 *ft.* (from start point of measurement)

Mumo (ICT)2 : 20 to 22.5 *ft.*

Mumo (ICT)3 : 28 to 30.5 *ft.*

Fly (ICT)1 : 38 to 40.5 *ft.*

Fly(ICT)2 : 49 to 51.5 *ft.*

Loop System design for return flow of cassettes to ICT:

Take off point to 12*ft.* elevation : 54 *ft.* (3 *ft.* after F2)

Drop point from 12*ft.* to 10*ft.* : 3*ft.* from start of delivery line (delivery line is the line at ICT drop points)

Currently, the area is being simulated manually with a conveyor prototype for better judgement and precise achievement of design and results.



Figure 7. Prototype of conveyor developed on ground level for concept realization

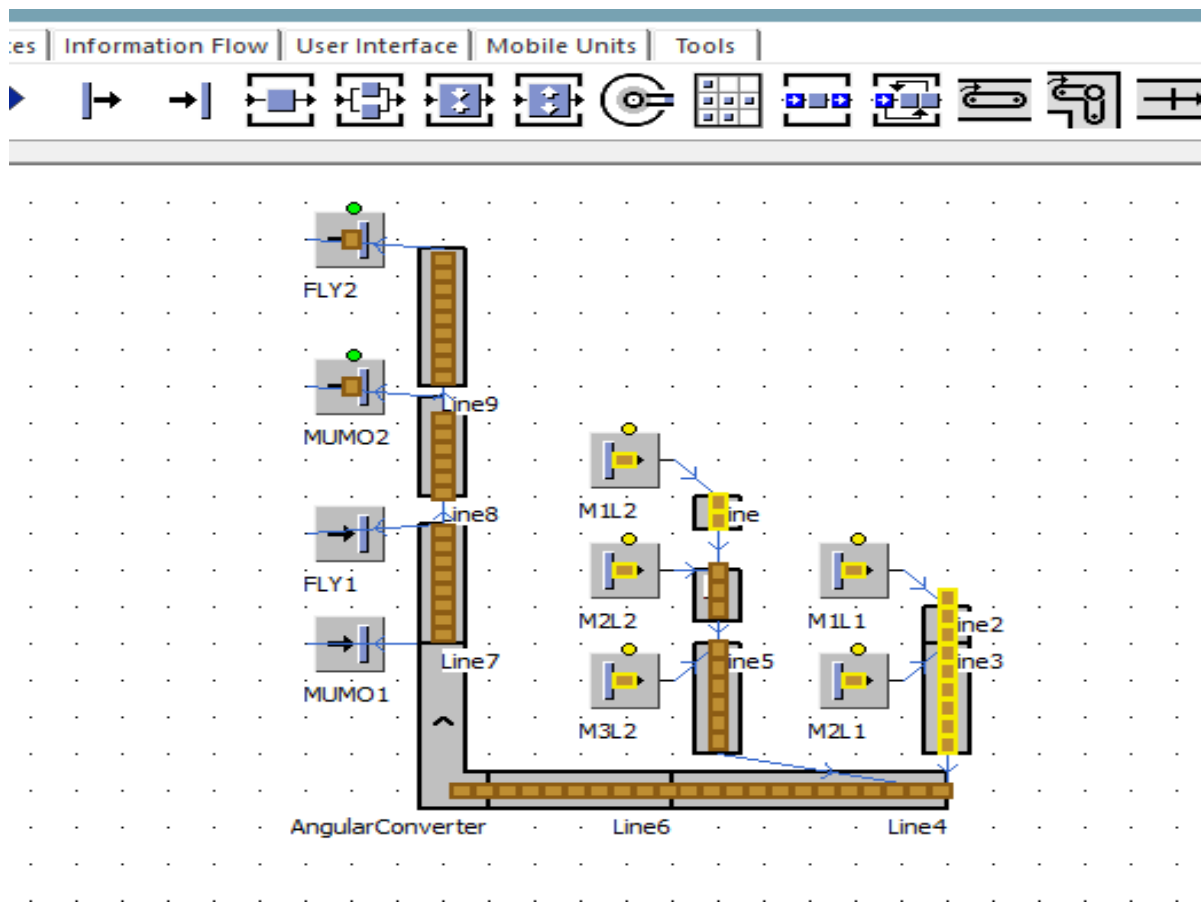


Figure 8. Tecnomatix simulation of automated material handling system highlighting greater density in material flow

3. Results and discussions

Analysing and understanding the two production run techniques, both were simulated in tecnomatix for their productivity/ throughput. It was found out that with an automated system the productivity increased considerably. Waiting wastages, ambiguity, space utilisation, manpower, etc. was taken into consideration and a clear-cut optimisation was achieved by incorporating automated material handling conveyor system.

Table 1. Productivity Chart comparing manual and automated process

Process	Output
Manual material transfer	1500
Automated material transfer	2400
Output improvement per day	900
Output improvement per week	5400
Output improvement per month	21600

4. Conclusion

An automated material handling system was being developed keeping the main focus on its throughput. Detailed study was carried out on the following for the development of automated system:

- i. Process involved in manual transfer of material.
- ii. Tecnomatix simulation analysing the ideal throughput.
- iii. Designing of an automated system for improving the productivity.
- iv. Validating the automated process by tecnomatix.

There was a huge benefit in the automated material handling system by overcoming many manual shortcomings and unnecessary waiting from one production line to another.

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