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MANUFACTURING ARCHITECTURE DIAGNOSIS USING DISCRETE MATERIAL FLOW MANAGEMENT

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Abstract: *All manufacturing architectures are facing flow concentrators problems. In this paper we focused our attention on a chest freezer manufacturing architecture divided in several assembly areas. We used WITNESS simulation software in order to create and simulate a model representing the studied architecture. Based on productivity increasement criteria our goal is to identify material flow concentrators that slow down and / or block the flow, thus diagnose the preliminary manufacturing architecture. As a next step, the concentrators will be eliminated and the architecture optimised.*

Keywords: *manufacturing architecture, simulation, manufacturing times, productivity*

1. INTRODUCTION

Five main elements must be defined in order to perform our simulation algorithm.

We define diffused manufacturing systems as architectures with more than two work points connected by transport & transfer systems and using deposits at local or system level [1, 4].

We agree here with the thesis that within the class of stochastic simulation models, one further distinction is necessary: simulations can be either terminating (sometimes called finite) or nonterminating in nature, with specific algorithms for each category.

We agree that virtual enterprises could be defined as ephemeral organizations in which several companies collaborate to produce a single product during a project cycle time.

Last but not least we consider a material flow and process synchronous simulation the simulation of a model where at the level at the work point the process simulation is concomitant with the material flow simulation.

Fig. 1. General overview of the preliminary manufacturing architecture

2. MANUFACTURING ARCHITECTURE SHORT DESCRIPTION

For this paper we chose as a case study a manufacturing architecture for assembling chest freezers. This production line is located in S.C.Arctic. From 2002 the company is part of the Arcelik group, member of the biggest holding in Turkey - Koç Group. In the present time it is the third European group who produces and distributes households in Europe [5].

Over the years the increasing market request generated the need for productivity improvement. For optimizing the process and for identifying the low productivity causes we must perform an overall analyse. In this paper our goal is to analyse the critical sectors in order to identify the potential flow concentrators that can cause the flow to slow down or even block it.

The layout of the preliminary manufacturing architecture was divided in 12 different succeeding areas (Fig. 2).

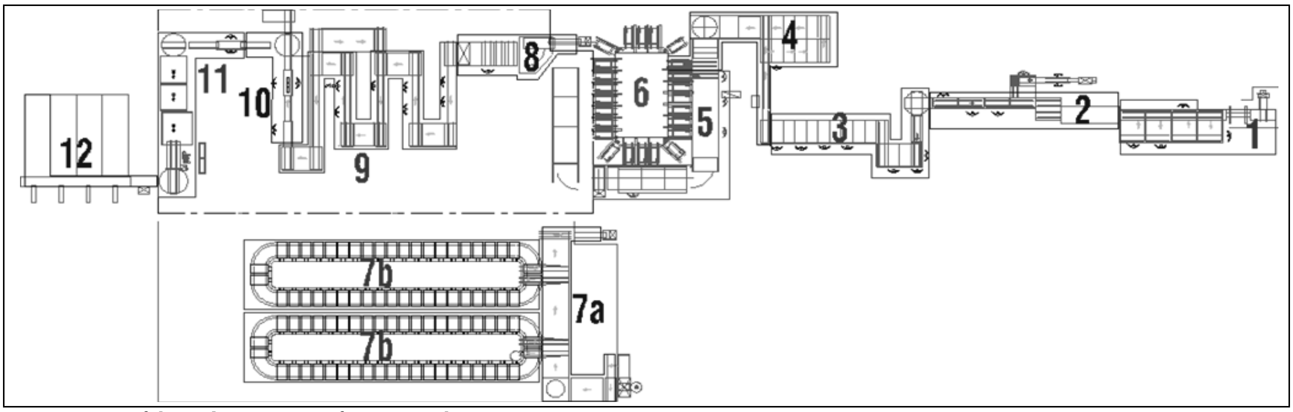

Fig. 2. Layout of the preliminary manufacturing architecture

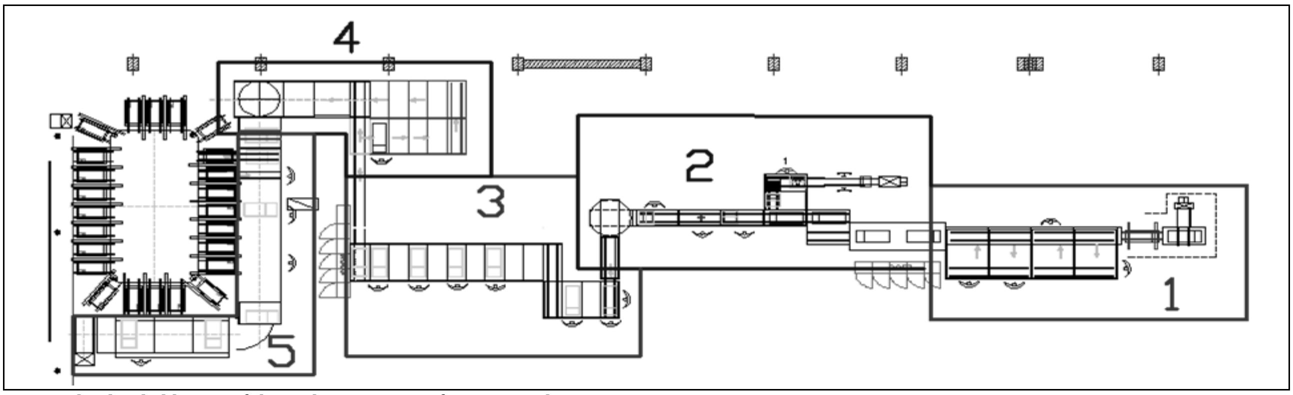

Fig. 3. The divided layout of the preliminary manufacturing architecture

For this case study we focused on the first three areas, which cause problems for all the other sectors (Fig. 3). It is very important to determine and eliminate the flow concentrators that appear in this first areas in order to prevent further material flow blockages.

3. GENERAL RULES FOR GENERATING WITNESS MODELS

Based on this layout we created models for the first 3 arias using WITNESS simulation software. This model contains the following elements:

- human operators (named op)
- conveyor belts (named C);
- One part (named cabinet).

All elements were defined and displayed using personalized icons. The part trajectory in the manufacturing system was established using rules as: “push … to….”, “pull…from…”, “push from … out of world”, “push … to ship”.

In order to complete the model we introduced manufacturing times for each operator and auxiliary times.

Manufacturing times are the ones how define the productivity rates opposed to auxiliary times that add non value to the products.

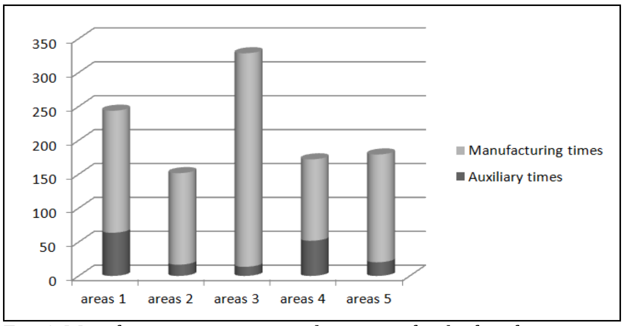

Fig. 4. Manufacturing times vs. auxiliary times for the first five areas

Before running a material flow simulation we must determine the simulated work time interval. In the company there are 3 work shifts each having 8 h, thus we run the simulation for 28800 seconds.

To help us monitor the productivity we defined another element (“count”) in the model for counting the cabinets finished for each area during a work shift. Having the simulation finished we can generate activity reports for all the elements. In this way we can diagnose the manufacturing system which can lead to identifying flow concentrators [2, 3].

The next step will be to analyze each of the 3 layout areas and their corresponding WITNESS models.

4. FIRST AREA MATERIAL FLOW SIMULATION AND RESULTS

Based on the layout of sector 1 in the preliminary manufacturing architecture we created a model using WITNESS simulation software. This model contains the following elements:

- 4 human operators (named op1 – op4)
- 5 conveyor belts (named C1 – C5);
- One part (named cabinet).

The four human operators carry on the following actions:

•op1 - The operator cleans the foam from the cabinet; the assembled thermostat is mounted, the probe is shaped and placed on the cabinet, release the exhaust hole, verifies the defrost resistance continuity. He performs a final check on the cabinet.

•op2 – Identifies and selects the corresponding cabinet from the labelling program, prints and positions the label on the cabinet. The operator positions ant tightens with two screws the housing on the fixing holes from the left side. In the same way he mounts the left rear cabinet base. A final control is performed.

•op3 – The operator fixes the compressor housing in the right side using two screws, he mounts the right rear cabinet base, and he cleans the foam from the back of cabinet. Next a part for fixing the compressor is mounted in a special place on the back of cabinet. The operator checks the state of the cabinet.

•op4 – The operator takes a heating coil that will be fixed with a help of two screws. He verifies if the heating coil works properly on the cabinet. For the final task he performs a general control.

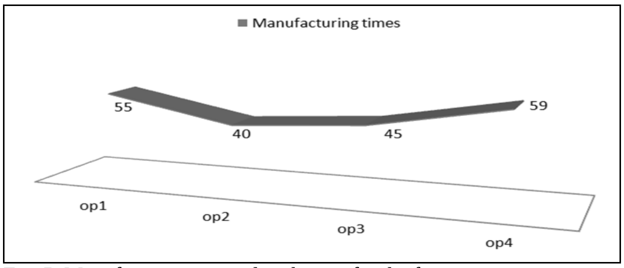

Fig. 5. Manufacturing times distribution for the first area

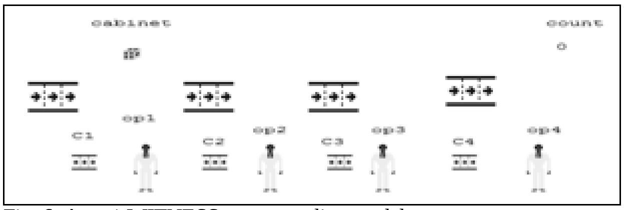

Fig. 6. Area 1 WITNESS corresponding model

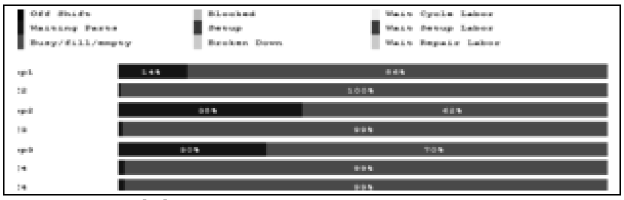
Fig. 7. Structural elements activity reports

The manufacturing times for each operator can be seen in Fig. 5. These values were defined in the simulation software, so that the model that we created would be similar to the real one. For area 1 the medium value for the auxiliary times is 63.75 seconds.

After the material flow simulation (Fig. 6) we counted 445 cabinets manufactured in 28800 sec. that are ready to enter in the second area.

Also we generated several activity reports meant to help us diagnose this sector. As one can see in Fig. 7, the work time percentage distribution is good, with percentages between 86% and 100%.

5. SECOND AREA MATERIAL FLOW SIMULATION AND RESULTS

In the same manner we created the model for the second studied area. We used:

- 3 human operators (named op1 – op3)
- 4 conveyor belts (named C1 – C4);
- One part (named cabinet).

The human operators working in this area will fulfil the following tasks:

- op1 – Removes protection film from the cabinet, cleans cabinet interior, labels the cabinet, and applies bar code. The operator introduced and fixed the baskets in the cabinet.
- op2 – The operator verifies the overall aspect of the door and positions the door. The left hinge is positioned and fixed on the cabinet.
- op3 – The operator positions and fixes the right hinge on the cabinet. He prepares and mounts the lamp cable. He checks if the door is well fixed and the gasket sealed.

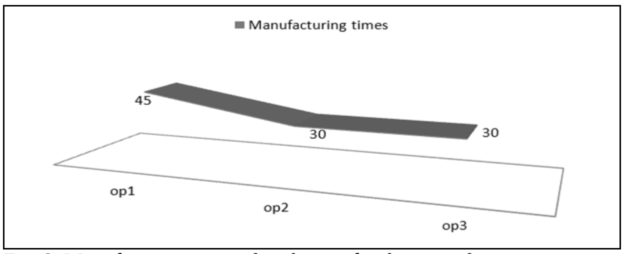

Fig. 8. Manufacturing times distribution for the second area

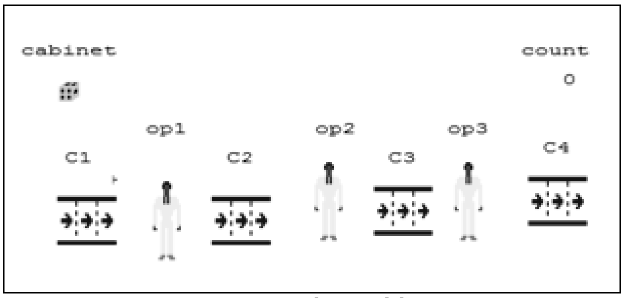

Fig. 9. Area 2 WITNESS corresponding model

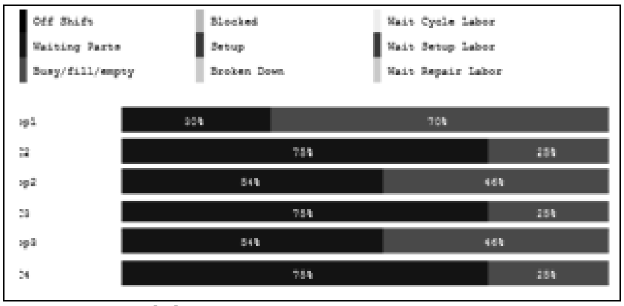

Fig. 10. Structural elements activity reports

The manufacturing times distribution is given in Fig. 8. For area 2 the medium non added value is 16.66 seconds.

Running the material flow simulation for this sector we learned that the cabinet number received from area 1 are finished before the work shift ended, in approximately 6 hours. The real production capacity for this sector is 637 cabinets.

After studying Fig. 10, we can tell that the waiting time exceeds the working time.

6. THIRD AREA MATERIAL FLOW SIMULATION AND RESULTS

In creating the model for sector 3 we used 6 human operators, 7 conveyor belts and the manufactured cabinet.

The operations made by the human operators are as follows:

- op1 - Checks the status of the condenser positioned on the back side of cabinet. The condenser is mounted in the top and bottom brackets. The operator takes and fixes the protection hinge and verifies that the condenser is well positioned. Next he places a cover in the thermostat box for fixing the condenser.
- op2 – The second operator verifies the status of the compressor and the damper. The operator positions the damper in the device, positions the compressor placed on the support, positions and assembles the compressor fixing part on the left and right side. The operator performs a final inspection.
- op3 – This operator checks the compressor position, passes the power cord trough the cabinet, fixes the PTC assembly on the socket. He fastens the lamp cable and the power cord in brackets and fixes the grounding conductor on the socket. He fixes the thermostat cable, fastens the thermostat cable in the bracket.

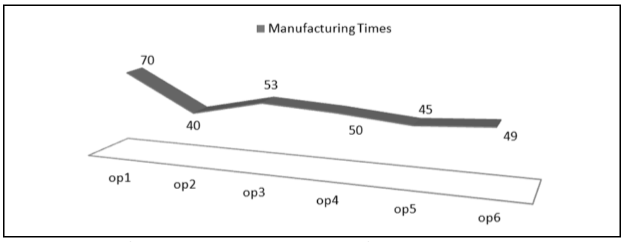

Fig. 11. Manufacturing times distribution for the third area

- op4 – The operator verifies if the lamp cable and the power cord are well fastened. He fixes and connects the thermostat cable and the grounding conductor in the compressor socket. He positions conductors of electrical cable for the lamp. Also he has to fix the protective hood on the compressor socket and verify if well connected.
- op5 - operator again verifies the protective hood and the condenser. This operator must remove the plugs from the filter drier and the condenser coil cut the ends of the capillary tube to a length of 3 - 5 mm with an ultrasonic clamp. The capillary tube is formed in one side and is calibrated on the internal diameter. The capillary tube is inserted on the filter. The operator forms and introduces the condenser coil in the filter drier and in the discharge compressor pipe. He introduces the pipe of refrigerant charge in the compressor connector charge. The last operation is to check the positioning of pipe according to the instructions.
- op6 - operator begins by checking pipes for brazing. The operator makes the pipes brazing for aspiration and discharge, for the two filters and for the loading/vacuum pipe. At the end the operator makes a visual self inspection of the brazing cord continuity.

The manufacturing time for each operator is given in figure 11. For area 3 the medium value for the auxiliary times is 13.5 seconds.

The number of cabinets assembled during a work shift is 398. It takes about nine and a half hours to complete 445 cabinets.

For determining the cause of this problem we generated activity reports for all structural elements. Comparing the percentage for the two time categories we noticed that the manufacturing times overcome the auxiliary times, so this doesn't influences the productivity.

One possible explication is related to the big number of operators and, thus to big manufacturing times in comparison with the first two areas.

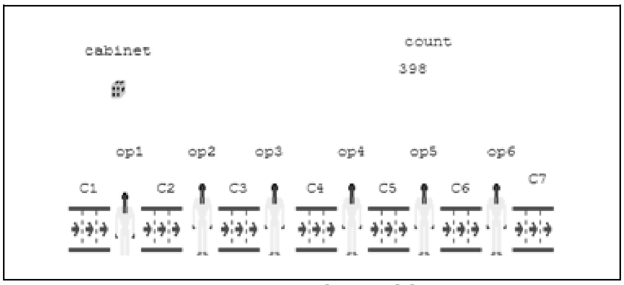

Fig. 12. Area 3 WITNESS corresponding model

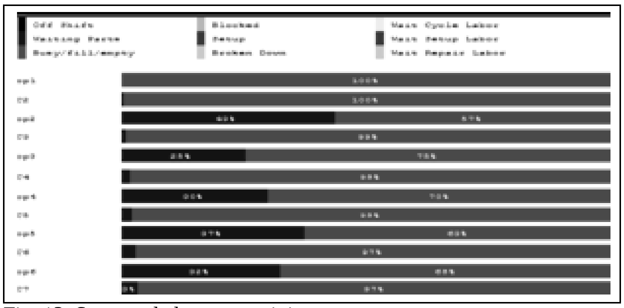
Fig. 13. Structural elements activity reports

7. CONCLUSION & FURTHER INTENSIONS

In this paper we used a case study based on a chest freezers manufacturing architecture. After a thorough overall system analyze we defined and simulated three models corresponding to the first three assembly areas from the manufacturing architecture, according to the company demand. The results are presented below.

Area	Cabinets	Time [S]	Time [S]	Cabinets
Area 1	445	28800	28800	445
Area 2		21120		637
Area 3		32194		398

Tab. 1. Productivity rates for different time units

The second area is working under its full capacity. The cabinets that can be assembled in 8 hours are 43% bigger than the incoming cabinets. The third area however is having a low productivity. The operators in this section can only assemble 89.43% from the incoming cabinets during a work shift. Based on the system diagnosis our further intension is to optimise the material flow in each area and in the same time in the whole manufacturing architecture.

8. ACKNOWLEDGEMENTS

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