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Research Article

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Productivity Enhancement by Using Lean Tools and Techniquesina Solar cell Manufactur Ingindustry

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Abstract

The objective of this work is to implement lean methodology in a solar cell manufacturing industry. The industry could not meet there requirement of the customers because of high cycle time nan individual process. High processing time occurs in the solar cell manufacturing industry tends to increase in lead time. Hence method study and time study are done and layout optimization has been implemented. Kaizen concept is introduced to increase the productivity of the plant. Due to the implementation of 5S and layout changes, unwanted excess movements the production line has eliminated leading to increased productivity.

Keywords: Layout optimization; Kaizen; Solar cell manufacturing industry; Productivity

Introduction

Productivity, in general is termed as a relationship between outputs (products) produced by the industry to the input (resources) that are utilized by the industry to achieve the output. In day to day life, productivity is a major cause for meeting the demands of the customer [1]. The application of lean tools helps in improvement in productivity. The major problem observed in a solar cell manufacturing industry was reduced productivity leading to increased cost and hence lack of customer satisfaction due to unsatisfied demand. It is proposed to provide a solution for the above problem by implementing lean principles to reduce resource wastages and thereby increase the productivity [2].

Findings–lean production is one of the major concepts involved in the productivity improvement in the industries. The main concept of lean is to find out the non-value added activities and to eliminate them. It helps to increase the efficiency of the process. In recent days, many industries are implying the concept of lean production to improve the overall efficiency and for the continuous improvement [3].

Industry Overview

The industry identified for the study is one of the leading manufacturers of solar cells operating on pull system. The level of initial production was 200 solar panels per day in 2010. Currently the level of production is around 400 solar panels with improved quality. The maximum range is 350 watts and the minimum range are 3watts [4].

Problem Statement

This company suffers from a wide range of wastages due to transportation facilities. It also suffers from increased lead time in its production line. It also suffers wastages in its manufacturing process levels. Another major problem involved in the industry is, poor layout design and facility. The production is affected due to unwanted excess movements by the workers within the work area. Due to the non-implementation of 5S concept, the work area is in state of total mess. As a result, the production lags behind the schedule and hence the industry is not able to meet the demands of the customer. Therefore his is the area that was decided to be targeted for improvement in productivity [5].

Methodology

The methodology was developed to carry out the project as per the sequential manner. It explains the processes involved in the production which is represented in the Figure 1 [6].

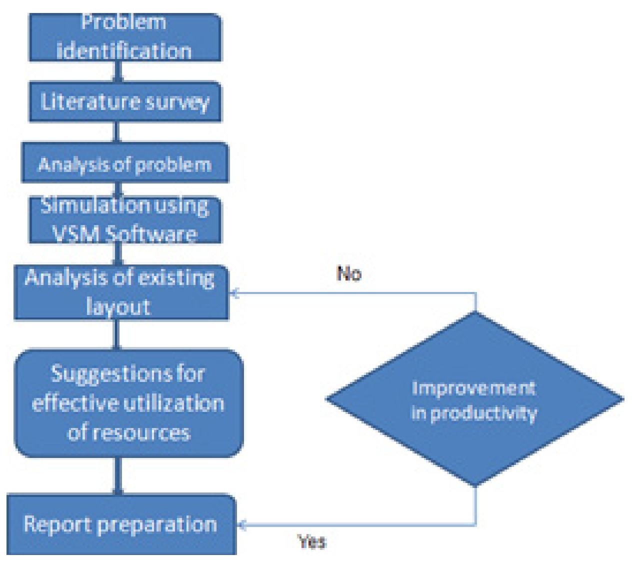

Figure 1: Methodology

Mechanical Characteristics

Mechanical characteristics are the parameters that have to be verified thoroughly for the purpose of preparing the solar modules and solar panels. Some of the important mechanical characteristics involved are listed below [7],

1. Solar PV modules.
2. Solar roof top power plants.
3. Solar water heaters.
4. Solar water pumps.

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5. Solar street lights.

Solar PV modules

Table 1 represents the characteristics of solar PV modules [8].

Table 1: Characteristics of solar PV modules.

Parameters	100 Wp	200 Wp	300 Wp
Cell Size	112*156	156*156	156*156
No of cells	36	70	72
Conifigurartion N of cell	9*4	10*7	12*6
Module WT	1095*675	1630*840	1975*990
Dimension	10kg	21 kg	24.5kg
Front class	3.2mm	3.2 mm	3.2mm
Junction box	IP 65 rated		
Cables	4.0 mm, 1000 mm long, Genuine MC4 connector		
Frame	Anodized aluminium		

Solar roof top power plants

Table 2 represents the ON grid characteristics and Table 3 represents the OFF grid characteristics of solar roof top power plants [9].

Table 2: ON grid characteristics.

Model No	Capacity	Energy generation (1 yr)
MAS-ONG-001K	1	1650 units
MAS-ONG-01.5K	1.5	2500 units
MAS-ONG-002K	2	3300 units
MAS-ONG-003K	3	5000 units
MAS-ONG-005K	5	8250 units
MAS-ONG-010K	10	16500 units
MAS-ONG-015K	15	24750 units

Table 3: OFF grid characteristics.

Mode No	Solar mode	Battery	Power	System voltage	Usage	Energy gen (lyr) units
MAS-OFG-10H- IK	I kWu	200Ah	1000 VA	24 V	800 w	1650
MAS-OFG- I0H-I.5K	I.5 kWu	300Ah	1500 VA	24 V	1200 w	2500
MAS-OFG-20H-2K	2 kWu	400 Ah	2000 VA	48V	1600 w	3300
MAS-OFG-30H-3K	3 kWu	600Ah	3000 VA	48V	2400 w	5000
MAS-OFG-50H-5K	5 kWu	800Ah	5000 VA	96 V	4000 w	8250

Solar water heaters

Table 4 represents the characteristics of solar water heaters [10].

Table 4: Characteristics of solar water heaters.

Model No	Capacity	No of persons can use
MAS-SWH-E100	100 LPD	3
MAS-SWH-E125	125LPD	4
MAS-SWH-EI50	150 LPD	5
MAS-SWH-E200	200 LPD	6
MAS-SWH-E250	250 LPD	8
MAS-SWH-E300	300 LPD	10
MAS-SWH-E500	500 LPD	15

Solar water pumps

Table 5 represents the characteristics of solar water pumps [11].

Table 5: Characteristics of solar water pumps.

Model No	Solar capac ity (Wp)	Drive capacity	Pump capacity	Total dynamic load (ft)	Water quantity (ltrs/day)
MAS-SWP -12H- H	1200	2 HP	I HP	150	27000
MAS-SWP-18H-2H	1800	3 HP	2 HP	150	40500
MAS-SWP-30H-3H	3000	5HP	3 HP	200	48000
MAS-SWP-48H-5H	4800	7.5 HP	5HP	250	58560

Solar street lights

Table 6 represents the characteristics of solar street lights [12].

Table 6: Characteristics of solar street lights.

Model No	Solar Module	Battery (iu AH)	Lumiarie	Pole height (mm)	Operatiug hours
MAS-SL-05T-10W	50 wp	40	10 w	6	2
MAS-SL-05T-15W	50 wp	40	15 w	6	1
MAS-SL-7.5T-15W	75 wp	75	20 w	6	1
MAS-SL-IOT-20\V	100 wp	100	30 w	6	2
MAS-SL-12T-30W	120 wp	150	50 w	8	1

Data Observation

As per the aim of the project, the data is collected on the basis of working hours and the process involved. Some of the data that an area valuable is represented in the Table 7 [13].

Table 7: Lab our data collection.

S.No	Description N	Data
I	Shiftsper day	2
2	Working hours	8 hours
3	Tea break	10 minutes
4	Lunch break	60 minutes
5	Working days	26
6	Total number of persons	79

Layout diagram

Figure 2 represents the layout diagram of solar cell manufacturing process [14].

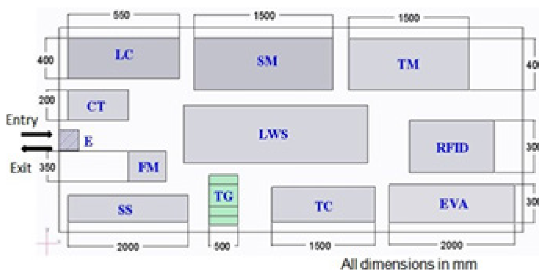


Figure 2: Solar cell manufacturing process.

Machines involved

1. Cell testing
2. Laser cutting
3. Stringing
4. Tapping
5. Bus Bar soldering
6. Sun simulator machine

Sub processes

1. EVA machining (Ethyl Vinyl Acetate)
2. Tempered glass laying
3. Tedlarcutting
4. Framing
5. Quality inspection

Takt time Calculation

Total available time for production=2 × 8=16

Hours total time for production=900 mins

Total production per month=26 × 14=364/month

Customer demand per month=430

Products total value added time =39 min per

Part total non-value added time =26 min per

Part total production time=65 minperpart

Total available time=480-30=450 min/shift

Takt time=

=21320/430

=49.6 min/product

VIP-PLANOPT simulation

The current state layout and future state layout of the solar cell manufacturing process can be analyzed by means of VIP-PLANOPT simulation software. The steps involved in the simulation are,

1. Module placement
2. Anchoring the module
3. Forbidden area module
4. Module orientation
5. Module padding
6. Formunit costmatrix

Current layout

Figure 3 represents the current layout design f solar cell manufacturing process [15].

Steps involved in VIP-PLANOPT simulation

Step 1: Open VIP-PLANOPT and create the module in which the layout has to be executed. The length, width and area has to be given along with the a spectratio as shown in Figure 4 [16].

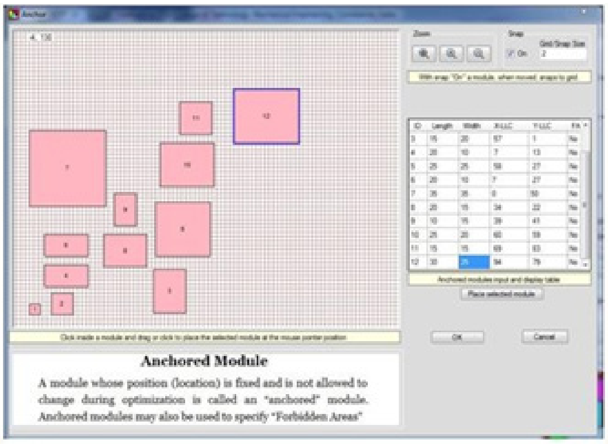


Figure 3: Current layout design.

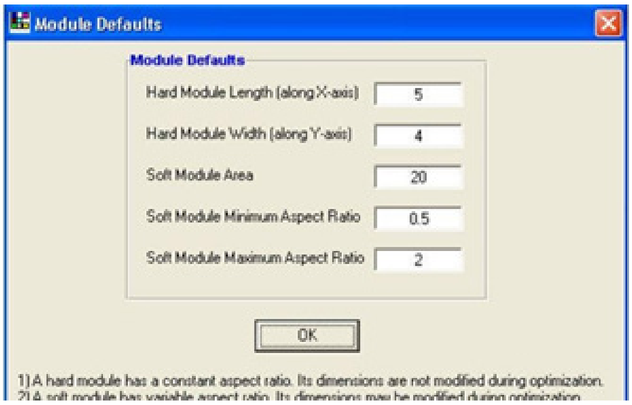
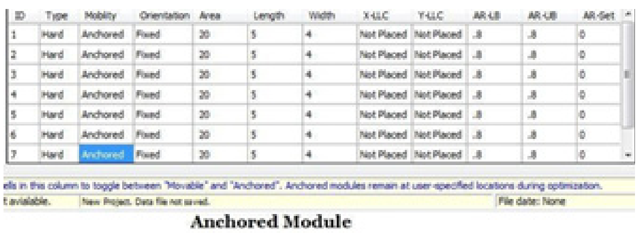


Figure 4: Module creation.

Step 2: After assigning the modules, the mobility is set to beanchored. And then the appropriate X and Y axis are to be set as shown in Figure 5 [17].

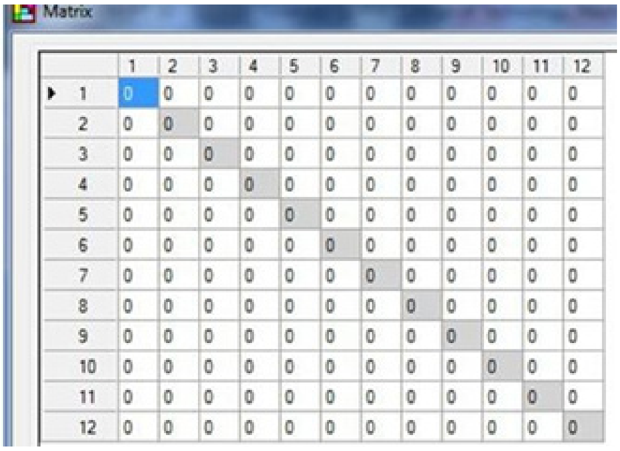


ID	Type	Mobility	Orientation	Area	Length	Width	X-LLC	Y-LLC	AR-LB	AR-UB	AR-Set
1	Hard	Anchored	Fixed	20	5	4	Not Placed	Not Placed	.8	.8	0
2	Hard	Anchored	Fixed	20	5	4	Not Placed	Not Placed	.8	.8	0
3	Hard	Anchored	Fixed	20	5	4	Not Placed	Not Placed	.8	.8	0
4	Hard	Anchored	Fixed	20	5	4	Not Placed	Not Placed	.8	.8	0
5	Hard	Anchored	Fixed	20	5	4	Not Placed	Not Placed	.8	.8	0
6	Hard	Anchored	Fixed	20	5	4	Not Placed	Not Placed	.8	.8	0
7	Hard	Anchored	Fixed	20	5	4	Not Placed	Not Placed	.8	.8	0

Figure 5: Anchoringthe module.

Step 3: The next step involved in the optimization is setting up of the function matrix, for which the sequence of operations is performed as shown in Figure 6 [18].

Step 4: In this step the current layout is drawn by means of assigning the co-ordinates and performing the function matrix as shown Figure 7 [19].



	1	2	3	4	5	6	7	8	9	10	11	12
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0

Figure 6: Function matrix formation.

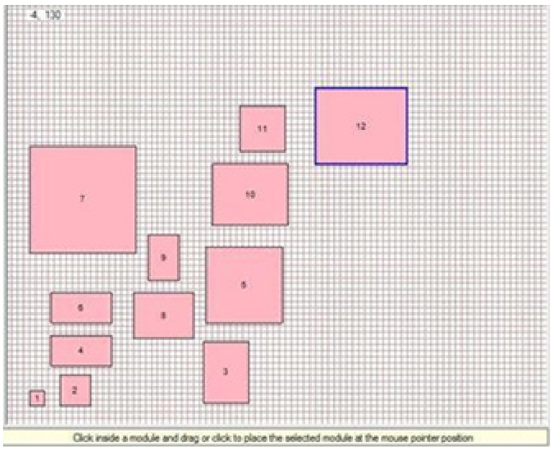


Figure 7: Assigning the co-ordinates.

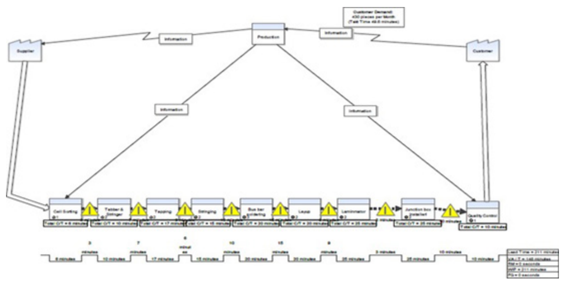


Figure 8: Current state value stream mapping.

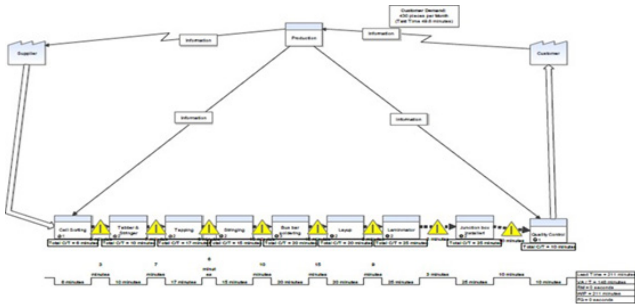


Figure 9: Future state value stream mapping.

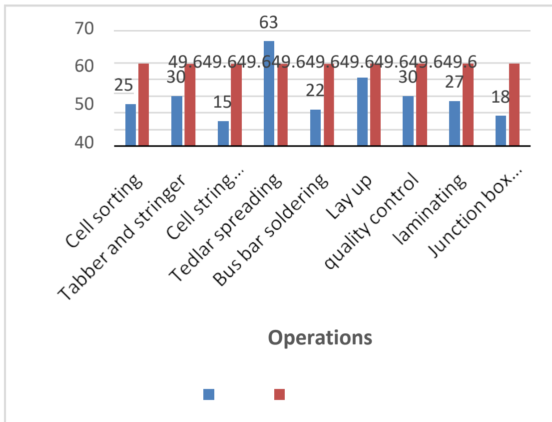


Figure 10: Time Vs. Operation.

Current State Mapping

Takt time calculation:

Demand per month=430 pieces

Shift per day=2 shifts

Production time=16 hrs/day

Total production per month=364pieces

Takt time=Available time per day/Demand per day=(16 × 60)=960-140=820

=820 × 26=21,320

=21,320/430

Figure 8 and Figure 9 can show the values of the takt time values.

Figure 10 represents the comparison between time and operations involved in current state mapping of solar cell manufacturing process.

Results and Discussions

Inferences from current state

VSM Solar panel production:

Takt time = 49.6 min/piece

Lead time =313minscvalue added time=148

Mins WIP =211mins

No of operators =9operators

Inferences from future state

VSM Solar panel production:

Takt time=49.6 min/piece

Lead time=301mins

Value added time=148 mins

WIP=203 mins

No of operators=9 operators

The comparison between the current state and future state map for the process is represented in Table 8 [20].

Table 8: Current state vs. Future state.

S.No	Content	Current state VSM	Future state VSM	Reduction (%)
1	Cycle time	271	259	4.4
2	Lead time	313	301	3.8

Basedon VIP-PLANOPT

• Arranging all processes sequentially reduces handling problem as also the time required is reduced to more extent [21].

• The outcomes like, the time for tedlar spreading gets reduced to 20%, the time required for bus bar soldering has been decreased to 5%, and the operations are made easy and safe [22].

Conclusion

Thus, the solar cell manufacturing process is analyzed with the intent of improving productivity and reducing wastages.

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