An Intelligent Simulation based case study of Indian Micro Small Medium Enterprise (MSME) of farm equipment manufacturing

Janpriy Sharma¹, Arvind Jayant²

Department of Mechanical Engineering, Sant Longowal Institute of Engineering and Technology, Longowal Distt. Sangrur, Punjab, INDIA.

arvindjayant@gmail.com, arvindjayant@sliet.ac.in

Abstract. The manufacturing field is the area where application of simulation is an essential tool for validating the methods and architecture before applying them to factory shop floor. In this paper an Indian Micro Small Medium Enterprise (MSME) is taken into consideration, which manufactures agricultural equipment’s with aim to mechanise the Indian farming techniques. Presented case study is authentic and adopted for Gahir Agro Industries situated in agricultural hub, state of Punjab. Proposed company is all set to launch a new farm equipment called ‘Laser Land Leveller’ which got approval from governing body and ready for its batch production because of seasonal demand. Present study encapsulates the modelling and simulation as tool for analysis of manufacturing process of laser land leveller and its predicted production levels under actual working conditions. Tool used for modelling and simulation is ARENA 15.1 by Rockwell Automation Studio.

Keywords – Modelling, Simulation, MSME, Laser land Leveller, Seasonal Industry, ARENA

1. Introduction

Micro Small Medium Enterprise (MSMEs) sector has developed as emerged as highly vibrant and dynamic sector of the Indian economy over the last five decades. MSMEs contribute nearly 8% of the country GDP 45 percent of the manufacturing output and 40 percent of the exports. They provide the largest share of employment after agriculture. MSME not only play crucial role in providing large employment opportunities at comparatively lower capital cost than large industries but also help in industrialization of rural & backward areas, thereby, reducing regional imbalances, assuring more equitable distribution of national income and wealth. MSME are complementary to large industries as ancillary units and this sector contributes enormously to the socio-economic development of the country (Katyal and Xaviour 2015). MSMEs are situated in suburban or rural area and do not have much exposure to the emerging trends of manufacturing, marketing, demand forecasting, material handling and logistics, struggle to withstand globalisation as well as fluctuating governing norms and policies. In this study industry considered is an ISO certified MSME situated in agricultural activity dominating area of Sangrur (Punjab) manufacturing farm implement namely laser land leveller which is combination of mechanical and laser beam-based technology. Company is all set to go for its production as per customer demand after getting necessary approvals form the governing bodies. Using modelling and
simulation as tool for evaluating the production volume scenarios of laser beam land leveller and solution to many if-then situations which arise generally before starting of mass production is provided in scientific way under feasible constraints. Tool used for modelling and simulation is ARENA 15.1. this study will be covering all the working aspects and resources utilisation with predicted work out to input ratio, with aim to strengthen production network and revolutionise the poor R&D and production system of MSMEs.

2. Literature Review
A vast literature supporting the challenges and barriers for the Indian MSMEs is available. (Kumar and Subramanya 2010) Founded that Trans-national corporations (TNCs) expand their production bases to developing countries having better conditions of manufacturing and domestic markets provide increasing opportunities for local small and medium enterprises (SMEs) to have subcontracting relationships with these TNCs. Resulted that substantiates in the Indian context that subcontracting relationship with a TNC can be an important source of technological innovations and enhanced economic performance for SMEs (Chawan and Vasudev 2014) done analysis of connection between many organizations like ministries / government departments, bilateral & multilateral agencies, academic, research & development institutions, implementing & executing agencies and industrial associations was framed and its importance was explained. (Anuradha et. al 2014) attempted to critically analyse the definitional aspect of MSMEs and explore the opportunities enjoyed and the constraints faced by them in the era of globalization. (Kumar and Singh 2015) studied the need of supply chain management for giving an edge to MSMEs overview their competitors for overall improvement. Found 13 critical success factors in implementation of supply chain to measure improvement in performance, the authors considered different measures related to customer service and satisfaction, innovation and growth, financial performance, and internal business. Results were analyses by testing research propositions using standard statistical tools. (Thanki and Govindam 2016) used analytical hierarchy process approach to investigate the impact of select lean and green practices on performance benefits, and to evaluate the influence of lean and green paradigms on overall performance of SMEs. Developed an integrated framework for lean-green system to guide SMEs towards sustainable growth. (Verma and Sharma 2017) Studied the implementation of lean manufacturing for improving quality and productivity on small scale MSMEs. Identified waste related problems, cause of equipment failure, bottleneck problems and rectify them. The above problems were analysed in concern with rejection control, inventory control, waiting time, set time and eliminating non-value-added time / activities. The complete problem was identified and depicted by value stream mapping Suggested improvements and implementation of lean tools in small scale industry in terms of reduced wastage and high productivity. (Sahoo and Yadav 2018) investigated the relationship between quality management dimension and firm performance, considering manufacturing SMEs as focal point of research. Studied barriers in the implementation of quality management prospects in manufacturing SMEs. Data for 127 manufacturing Indian SMEs was drawn to addresses the research objective. Test of the structural model supports the proposed hypothesis, that TQM related to manufacturing performance.
Anjali et al. (2009) Presented a layout of Automated guided manufacturing systems with four machines, 2 AGV, one loading/unloading zone and one parking station for AGV recharging facilities. For the given layout simulation was performed for parts scheduling and routing by Arena Software. Result produced gave the best scheduling policy for parts sequencing, part dispatched by AGVs and part processing at machines. Nancy Ruiz et al. (2014) Studied application of Simulation process in manufacturing field used SimlSHOP as simulation tool which includes the tasks like model creation, simulation, animation and distribution of elements. Simulation result validated that agent supported architecture for simulation and an intelligent manufacturing meta-model proposed was working well with requirements of new manufacturing era and provided enough flexibility for designing complex models and experiments. Jayant et al. (2014) studied reverse logistic network and sustainable supply chain systems of used inverter batteries collection in North India aim was to model and simulate the reverse logistic network for collection of EOL products for XYZ industry. Tool used for modelling & simulation was Arena
software (11.0) by Rockwell animation studio to find solution to problem areas identified and to improve reverse logistic operation. Nyemba et al. (2017) Studied the dynamic factors impacting the movement of materials within manufacturing environment, complexity in assembling owing to the multiplicity and interconnectedness of these factors. Presented a case study of a furniture manufacturing and timber processing industry having batch production tool used for this problem was modelling and simulation by ARENA software. This paper corporates small level MSME which is manufacturing agricultural equipment and demand is seasonal. Gahir Agro industries of Punjab is upcoming with production of laser land leveller, by using modelling and simulation as tool based on existing setup of company its expected production volume, resources utilisation level will be explored. Tool used for modelling and simulation is ARENA 15.1 by Rockwell Automation Studio.

2.1. Micro Small Medium Enterprise (MSMEs)
In accordance with the provision of Micro, Small & Medium Enterprises Development (MSMED) Act, 2006 the Micro, Small and Medium Enterprises (MSME) are classified in two Classes:

**Manufacturing Enterprises**- The enterprises engaged in the manufacture or production of goods pertaining to any industry specified in the first schedule to the industries (Development and regulation) Act, 1951) or employing plant and machinery in the process of value addition to the final product having a distinct name or character or use. The Manufacturing Enterprise are defined in terms of investment in Plant & Machinery.

**Service Enterprises** - The enterprises engaged in providing or rendering of services and are defined in terms of investment in equipment.

The limit for investment in plant and machinery / equipment for manufacturing / service enterprises is as following.

- **Micro Enterprise** Does not exceed investment* of 25 Lakh
- **Small Enterprises** Investment* of more than 25 Lakh rupee but less than 5 Crore
- **Medium Enterprises** Investment* of more than 5 Crore rupee but less than 10 Crore

*Investment in terms of plant and machinery

![Classification of MSMEs of India](image)

3. Research Methodology
- **Tier 3** represents the most demanding part of research or laid foundation of research here by using some selective keywords, phrases demanding need of research are used and on the basis of which research literature is reviewed from data base. Papers which meet objectives are accepted and details are checked for methodology opted.
- **Tier 2** extends the works of tier 3 which allows to carry on with gaps found in literature by checking references. If gaps formulated decision variables and chosen and scope of extension is presumed.
- **Tier 1** sum ups the work of tier 2 and tier 3 here actual work begins and its elaborated by experimentation as here review of manufacturing process at industry chosen, usage of modelling and simulation as tool for solving problem and at last summation of results and conclusion in the form research paper, to guide other researchers.
3.1 System analysis of Company - Gahir Agro Industries

Gahir Agro Industries Limited is an ISO 9001: 2008 certified organization that has introduced a sophisticated range of Combine Harvesters and comes in the range of small enterprise out of MSMEs. Company has successfully developed a range of Combine Harvesters (Tractor mounted and self-propelled), rotavator (6 feet, 7 feet and 8 feet range) and Tractor Mounted Sprayer Pump. Company has recently launched Laser land leveller for which they have taken approval from governmental organizations. These organizations include Government of India Ministry of Agriculture (Department of Agriculture & Co-Operation) Tractor Nagar, Punjab Agriculture University Ludhiana, Hisar and Central Farm Machinery Training & Testing Institute Budni (Madhya Pradesh). After getting mandatory approvals company is all set to start production of laser land leveller. Laser land leveller demand is seasonal and accordingly its production plan too.

4. Laser Land Leveller

As per data provided by Department of soil and water conservation of state of Punjab, a significant (20-25%) amount of irrigation water is lost during its application at the farm due to poor farm designing and unevenness of the fields. This problem is more pronounced in case if rice fields. Fields that are not level, have uneven crop stands, increased weed burden and uneven maturing of crops. All these factors lead to reduced yield and poor grain quality. Solution to this problem is using combination of mechanical and electronics-based Laser land levelling and equipment used for this designated purpose is known as Laser land Leveller.

Laser Land Levelling (also known as Laser Levelling) is a process of smoothening the land surface from its average elevation with a certain degree of desired slope using a guided laser beam through out the field. Unevenness of the soil surface has a significant impact on germination, stand and yield of crops. Farmers also recognise this and therefore devote considerable time resources in levelling their fields properly. However, traditional method of levelling is cumbersome, time consuming as well as expensive.
4.1 Components in Laser Land Leveller

A laser-controlled land levelling system consists of the following five major components:

i. **Drag Scrapper/bucket**: The drag bucket can be either 3-point linkage mounted on or pulled by a tractor. This system is preferred as it is easier to connect the tractor’s hydraulic system to an external hydraulic by the 3-point-linkage system.

ii. **Laser transmitter**: The laser transmitter mounts on a tripod, which allows the laser beam to sweep above the field.

iii. **Laser receiver**: The laser receiver is a multi-directional receiver that detects the position of the laser reference plane and transmits this signal to the control box.

iv. **Control box**: The control box accepts and processes signals from the machine mounted receiver. It displays these signals to indicate the drag buckets position relative to the finished grade.

v. **Hydraulic system**: The hydraulic system of the tractor is used to supply oil to raise and lower the levelling bucket.

![Figure 3 Laser Land Leveller (Manufactured by Gahir Agro Industry)](image)

![Figure 4 Detail of components in laser land leveller](image)

![Figure 5 Basic Layout of Laser Land Leveller](image)
4.2 Working of Laser Land leveller

The system includes a laser-transmitting unit that emits an infrared beam of light that can travel up to 700 meters in a perfectly straight line. The second part of the laser system is a receiver that senses the infrared beam of light and converts it to an electrical signal. The electrical signal is directed by a control box to activate an electric hydraulic valve. Several times a second, this hydraulic valve raises and lowers the blade of a grader to keep it following the infrared beam. Laser levelling of a field is accomplished with a dual slope laser that automatically controls the blade of the land leveller to precisely grade the surface to eliminate all undulations tending to hold water. Laser transmitters create a reference plane over the work area by rotating the laser beam 360 degrees. The receiving system detects the beam and automatically guides the machine to maintain proper grade. The laser can be level or sloped in two directions. This is all accomplished automatically without the operator touching the hydraulic controls.

5. Technical Specifications of Laser land leveller

Proposed industry manufactures laser land levellers with specifications as

- **Width**: 7 feet
- **Thickness**: 8 mm/10 mm (mm = Millimetres)
- **Mast**: Gear / Power
- **Blade**: L – 84", H – 127 mm, T – 16 mm
- **Tyres**: 6 – 16 SL
- **Hydraulic Cylinder**: Double Acting Heavy-duty Cylinder

5.1 Manufacturing process of laser land leveller

Manufacturing process of laser land leveller comprises of 3 main process which have distinct processes and Sub process associated with it. Raw material required initially consist of metal sheets of thickness (5 mm, 10 mm) which are cut, bent and shaped as per specifications. Details of all processes is appended in figure 7.

Main processes are

i. Bucket/Scraper manufacturing

ii. CURVO and Draw bar manufacturing

iii. Final assembly of manufactured products
Modelling represents the key characteristics, behaviours and functions of the selected physical or abstract system or process. Simulation refers to intimate of the operation of a real-world process or system. The model represents the system itself, whereas the simulation represents the operation of the system over time. Model can be physical or mathematical which is based on the real system which is under consideration. Modelled part is looked for its suitability in compliance with real system. Simulation undertakes the developed model check for its functionality under real working conditions, briefly it is intimate of original system. Getting simulation runs and its working behaviours verify model and validate the system under account.

6 Modelling and Simulation

Modelling and Simulation Tool – ARENA Overview

Tool used for modelling and simulation in this study is ARENA 15.1 version by Rockwell Automation Studio. One of Arena’s most beneficial traits is that users across the whole spectrum of skill-levels can use the product to generate useful results. This robustness is achieved by expanding upon an evolved version of the SIMAN language, meaning that Arena has been built upon the shoulders of an already successful product. Arena allows users to choose from various modules that are presented in various templates ranging from basic logic pieces to complex items such as conveyors and transporters Each
module represents a combination of SIMAN code that has been pre-packaged to allow the user to drag and drop pieces of code into the model without having to work with the code itself.

7 Case Study: Modelling And Simulation Of Laser Land Leveller Process

As Gahir Agro industry is ready to begin for its production of laser land leveller, after getting mandatory approvals form the regulating and governing bodies of this field. Major consumers of laser land leveller are in agriculture rich states of Punjab, Haryana, Uttar Pradesh and Telangana. This study will be analysing the the production process, resources utilisation, predicted work in process, seizing capacity of various processes and sub processes associated with manufacturing and number in and number out by using ARENA 15.1 version as modelling and simulation tool. Presented work will be guiding manufacturers about their predicted performance and bottlenecks in existing setup without going for actual trial. Generated results are well validated and verified for their correctness. As for, in deepening the manufacturing process of each stage, efforts are done for individual process modelling and simulation with collaboration of its sub activities. All processes as in figure 6 have being modelled and simulated to their full potential.

7.1 Assumptions for modelling and Simulation

i. Customer demand arrival follows the uniform distribution UNIF [15,20] in the batch of 5.
ii. Company has single tractor mounted crane which is used for inter shop transfer and has speed of 15 km/hr.
iii. It is assumed that all necessary spares and parts are available for assembly to product being manufactured.
iv. Production timings have constant value for distinct process.
v. Once process is completed finished product is placed in buffer having First In First Out (FIFO) sequence.

Table 1. Modelling logic of various manufacturing process
**STEP 2**

CURVO/Draw Bar Manufacturing

- **START**
- Manufactured Scraper/Bucket arrives
- Request for transport to shop floor for processing made
- Tractor arrives picks raw material & deliver at shop floor and made free for further use
- Processing begins on raw material Shop Floor area
- CURVO mounting
- Single/Double axle mounting
- Painting
- Request made for processed material pick up to next destination
- Tractor arrives pick done
- Shop Exit taken
- CURVO / Draw bar manufacturing completes

**STEP 3**

Final Assembly Process

- **START**
- Manufactured CURVO/Draw bar arrives
- Request for transport to final assembly area made
- Tractor arrives picks raw material & deliver at final assembly area and made free for further use
- Final assembly begins on Shop Floor
- Final Assembly and Inspection
- MAST mounting
- Request made for finished product pickup
- Tractor arrives pick done
- Shop Exit taken
- Finished Product moved to finished goods area and stock checked
- Laser Land Leveller ready for customer use
7.2 Modelling and Simulation of manufacturing of Laser Land Leveller Processes

7.2.1 SCRAPPER/BUCKET MANUFACTURING
I. This process begins with arrival of demand of customer and raw material in form of sheets having thickness of (5 mm and 10 mm).
II. Firstly, raw material arrives at arrival dock of processing shop from where it is picked up by tractor mounted crane and moved to shop floor where processing begins. Once raw material is delivered by tractor mounted crane at shop floor, its made free for further use (Used Request, Transport and Free module of ARENA).
III. Raw material is available at processing stations and firstly sheet is cut into various sizes by plasma cutting machine deployed on shop floor, where it takes total of 3.5 hours. (Used Station and Process module of ARENA)
IV. After cutting of sheet it is bend into required shapes by sheet bending machines and it takes total of 3.5 hours (Used Process module of ARENA).
V. On completion of cutting and bending of sheets they are welded and assembled to make scrapper/bucket which takes 2 hours (Used Process module of ARENA).
VI. On completion of operation sequences as mentioned above, manufactured scrapper/bucket takes shop exit by requesting tractor mounted crane for its movement. (Used Request, Transport, Station, Free and Dispose module of ARENA).

Table 2 Detail of Operation performed for Scrapper/Bucket Manufacturing

| Operation No. | Operation Name (In sequence of operation) | Operation Timing | Resources deployed |
|---------------|------------------------------------------|-----------------|--------------------|
| 1             | Plasma Sheet Cutting                      | 3.5 hours       | Single Plasma Cutting Machine |
| 2             | Sheet Bending                             | 3.5 hours       | Single Sheet bending machine |
| 3             | Assembling and Welding                    | 2 hours         | Assembling of parts by using Jigs and fixtures. Welding by single arc and single MIG welding set |

Table 3 Inter Shop station distances for Scrapper/Bucket Manufacturing

| Sr. No. | Station Name (From) | Station Name (To) | Distance (In Feet’s) |
|---------|---------------------|-------------------|----------------------|
| 1.      | Arrival Dock        | Plasma Cutting Area | 200                  |
| 2.      | Plasma Cutting area | Shop Exit         | 130                  |
| 3.      | Arrival Dock        | Shop Exit         | 50                   |
Table 4 Data related to Costing of Entity

| Name of Entity            | Holding Cost/ Hour (In Rupee) | Initial value-added cost (In Rupee) | Initial trans Cost (In Rupee) |
|---------------------------|-------------------------------|------------------------------------|-----------------------------|
| Laser Land Leveller       | 1.2                           | 1100                               | 1.3                         |

7.2.2 CURVO/DRAWBAR MANUFACTURING

i. Process begins with arrival of pre-manufactured scraper/bucket and other raw material at arrival dock (Used Create module)

ii. Request for transport to shop floor is made and material is transported to draw bar and Curvo mounting station where processing occurs by tractor mounted crane. (Used Request, Transport and Station module of ARENA)

iii. After delivering material at shop floor, processing begins and pre-assembled CURVO is assembled there it takes 3.2 hours for single piece mounting. (Used Process module of ARENA)
iv. After CURVO mounting rear axle (Single/Double rear axle) is mounted with mounting time of 2 hours on each pre-assembled piece (Used Process module of ARENA).

v. After rear axle mounting painting is done by spray guns which take operation timing of 2.3 hours per piece. This include primer coating, primary paint coating and secondary coating (Used Process module of ARENA).

vi. After painting manufactured CURVO/ Draw bar is ready to take shop exit and tractor mounted crane is requested for pick up when pick completes it takes shop exit and made free for further use. (Used Request, Transport, Free, Station and Dispose module of ARENA)

**Table 5** Detail of Operation performed for CURVO/ Draw Bar Manufacturing

| Operation No. | Operation Name          | Operation Timing | Resources deployed                  |
|---------------|-------------------------|------------------|-------------------------------------|
| 1             | CURVO Mounting          | 3.2 hours per piece | Pre-Assembled Curvo                |
| 2             | Rear Axle Mounting      | 2 hours per piece | Single and Double Rear Axle         |
| 3             | Painting                | 2.3 hours        | 4 Painting spray guns               |

**Table 6** Inter Shop station distances for CURVO/ Draw Bar Manufacturing

| Sr. No. | Station Name (From)          | Station Name (To)          | Distance (In Feet’s) |
|---------|------------------------------|----------------------------|----------------------|
| 1       | Arrival Dock                 | Draw bar and CURVO mount   | 200                  |
| 2       | Draw bar and CURVO mount     | Shop Exit                  | 150                  |
| 3       | Arrival Dock                 | Shop Exit                  | 50                   |
| 4       | Arrival Dock                 | Plasma Cutting area        | 130                  |

![Figure 11 ARENA window depicting distance between shops](image)
7.2.3 Final Assembly and Mast Mounting

i. Manufactured Bucket/ Scraper and CURVO/Draw Bar are taken at this station and final assembly with inspection is done. (Used Create module of ARENA).

ii. Request for transport to shop floor is made and material is transported to final assembly area where processing occurs by tractor mounted crane. (Used Request, Transport and Station module of ARENA).

iii. After delivering material at shop floor, processing begins, and final assembly is done which takes 2 hours per piece (Used Process module of ARENA).

iv. Last process comprises of mast mounting which takes 2 hours per piece (Used Process module of ARENA).

v. Now laser land leveller is ready for customer use and it is taken to finished good area by requesting tractor mounted crane to pick up and take it to finished area storage (Used Request, Transport, Free and Station module of ARENA).

vi. Record module calculates the total finished product out for customer use. (Used Record and Dispose module of ARENA).

Table 7 Detail of Operation performed for Final Assembly and Inspection

| Operation No. | Operation Name (In sequence of operation) | Operation Timing | Resources deployed         |
|---------------|------------------------------------------|------------------|---------------------------|
| 1             | Overall Assembly                         | 2.5 hours per piece | Assembly and Inspection tools |
| 2             | Mast Mounting                            | 2 hours per piece | Pre-assembled mast        |
Table 8 Inter Shop station distances for Final Assembly and Inspection

| Sr. No. | Station Name (From)          | Station Name (To)                      | Distance (In Feet's) |
|---------|------------------------------|----------------------------------------|----------------------|
| 1.      | Arrival Dock                 | Draw bar and CURVO mount               | 200                  |
| 2.      | Draw bar and CURVO mount     | Shop Exit                              | 150                  |
| 3.      | Arrival Dock                 | Shop Exit                              | 50                   |
| 4.      | Arrival Dock                 | Plasma Cutting area                    | 130                  |
| 5.      | Arrival Dock                 | Final Assembly Area                    | 120                  |
| 6.      | Arrival Dock                 | Shop exit                              | 60                   |

Figure 13 Arena window depicting Station distance for Overall Assembly area

8 Results and Discussions

ARENA based results need to be validated and verified for their correctness. All the results generated here are by latest ARENA 15.1 version installed on computer having 8 GB RAM, Intel i7 processor and Window 10 (Pro) licensed version.

The random nature of simulation inputs renders the simulation run able to produce a statistical estimate of the performance measure, not the measure itself. So that estimates can be statistically precise (have a small variance) and free from the bias, the following parameters were specified.

- Length of each simulation run = 30 days (One Month)
- Number of independent simulation Runs = 60
- Work hours for which simulation done = 10 hours per day

8.1 Verification and Validation

Verification concerns the operational model (whether it is performing properly). It is done to ensure that

- The model is programmed correctly
- The model does not contain errors, oversights, or bugs.

In laser land levelling manufacturing process, model verification took place as a continuing process. In this case percentage error is at an acceptable level of less than 5%.

Validation of Simulation runs - To make sure that model data accurately represent the actual process, hence enhance model validity, a confidence interval analysis was carried out. A 95% confidence interval was determined, and the required number of simulation replications were calculated by the following equation (Kelton et al., 1991)
\[ n = \frac{(z_\alpha/2)^2 \sigma^2}{d^2} \]

where \( n \) = number of desired replications, \( d \) is the sensitivity level, \( \sigma \) = standard deviation (\( \sigma = 1.43 \)), \( z \) is the critical value from the standard normal table at the given confidence level (\( z = 1.96 \) at 95% confidence level). For our model to achieve 95% confidence level, 50 replications are required.

**Validation of distribution used** – Since simulation results are totally dependent on the, probabilistic distribution used, in our model we used uniform distribution of [15,20] for demand arrival its goodness of fit, statistical value will be validated and authenticated by inbuilt Input Analyser module of ARENA shown in figure 14 (a) and 14(b).

It can be seen from figure 14(a) and 14(b) that mean square error of distribution used very less than 5% i.e. 0.000144. Chi square test and Kolmogorov test value greater than 0.15 depict goodness of fit of curve.

**8.2 Results for Scraper/Bucket Manufacturing**

**Predicted Number In/Out**

![Figure 15 Predicted Number In/Out](image-url)
Figure 15 ARENA window depicting predicted Number in and Number Out at Scrapper/Bucket Manufacturing Predicted number in for processing is 60, number Out will be 35 and work in process will be 43 (approx.) for 50 replication length and 30 days run length.

**Predicted Resources Utilisation**

| Scheduled Utilisation | Average | Half Width | Minimum Average | Maximum Average |
|-----------------------|---------|------------|----------------|----------------|
| Arc Welding           | 0.1028  | 0.00       | 0.1028         | 0.1028         |
| Jigs and Fixtures     | 0.1020  | 0.00       | 0.1020         | 0.1020         |
| MIG Welding           | 0.1028  | 0.00       | 0.1028         | 0.1028         |
| PLASMA CUTTING MACHINE| 0.5206  | 0.00       | 0.5206         | 0.5206         |
| Sheet Bending Machine | 0.5139  | 0.00       | 0.5139         | 0.5139         |

**Figure 16** Arena window depicting predicted resources scheduled utilisation for scrapper/bucket manufacturing

For the process of scrapper/bucket manufacturing plasma cutting machine predicted utilisation stands for 52.08%, sheet bending machine predicted utilisation is 51.39%, Arc and MIG welding predicted utilisation is 10.28% respectively and similar is for jigs and fixture predicted utilisation i.e. 10.28% for 50 replication and 30 days run length.

**Number Seized by Resources**

| Total Number Seized | Average | Half Width | Minimum Average | Maximum Average |
|---------------------|---------|------------|----------------|----------------|
| Arc Welding         | 37.0000 | 0.00       | 37.0000        | 37.0000        |
| Jigs and Fixtures   | 37.0000 | 0.00       | 37.0000        | 37.0000        |
| MIG Welding         | 37.0000 | 0.00       | 37.0000        | 37.0000        |
| PLASMA CUTTING MACHINE | 38.0000 | 0.00    | 38.0000        | 38.0000        |
| Sheet Bending Machine | 37.0000 | 0.00   | 37.0000        | 37.0000        |

**Figure 17** Arena window depicting predicted number seized by resources for scrapper/bucket manufacturing

It can be seen from figure 17 that predicted total number of entities seized by Plasma cutting machine is 38, sheet bending machine is 37, MIG and arc welding is 37 respectively and for assembly purpose jigs and fixture used seized 37 entities.
Costing data

![Costing Data Diagram](image)

**Figure 18** Arena window depicting predicted costing of resource operation for 30 days run of scrapper/bucket manufacturing

It can be seen from figure 18 that for 30 days run usage cost will be Rs. 78700, wait cost will be Rs. 16,811 and predicted overall cost will be 97,217 for manufacturing neglecting raw material cost.

8.3 Results for CURVO/ Draw Bar Manufacturing

**Number In and Out**

|                | Average | Half Width | Minimum Average | Maximum Average |
|----------------|---------|------------|-----------------|-----------------|
| CURVO MOUNTING | 36.0000 | 0.00       | 36.0000         | 36.0000         |
| DOUBLE REAR AXLE MOUNTING | 36.0000 | 0.00       | 36.0000         | 36.0000         |
| PAINTING       | 36.0000 | 0.00       | 36.0000         | 36.0000         |
| SINGLE REAR AXLE MOUNTING | 36.0000 | 0.00       | 36.0000         | 36.0000         |

![Number In and Out Diagram](image)

**Figure 19** ARENA result window depicting predicted number in and number out for the various processes at CURVO/ Draw bar manufacturing
In sight to above figure predicted number in for CURVO mount is 36 corresponding number out is also 36. For double axle and single mounting number in and number out is 36 respectively. Similarly, for painting shop number in and number out will be 36 respectively. All these results are for 30 days run length with 50 replications.

**Waiting Queue Length**

| Number Waiting          | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|-------------------------|---------|------------|-----------------|-----------------|--------------|--------------|
| PAINTING.Queue          | 17.6350 | 0.00       | 17.6350         | 17.6350         | 0.00         | 36.0000      |
| REQUEST A TRUCK.Queue   | 41.0000 | 0.00       | 41.0000         | 41.0000         | 0.00         | 50.0000      |

*Figure 20* ARENA result window depicting predicted predicted waiting queue length for the various processes at CURVO/ Draw bar manufacturing

In sight to above figure Arena predicted results yield that waiting queue will be only for painting process and request for transport for the 50 replication and 30 days run.

*Figure 21* ARENA result window for predicted costing of operating resources for manufacturing of draw bar/ CURVO

Insight to above figure cost depicted here is excluding raw material cost and labour cost. It comprises of expense of resources on manufacturing. It is predicted to be 41,400 for the 50 replications and 30 days run length.
8.4 Results for Overall Assembly and Inspection

**Number In/Out**

As depicted in figure 22 predicted number in and number out is 60 respectively at final assembly area and 60 number in and number out is for mast mounting station. These results are for 50 replications and 30 days run.

**Scheduled utilisation of resources**

As depicted in figure 22 predicted number in and number out is 60 respectively at final assembly area and 60 number in and number out is for mast mounting station. These results are for 50 replications and 30 days run.

In reference to figure 23 predicted resources utilisation for the assembling of mast is 16.67% and for final assembly tools it is 20.83%. These results are for 50 replication and 30 days run.
**Number Seized by Resources**

| Total Number Seized | Average | Half Width | Minimum | Maximum |
|---------------------|---------|------------|---------|---------|
| ASSEMBLED MAST      | 60.0000 | 0.00       | 60.0000 | 60.0000 |
| FINAL ASSEMBLY TOOLS| 60.0000 | 0.00       | 60.0000 | 60.0000 |

![Figure 24 ARENA result window depicting predicted total number seized by resources for final assembly and inspection of laser land leveller](image)

In sight to figure 24 predicted total number seized by resources is as 60 for assembled mast, 60 for final assembly tools.

**Costing data**

![Figure 25 ARENA result window depicting predicted cost of operation of resources for final assembly and inspection of laser land leveller](image)

Figure 25 refers to the operation costing of the resources for the final assembly and inspection of laser land leveller. It is valid for the 50 replications and 30 days simulation run.
Total number out of finished laser land leveller

| Counter                      | Average | Half Width | Minimum Average | Maximum Average |
|------------------------------|---------|-----------|----------------|-----------------|
| FINISHED LASER LAND LEVELLER | 35.0000 | 0.00      | 35.0000         | 35.0000         |

Figure 26 ARENA result window depicting predicted number out of finished laser land leveller for customer use

Figure 26 depicts the predicted value of total finished laser land leveller ready for customer use, which is 35, when model is simulated for 60 replications and 30 days run length.

9 Conclusions And Recommendations

Approach taken here for MSMEs manufacturing process step wise modelling and simulation prior to beginning of mass production, will be exploring the real time production scenario and its expected outputs from existing shop floor. By using modelling and simulation as a tool without going for actual production levels, an overview of production network is provided to company, which is not having any well-defined research and development centre, production planning and controlling department which regulate production lines. For in deep sights for each step of laser land leveller its major activities and associated sub activities have been modelled and simulated, with predicted number in and number out for each process, resources utilisation, waiting queue, operational cost of resources and number seized by resources. All results are validated and verified for there correctness under working constraints. Company can use these results to see bottlenecks, which hamper production scenario, in a predefined manner with actual figures to over come those when actual production begins and in order to achieve improved productivity targets.

Few improvements which can be visualised from the results generated are as follow

i. For step 1 of scrapper/bucket manufacturing resources utilisation is very high for plasma cutting (0.52 approx.) and sheet bending (0.51 approx.) but lesser for welding and jigs fixture usage (0.1028 approx.), which needs to be balanced.

ii. For step 2 of draw bar/ CURVO mounting queue length is high for entities waiting at painting shop (17 approx.) and pick up by tractor mounted crane (41 approx.) for next destination transfer. Company need to work on these waiting queue so that resources utilisation can be optimum and production volumes can be enhanced.

iii. For step 3 of final assembly and inspection, its potential of predicted work in (60) and out (60) is more as compared to other processes but due to high waiting times and imbalanced utilisation of resources in previous processes it is not being utilised to its full throttle. Resources utilisation is very low here due to imbalanced production loads which is cause of high work in process (43 approx.) value of entities and widening the gap between number in and number out.

iv. Effective utilisation of resources in terms of operation timing and seizing capacity of machine is important as is affects the waiting cost, holding cost and processing cost of entities waiting for operations, which tampers the profit margins and manpower working with it. In this waiting cost was as high as Rs. 16,811 which needs to be curbed for achieving new horizons of profitability.

Presented work here for the industry is flexible enough to accommodate changes at any level and its effect on production volumes. Company can turn up their fortunes by implementing these suggestions in order to achieve target value and better profit margins. Modelling and simulation can be boon for these type of small MSMEs, which spend hefty money to check the expected outcomes of production
by experimenting with real setup, which also cause overflowing levels of inventory and mis management on shop floor.

Analysis done here can help company to increase product throughput by reorganisation of process flows and thus fulfilling customer orders on time and ultimately result in sustainable operations and company growth. Implementation of these results is within working constraint limit of 10 hours per day, which also enables managers to gain insight of costly opinion of workers overtime depending upon need of demand. Modelling and simulation results generated here provides a reasonable measure for predicting performance and planning for production through experimenting on various what-if scenarios which occurs prior to new product launch. The generated results were welcomed by company directors and shown the glimpse of production scenario which would be and its expected output, now on the basis of results shown directors can redesign their production strategy with more refinement to achieve high profit margins, reduced lead time of demand fulfilment and utmost customer satisfaction and leading edge over competitors of same field.

Work presented here can be validated by other simulation software like SimLShop, FlexiSIM etc. Presented work can be extended by including the delay time of inventory accumulation and wait for inventory availability on shop floor.

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4.1.1. A subsubsection. The paragraph text follows on from the subsubsection heading but should not be in italic.

References

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