

## Reduction of Un-safe Work Practices by Enhancing Shop floor Safety– A case study

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### ABSTRACT

Industrial safety is of utmost important in the present industrial scenario in order to protect employees, plant and environment. The present study is carried out in a machine tool manufacturing company. The initial study revealed several problems with respect to industrial safety and productivity. Keeping these problems in view, the aim of the present study was to analyse the existing layout and designing the new layout to improve the productivity by ensuring safety in the shop floor according to the standards. The existing problems were analysed systematically and solved by adopting and implementing DuPont Safety Model. The implementation resulted in increasing the safety and productivity in the organization.

**Key words:** Layout, Productivity, safety, DuPont Safety Model.

### I. INTRODUCTION

#### 1.1 Industrial Safety

Industrial safety refers to the operations which are carried out by the management are within the workplace in order to safe guard organizations, employees and assets thereby minimizing near miss incidents and fatal accidents. Any system related to safety will be an important countermeasure within the workplace. Priorities are given to safety measures in order to safe guard workers and assets in case of emergency. Industrial safety includes solving number of issues which affects safety of worker and assets in any organisation or industry. There are various industrial safety causes in the following areas like: Process and Production Safety, General Safety, Fire Safety, OSH- Occupational Safety and Health, Workplace Safety, Material Safety, Electrical Safety, Environmental Safety.

#### 1.2 Objectives of Safety

- To minimize hazards that can help in preventing accidents.
- To eliminate the accident caused due to Work stoppage and loss of production.
- To prevent permanent disability, fatality of worker.
- To Train workers on safe work place and good working condition that helps to evaluate employee's morale.
- To educate all employees about safety in the organization to ensure continuous state of safety and also to supervise about competent and safety rules.

#### 1.3 Hazards

Hazard is termed as a condition, substance, behaviour or practice that can cause injury, illness or damage to the property.

The nature of hazards are as follows: Safety hazards, Chemical exposure, Heat stress, Fire and explosion, Ionizing radiation, Electrical hazards, Cold exposure, Noise, Biologic hazards.

#### 1.4 Safe Work Practices

A safe work practice is a series of processes which allows employees to work safely by ensuring safe working procedure which are associated with a particular task.

In situations where a safety is required, a task is not needed, a safe work practices is sufficient. However, it is more complex or high-hazard situation, when it is often necessary to use safe operating procedure more precisely.

#### 1.5 Benefits of Safe Work Practices

- Ensuring safe working which provides standards for completing work activities safely
- Safe work affects quality, safety, productivity and efficiency
- potential hazards caused due to injury and illness will be eliminated
- Focuses on training and information sharing to all grade of employees
- Fulfils legal requirements

#### 1.6 Steps for Developing Safe Work Practices

**Step1:** Job Inventory

**Step2:** Complete Job Hazard Analysis

**Step3:** Implement Safe work practices and procedures

**Step4:** To follow and sustain Safe work procedures and practices

**Step5:** Evaluates Safe work

### 1.7 Incident & Accident Investigation and Reporting

Any Accident/Incident (including near miss) involving acute injury, illness to personnel, loss of revenue or damage to company property or personal property while working must be reported by an employee to Safety Management Department as soon as possible or within 24 hours. Every accident that causes or may cause death of a worker or that requires a worker to be admitted to a hospital as an in-patient for a period of 24 hours or more must be investigated as soon as possible. Immediate reporting is also required when a worker is aware of a condition that may cause a work-related incident.

The incident must be documented and forwarded to Industrial Scale within a reasonable period of time (7 days maximum).

Any Near Misses that occur during company time must be reported in the form of documentation to the Top Management.

A worker (Owner/Manager or a Supervisor) who is qualified and competent in investigation techniques must investigate all Incidents or Accidents. Company should provide training on the investigation techniques to be used during an incident investigation (if no qualified investigator is available, the company shall use a third party trained investigator).

These investigations must be completed as early as possible so that all evidence can be preserved. Once an incident or accident has been investigated, the investigator must make a written report to be placed in file in the office. If the incident or accident still poses a hazard for employees, Management must ensure all employees are immediately informed of the hazard. If the incident, accident, or near miss does not pose a hazard to workers at current time, the Safety Committee should discuss regarding these investigations to each member or the supervisor to ensure that all workers are made aware of the situation.

### 1.8 Shop Floor Layout

The shop floor layout design helps to achieve small product life cycles, higher varieties of product with smaller lead times in assembly shops which are dedicated to all individual assembly lines. Shop floor layout improvement is the tool in order to increase Productivity. The design of a shop floor layout plays a vital role on basis of today's workstations which influence many parts of work efficiency. It requires arranging the machines and positioning employees,

materials and other manufacturing supports to create the most effective shop floor layout.

Shop floor layout is designed in every organisation to minimize the number of transportation, motions and waiting in order to increase the productivity. Productivity is illustrated as a method to analyse the performance or efficiency in the industry, organisation or factory. The improvement of productivity is done by modifying the design of shop floor layout, supporting multi-machine operating and streamlining the material flow between the machines or workstations.

### 1.9 Types of Shop Floor Layouts

Shop Floor layouts are broadly classified into following five categories:

- Process
- Product
- Cellular Manufacturing(CM)
- Fixed Position
- Hybrid Layouts

## II. LITERATURE SURVEY

### 2.1 GEOCEL- Unorganized and Unsafe Working Environment

Geocel was one of the leading Plymouth Company who was suppliers of sealants and adhesive. This company was facing lot of problems with unorganized and unsafe working environment which included lot of safety and health issues and also there were more number of accidents that happened on the shop floor which in turn involved more reduction in sales and increase in manual tasks. The members of company decided to hire a safety adviser to resolve the issues and also to take workers suggestions regarding the positions of machinery and gangways along with the ergonomically designed plant layout which helped workers to work easily. Training was given based on safety and health which gave huge benefits to the company in the reduction of accidents and lost time. Installing heavy machinery also was not a problem as there were high safety levels on the shop floor and working environment was also very safe and organised as there were health safety committee which was formed in each department to control and ensure safety in the shop floor. [5]

Tata steel company had around 15000 workers working every day at their industrial site in Jamshedpur, unlike other companies even they experienced safety issues in terms of increasing fatalities in their 80 other sites. So ensuring safety to its workers became the biggest challenge for company and hence they implemented DuPont safety approach to overcome their safety problems.[6]

Tata steel firstly encountered the total number of safety incidents occurring in their project sites and

when the number of safety incidents increased they adopted the six step process from DuPont; this process helped them to develop a clear and well defined safety roadmap for their improvement in safety issues. The focus on training and competency building in the six step process raised a benchmark in the industry. For the implementation of DuPont safety Model the company developed a three phase Pronged plan to improve the safety performance. The three phases were:

### Phase 1: Containment

In this phase, the priority was to contain the injuries and fatalities and it was achieved by including safety audit, sharing job hazards and preventive measures, setting standards for Personal Protective Equipment (PPE), conduct training and meetings to train the workers on safety measures.

### Phase 2: Establishing systems and processes

The main aim of safety system is maintain the safety measures and to reduce the injuries .The same system was adopted by Tata steel to first ensure safety for the contract labours and to reduce the accidents occurring. To maintain the safety systems some of the steps were incorporated they are: contractor safety committees, initiating contractor field safety audits, having safety metrics for contactors and making contractors responsible for safety of their people even though the final accountability remained under Tata steel management.

### Phase 3: Sustaining the safety way

To keep motivating the employees in the organisation, measures were taken to drive safety culture momentum which included: operating discipline, Rewarding and recognizing positive safety behaviour, monitor some safety indicators and to convey safety messages to the workers.

As a result of the implementation of DuPont Safety measures, the company achieved no fatalities and no injuries which made the company to create some safety initiatives such as online incident reporting system to capture incidents or near-misses so that the causes could be identified and suitable corrective and preventive measures could be taken.[6]

## 2.2 DuPont's Model

E.I DuPont the founder of the DuPont Company which was established in the year 1802 (two centuries ago), which laid a strong foundation for safety precautions to be taken in a company, remains as one of the core corporate value today. This company was established to manufacture high quality gun powder in United States.E.I DuPont was almost uniquely qualified as he had done internship with one

of the famous French Chemist by name Antoine Lavoisier, who was also the French royal powder company chief, a manufacturer of gunpowder. While his internship there, he recognized that everyone should understand the hazards which occur in any business organisation. Due to his past experience he made a list of process hazards and established a strong safety process in his Company. This was the foundation for the evolution of the process hazards and safety programmes of the current day. The picture below shows the modern DuPont's triangle which has its roots to the earlier DuPont's triangle. [9]

## III. Problem Formulation

The aim of the present study is to analyse the existing layout and designing the new layout to improve the productivity by ensuring safety in the shop floor according to the standards. The following are the some of the problems encountered:

- There was no effective utilization of the layout.
- More number of accidents occurred due to high unsafe work practices.
- Difficulty in completion of assembly operations within the target time.
- Fire hazards occurred due to ineffective plant layout.

There was no proper design of the layout and also comparatively less standardization of the process. The assembly process adopted there was unscientific and were carried based upon the parts available in the shop floor and hence there was no standard safety measures for the workers to follow.

## IV. Objectives

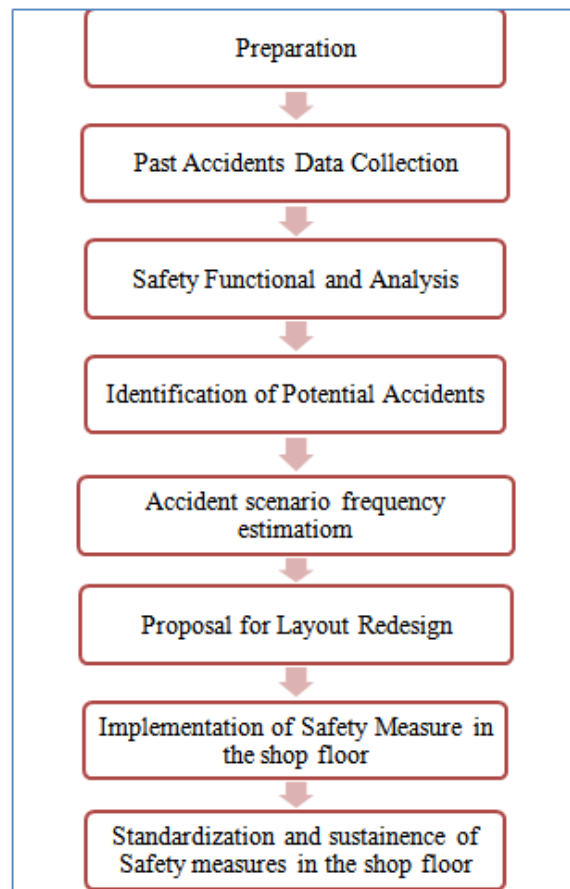
The following are the objectives of the present study.

- To ensure Shop floor safety.
- To create efficient safety management within the shop floor that will boost employee's morale to work more effectively and efficiently.
- To complete Assembly and production activity on time.
- To increase Productivity with high safety standards.
- To ensure Safety that creates enjoyable work place.
- To ensure Operator's job satisfaction.

## V. METHODOLOGY

The methodology used to achieve the above mentioned objectives were:

- Safety functional and analysis
- DuPont Safety Model
- Increased shop floor safety
- Layout redesign



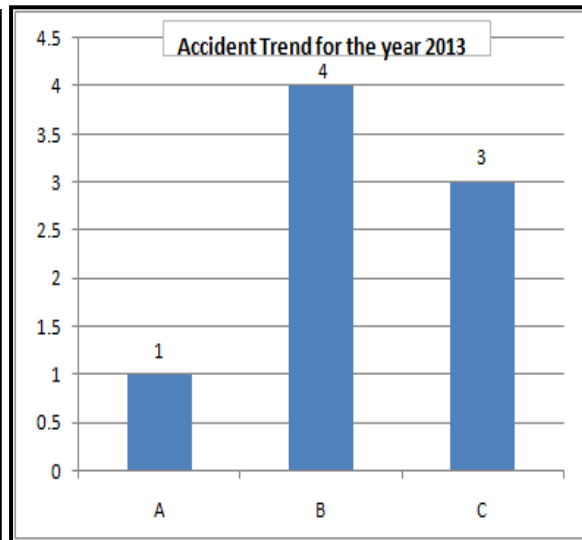
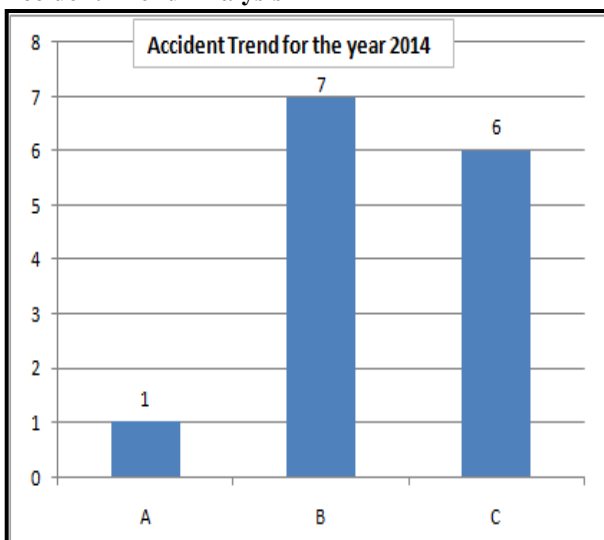
## VI. Data Collection

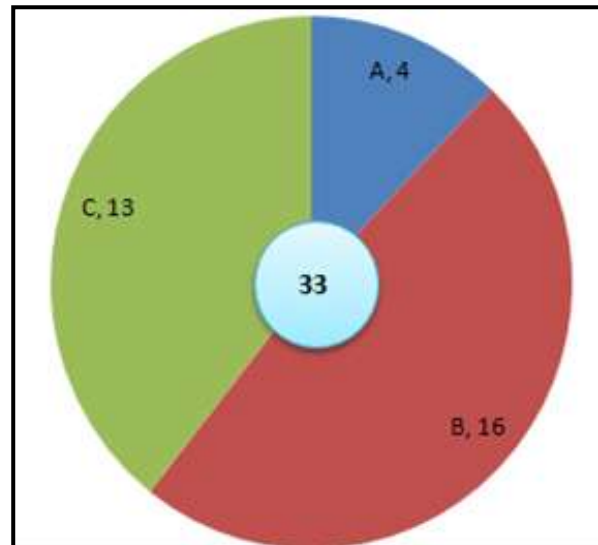
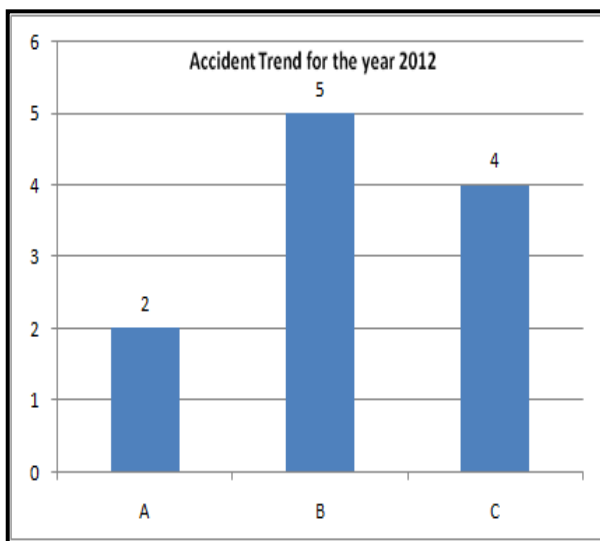
VLD SHOP FLOOR AUDIT MONITRING SHEET				
S. No.	Year	Area	Issue	Rank
1	2012	Mechanical	Guards were not used while grinding	B
2	2012	Materials	Fall of pallets while storage	A
3	2012	Electrical	Live wires left out on shop floor	A
4	2012	Chemical	Irritation and itching due paint sprays in shop floor	C
5	2012	Mechanical	Worker falling down while doing height works	B
6	2012	Materials	Hitting objects with the part of the body	C
7	2012	Mechanical	Hit Injury- While fillment of Accumulator	C
8	2012	Mechanical	Eye disorders while welding	B
9	2012	Electrical	Electrical Shock while operating Oven	C
10	2012	Mechanical	Pinch point injury: while Manual handling of parts	B
11	2012	Mechanical	Hand injury during filing and chipping operation	B
12	2013	Mechanical	Injuries to nerves and spinal cord while fillment of accumulator	B
13	2013	Chemical	Irritation and itching due paint sprays in shop floor	C
14	2013	Electrical	Trip and fall due to lengthy tangled electrical wires of the devices left on the shop floor	C
15	2013	Materials	Trips and fall due to contact with materials	C
16	2013	Mechanical	Cut in High Pressure air hose	B
17	2013	Materials	Back and Shoulder Injury while manually handling materials	B

18	2013	Electrical	Burns due to short circuit	B
19	2013	Mechanical	Hit by the movement of hoist	A
20	2014	Materials	Worker getting injured while removing parts from trolley	C
21	2014	Mechanical	Fall from storage racking	A
22	2014	Chemical	Potentially contaminating scratches	C
23	2014	Mechanical	Fall from ladder while assembly of accumulator	B
24	2014	Materials	Back and Shoulder Injury while manually handling materials	B
25	2014	Mechanical	Guards were not used while grinding	B
26	2014	Mechanical	Injuries to nerves and spinal cord while fillment of accumulator	B
27	2014	Chemical	Slip due to oil sludge on the shop floor	C
28	2014	Mechanical	Improper fastening of the heavy components while lifting on crane.	B
29	2014	Electrical	Electrical Shock while operating Oven	C
30	2014	Chemical	Potentially contaminating scratches	C
31	2014	Mechanical	Machine turned on when maintenacecrew working on the machine, Due to improper sigh boards of maintenance.	B
32	2014	Chemical	Slip due to oil sludge on the shop floor	C
33	2014	Mechanical	collision during machine assembly process	B

<b>Rank A</b>	<b>Impact on routine work / Fatal</b>
<b>Rank B</b>	<b>Contribute to work may causes to work delay/ Incidents or Recordable injuries</b>
<b>Rank C</b>	<b>Issue is their not effected to routine work/ Near Miss Accidents</b>

**Accident Trend Analysis**





## VII. Root Cause Analysis & Solution Implementations

### 7.1 Problems Encountered

In Vertical Lathe Division of BFW they assemble the Vertical CNC machines, this division does not have any standardized process which is being followed. While assembly parts from the supplier are delivered directly to shop floor and quality check is done at the shop floor only. The flow process of the assembly operations is followed as given in the below figure 5.2. The process of the assembly operations were not followed as given due

to many problems. Some of the most bottle neck problems were:

- Ineffective utilization of plant layout.
- There are no safety concerns for the workers.
- Accidents due to improper storage of pallets were occurring
- Fire hazards occurred due to ineffective plant layout
- Accidents were occurring while movement of hoist as there were no safety signals.

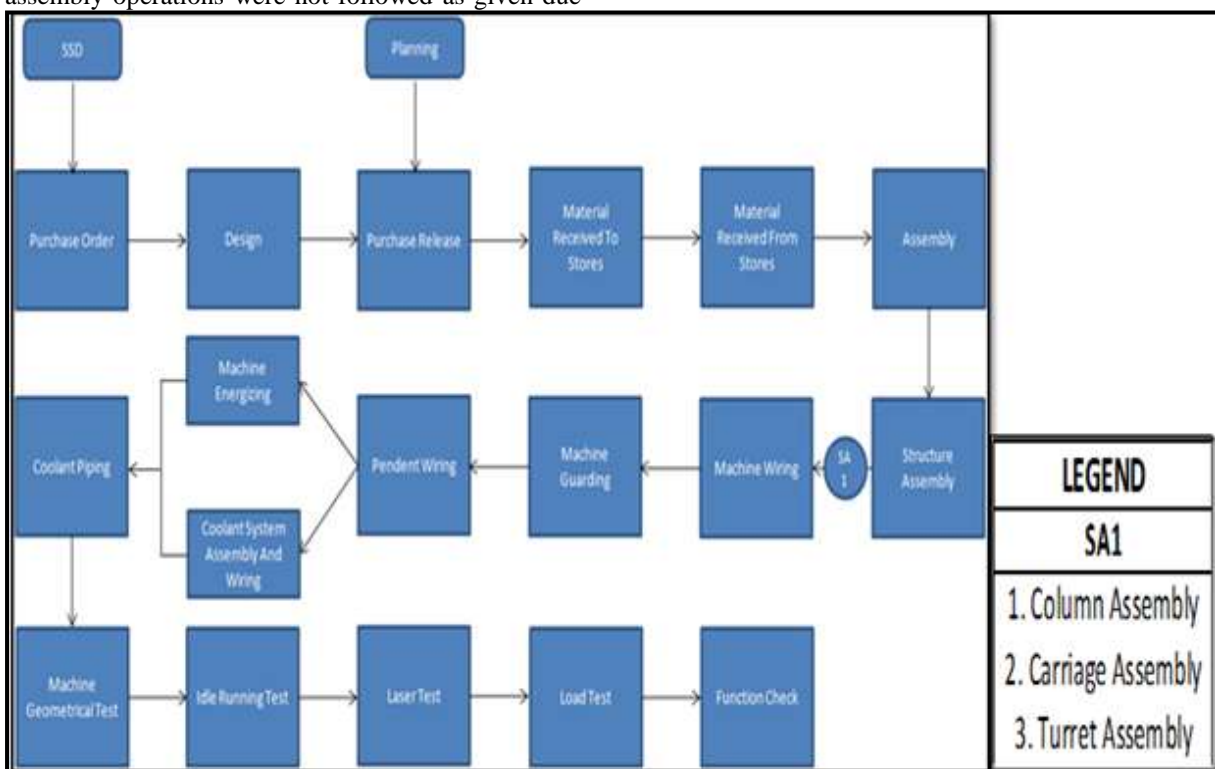


Fig.6.2. Flow Process Chart of VLD

## 7.2 Analysis of the Problems

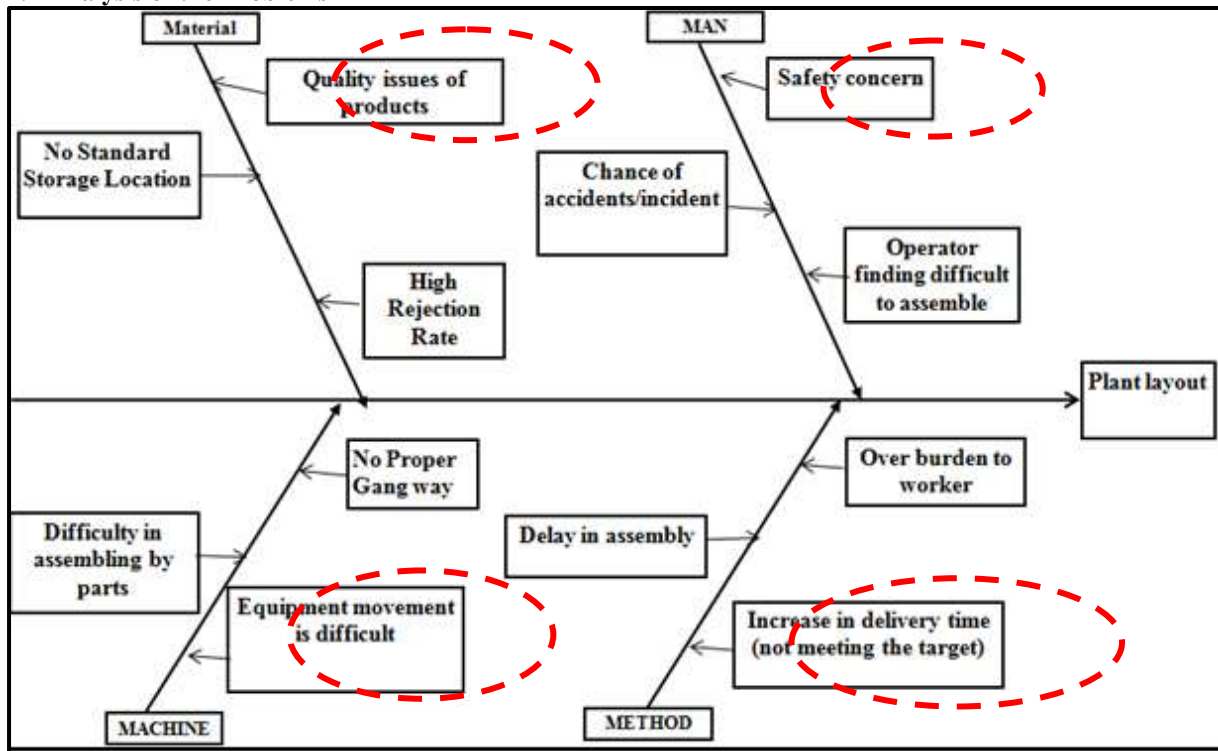


Fig.6.3. Fish bone analysis of problem

## 7.3 Implementation of Corrective Actions

### 7.3.1 Elimination of Pallet Collapsing During Stacking Process

#### Problem Root Cause

- 1) Accessing the pallet is difficult for the forklift operator
- 2) Safety is not ensured while stacking the pallets
- 3) Chances of pallet falling are more due to improper stacking
- 4) More movement of forklift to ensure proper stacking.

#### Countermeasure Taken

Forklift operator can easily access & stack the pallets

1. Safety is ensured while stacking the pallets & Chances of pallet falling is eliminated
2. Less movement of forklift to ensure proper stacking

### Elimination of Fire Hazard by Redesigning the Layout

#### Countermeasure Taken

- 1) U-type layout is designed to separate oil storage area & oven
- 2) Flammable materials are avoided that are coming in contact with fire from oven
- 3) High level of safety is ensured.
- 4) Chances of fire hazards is totally eliminated.

### Elimination of Worker Injury during Part Loading Process

#### Problem Root Cause

- 1) Cherry picker is used to carry out height work
- 2) Chances of worker falling from top resulting in fatal accident
- 3) There is more unsafe condition, unsafe act practiced in the shop floor
- 4) Cherry picker has to be rented from an outside contractor
- 5) Rent cost of cherry picker is more
- 6) One worker to operate cherry picker and the same worker has to carry out height related works which is very unsafe.
- 7) Chances of Man & machine and Machine & machine collision is more within the shop floor.

#### Countermeasure Taken

- 1) In house height work pallet is fabricated to carry out height related works within the shop floor
- 2) Fatal accident of worker falling from height is completely eliminated as more safety is ensured.
- 3) Double locking is ensured to eliminate un safe act and un safe condition.
- 4) Easily available and no need to depend on the contractor for cherry picker.
- 5) Rent cost is saved to the company as usage of cherry picker is eliminated.
- 6) Chances of Man & machine and machine & machine are eliminated and thus safety is ensured in the shop floor.

### VIII. Calculations

Additional Benefits of Safety Height Work Pallet Fabrication				
Total Usage Hours= 38.5/Month				
Division	Monthly Usage Hours	Required	Fuel Consumption/ Hours	Cost of Fuel
VLD	9		10.5	1944
MFD	2		9	432
MLD	0.5		2.25	108
HLD	4		18	864
CNC	3		13.5	648
KAIZEN	6		27	1296
Fabrication	3		13.5	648
Foundry	9		40.5	1944
Stores	1		4.5	216
Dispatch	1		4.5	216
<b>TOTAL</b>	<b>38.5</b>		<b>173.25</b>	<b>8316</b>

- Cherry Picker Rent Data& Calculation:**  
 Cherry Picker Rent consumption for one hour=  
 `1500/1hour  
 Total Cherry Picker Usage in VLD (9hours\*1500)=  
 `13500/Month i.e. `162000/Year  
 Total cherry Picker Usage in the company  
 (38.5hours\*1500) =`57750/Month i.e. `69300/Year

- Cherry Picker Fuel Consumption Data& Calculation:**  
 Cherry Picker diesel consumption for One Hour use=  
 4.5Lit/ Hour  
 Total Cherry Picker usage in VLD = 9hours\*4.5=  
**40.5/Month i.e. 486/Year**  
 Total Cherry Picker Usage in the Company=  
 38.5hours\*4.5= **173.25/Month i.e. 2079/ Year**

- Cherry Picker Fuel Cost Consumption Data & Calculation:**  
 Cherry Picker diesel cost consumption for one litre=  
 48/lit  
 Total Cherry Picker Fuel Cost Consumption in VLD  
 (48\*40.5) =` **1944/Month i.e.` 23328/Year**  
 Total Cherry Picker Fuel Cost Consumption in the  
 Company (48\*176.25) =` **8316/Month i.e.`**  
**99729/Year**

- Total Cost Saved in Rupees:**  
 Total Cherry Picker Rent Cost + Total Cherry Picker  
 Fuel Cost  
**At VLD, ` 13500+` 1944=` 15444/Month i.e. `**  
**185328/Year**  
**For the Company, ` 57750+` 8316=` 66066/Month**  
**i.e. ` 792792/ Year**

- COLLISION & NEAR MISS ACCIDENTS AT VLD**  
 Before machine to machine collision =16times/ hour

Before machine to machine collision=16\*9=  
 144time/ Month  
 After machine to machine collision= 3\*9= 27 time/  
 Month  
 Total Collision Avoid= Before Collision- After  
 Collision  
 Before man to machine collision= 8time/Hour  
 Before man to machine collision= 8\*9 = 72 time/  
 Month  
 After man to machine collision= 2\*9=  
 18Time/Month  
**Total Man to Machine collision avoid= 72-18= 54**  
**collision/Month i.e. 648 collision/Year**  
**Total Machine to Machine collision avoid= 144-**  
**27=117 collision/Month i.e. 1404 collision /Year**

### IX. CONCLUSIONS

#### General Conclusions

- By implementing the DuPont's Model, the organisation could change the mindset and behaviour of the workers by training them about the safety measures and its importance.
- DuPont's safety model helps the organisations to categorise their past accidents and to reduce the cost involved in the compensation given to the employees for which the root cause was not adopting the safety measures in the shop floor.
- Implementing sign boards showing movement in the shop floor will avoid fatal accidents.
- Identification of specific areas in the shop floor where the high speed cutting tools and equipments are to be kept and used which will increase the safety of the employees on the shop floor.
- Proposal of safety audits within the shop floor helps the organisations to monitor on every small injury that take place.



6. Efficient safety management within the shop floor will boost the employee's morale to work more effectively and efficiently.

### Specific Conclusions

1. High level of safety standards were implemented which increased productivity and also the safety of workers.
2. Implementation of proper design for storage of pallets helped the organisation in reduction of the fatal accidents.
3. Reduction of cost by implementing the basic safety standards within the shop floor.
4. Redesign of shop floor layout avoided the occurrence of the fire hazards.
5. Elimination of the worker injury during part loading process ensures the safety of the workers.
6. Quality check of the material in the stores helps in the effective utilization of the layout as idle time is reduced.
7. The implementation of signals while the movement hoist or heavy fork lift prevents workers from being injured.
8. By the implementation of safety management in the shop floor, the secondary benefits such as equipment movement became easy and safe, standard storage location was developed and high rejection rate were eliminated.

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