Implementation of Value Engineering and Zero Defect Principle in Manufacturing of Go-Kart

Samarth Gurudatt Gaikwad[1], Chaitanya Milind Parchure[2], Apurva Vinay Patil[3], Akshay Chandrakant Vibhute[4]

[1,2]B. E Student, Department of Mechanical Engineering, DKTE Society's Textile & Engineering Institute Ichalkaranji, Maharashtra, India.
[3,4]B.E Student, KIT College Of Engineering Kolhapur, Maharashtra, India.

***Abstract*: The ongoing scenario of industrialization is dynamic and also various technologies are evolving at drastic rate. Due to this market has become more competent and to survive in this cut throat environment industries are working on unearthing techniques for optimum use of resources to bring down the cost. There are various principles and techniques in Industrial Engineering such as Value Analysis and Value Engineering (VAVE), Zero defect manufacturing which serve as potential solution for this problem. This research deals with the implementation of VAVE and Zero defect manufacturing in the Electric kart manufacturing process for the value addition in the kart. Though this research is specifically related to kart manufacturing but its scope is not restricted to this purpose only. VAVE is an effective tool which can be used for value creation in the product through reduction of manufacturing cost, weight of the product along with improving the functioning of it. Detailed procedure represented for implementation of these principles in kart manufacturing also apply to diverse range of products consisting of multiple assemblies with little modifications. Electric kart is the motor driven vehicle which comprises of numerous parts with various functions which form a complex assembly. Hence manufacturing of such product is prone for the occurrence of defects. To avoid this problem zero defect manufacturing can be used which potentially reduces the occurrence of such defects. Hence this research work will give proper understanding of these two principles and the procedure for their implementation in any product with little modification in represented procedure for implementation of them in cart manufacturing.**

***Keywords*: Value Analysis and Value Engineering, Zero Defect Manufacturing, Value Addition, electric kart.**

1.0 Introduction

Large changes are taking place across the globe today and industries are manufacturing products for a buyers' market. Customer is on the top and his demands, preferences and needs are of paramount importance. This is the key concept in the Value Methodology. Those functions which contribute to the working of final product and also demanded by customer must be prioritized. Customer view should be examined or analyzed and accordingly policies must be adopted to satisfy the customer's needs.
In the manufacturing of kart we have to fulfill the primary requirements of end users such as speed, better steering capabilities and safety. All these functions should be maximized with optimum use of resources so that the final costs are within permissible limits.

The fast-growing movements of the manufacturing firms show increasing implementation of various industrial engineering principles to carry out improvements in product and processes. In the automotive industry value methodology is dominantly implemented to enhance the functionality. As automotive environment is evolving by undergoing great changes every day, industries should cope with these changes effectively in order to sustain in the marketplace. To fulfill the needs of customer and improving the overall time and cost statistics of a product there is need to develop a change in processes and in the workflow implemented by various methods. For this to achieve only effective way is through value methodology.

As the VAVE is important value addition tool ZDM is also a process improvement process which reduces the downtime caused due to errors and defects. Zero Defect Manufacturing is a management tool aimed at the reduction of defects through prevention. It is directed at motivating people to prevent mistakes by developing a constant, conscious desire to do their job right at the first time.

Eco kart or Electric Go-kart is a vehicle which is driven by Electric motor which uses electric current from the lithium ion cell. Dc motor is used to drive the vehicle. The Kart is single seated vehicle which can fit in single driver/passenger.

As stated above the design of an automobile is combination of a number of processes along with variety of components assembled together. The important factors such as manufacturing cost, time required, inventory depends the complexity of manufacturing processes. The VAVE implementation in manufacturing of E-kart has improved the overall efficiency of the system. The application of VAVE has reduced the cost of the vehicle. VAVE improves the processes of manufacturing by eliminating the unwanted processes. In overall contexts the VAVE has a positively affected in many aspects for overall improvement process of kart. As a number of processes are involved in the manufacturing of kart ZDM also plays as important factor in process improvement and defect reduction.

The results we got by using the VAVE and ZDM techniques are noteworthy. We will see both the concepts in details.

1.1 What is Value Analysis and Value Engineering (VAVE)?

In the cut throat competition being faced at this moment by various companies is leading to race for securing a large market share for their products, this cannot be just achieved by reducing the cost but by improvising the processes by implementing the innovations at all levels in the organizations. This thought process creates necessity to implement the VAVE principles in the existing products. To start with the concept of VAVE was coined firstly by an Engineer Miles which is now very much accepted in various industries effectively.

The very basics of value engineering concept is the effort to determine and eliminate those characteristics of products or services with no real value for the customer or the product but which cause costs in the production process or service delivery. The value engineering concept ensures a better product or service for the customer at minimal costs compared to replacing the existing product with a less favorable alternative.

Value engineering is one of the most effective techniques available to identify and eliminate unnecessary costs in Design, testing, manufacturing, construction, operations, maintenance, procedures specifications and practices. It involves the application of systematic planned procedure to obtain a desired effect by comparing the cost of component with respect to its purpose or functioning in the production or assembly. The VAVE can be stated as "*A systematic approach to analyzing functional requirements of products or services for the purposes of achieving the essential functions at the lowest total cost.*"

Value engineering is a process analysis method which identifies and eliminates those features of product and service that has no real value to the customer needs or the product but increase manufacturing process cost of product or service .The value engineering method is implemented to provide a high performance product or service to the customer at minimum cost. The basic principle of value engineering is providing value at the lowest optimal cost of production but never compromised with its features and quality. Basically in short we can say that Value Engineering/Analysis is about to increase the net profit of an organization without sacrifice the product quality.

The very core of value engineering concept is the effort to determine and eliminate those characteristics of products or services with no real value for the customer or the product but which cause costs in the production process or service delivery. Therefore, the value engineering concept ensures a better product or service for the customer at minimal costs compared to replacing the existing product with a less favorable alternative. The value engineering is a continuous process in which the functions which are being carried out are analyzed, suitable alternative is found out on both the functions i.e. previous and new functions are evaluated. We can get good results once we evaluate both the values.

Before practicing the VE each and every employee must understand it completely and try to apply effectively. A definite mind set change is necessary before a value engineering project can be started. The entire organization must be involved and strive together to achieve the desired objectives. The main standing pillars of the VE are based upon the cost optimization along with refinement in functions of each and every part along with processes. The VE also highlights the concept of change in manufacturing processes or eliminating the un-required ones.

1.2 What is Zero defect manufacturing (ZDM)?

Companies produce new products faster than ever for two main reasons: for achieving higher profits and to meet increasing demand from their customers. This phenomenon has imposed emergence of new tools and techniques for the manufacturing of products, making strategies which had been successfully used in the past useless or not as efficient as needed. Zero Defect Manufacturing is one of the important techniques which makes manufacturing process defect free. Zero Defect Manufacturing is a management tool aimed at the reduction of defects through prevention. It is directed at motivating people to prevent mistakes by developing a constant, conscious desire to do their job right at the first time. Zero Defects, originally pioneered by Philip Crosby as "Zero Defects", is a business practice which aims to reduce and minimize the number of defects and errors in a process while manufacturing and to do things right the first time. The ultimate aim will be to reduce the level of defects to zero.

In recent years by seeing the fruitful results of this technique many industries are applying the same concept in their processes to gain the higher results and good efficiency. The concept of zero defects can be practically utilized in any situation to improve quality and reduce cost. A process, system or method of working has to be established which allows for the achievement of zero defects. Cost reduction is caused by a decrease in waste by reducing the material wastage and reduced amount of errors. This waste could be both wasted materials and wasted time due to unnecessary rework Cost reduction due to the fact that time is now being spent on only producing goods or services that are produced according to the requirements of consumers. Utmost precautions are taken while applying the ZDS, as sometimes a process can be over engineered by an organization in its effort to implement the ZDS. While trying to create a situation of zero defects increasing time and expense may be spent in an attempt to build the perfect process that delivers the perfect finished product.

2.0 Implementation of VAVE

2.1 Pre-workshop Stage:

During this time frame core team involved in the implementation of VAVE can be formed which will strategically decide the necessary steps to be taken for the implementation of value analysis principles. This team can take decisions regarding the

subdivision of team members into various departments. Considering the implementation of Value analysis principles in the kart manufacturing process, overall team size can be subdivided into various departments such as design department, Manufacturing Department and Quality department etc. Team members in each department will be concerned with their aspects in manufacturing of kart. After this division, core team can form road map indicating the step by step procedure to implement the VAVE in kart manufacturing. One of the vital steps in that involve providing proper information in the workshop about value analysis principles, the key role they plays in the value addition of kart and how this is going to be executed during the tenure of kart manufacturing. Pre-workshop stage also involves arrangement of the various resources required to carry out the workshop which are as follows-

- Creation of VAVE Sheet format which can be used by team members to represent their ideas of value creation in the manufacturing process or enriching the current value of kart.
- Ensuring that computer modelling and detailed drawings of all the parts of kart are present, so that it can be referred during the workshop for taking the decision, like whether to accept or reject the idea. These drawings can be utilized by many departments such as design, Quality or Technical assistance team to do the same.
- Assuring that previous years kart or model is available with some other efficient karts already available in market which can be utilized during the Benchmarking process of workshop.
- Creating the power point presentation and reports which effectively convey the idea to all the team members is necessary.
- Selection of representative of various departments should be done before workshop as per the interests and their capabilities. For example if person is really interested in Design aspects of the kart and has sound knowledge of design, simulation and analysis, he can represent the design group.
- So the overall function of pre workshop phase represents creation of all the prerequisites such as syndication sheets, CAD modelling and the most important thing being defining he function played or represented by each part so that value analysis can be carried out on it.

After all these preparation suitable dates can be taken for carrying out the workshop. During the workshop effective involvement and interest of all the team members should be ensured. This can be done by creating various plans such as group activities and competition within formed team members in idea generation process, and all these plans should be made in the pre workshop stage of the core team committee involved in the implementation of value analysis and value engineering principle.

VAVE Idea Evaluation Sheet

Name	Person XYZ			
PartName		**Idea Description**		
Lithium Ion Battery		Lead Acid Batteries are changed with Lithium Ion Battery. The lithium ion battery is light in weight, durable and more efficient. Current batteries are heavy which reduces the speed of kart so using lithium ion is more efficient.		
CurrentStatus		**ProposedChange**		
Lead Acid Batteries are used as power pack.		Lead Acid Batteries are replaced by Lithium Ion Batteries.		
Manufacturing	**Quality**	**Purchase**	**Design**	**Technical Assistance**
NO major changes in the manufacturing process can be implemented using current setup.	The proposed idea can be implemented without affecting the quality parameters. Hence Idea can be implemented.	Can be purchased with the current budget. Hence ok for implementation.	As the weight reduces the overall stresses induced in kart are reduce hence design becomes more safe. Hence proposed idea can be implemented.	The proposed changes meet end requirements hence idea is accepted.

2.2 Workshop Phase:

This workshop phase can be subdivided into various stages. The first stage involves giving primary information to all the team members about VAVE. As core team is well conversant due to their research in implementation of value analysis and value engineering principles; they can effectively represent the necessary information related to it to group members. Following information must be conveyed to all the incognizant group members who will be involved in this process of workshop:

- What is Value analysis and Value engineering? And how value methodology works
- Need for the implementation of VAVE.
- Probable outcomes from the process.
- Representation of detailed step wise procedure to implement the same.

Functional Analysis of Kart and its components:

In this stage of workshop, all the parts of kart are analyzed and there function played in working of kart is noted. This analysis gives idea to team members through which they can distinguish between primary function, secondary function and some unnecessary parts. For this to be carried out detailed drawings of kart with separate components should be provided. Also subdivision can be done for functional analysis, such as one group of team members can concentrate on powertrain, one on steering system, one in transmission system etc. Through this all the parts with some important function can be sorted out from unimportant one. This sorting helps to represent elimination of the non-value adding parts in idea generation process.

Idea generation process-

After defining the function of the various parts, various ideas need to be generated by team members. This demands for creativity within team members and also requires analytical thinking to generate the value addition ideas. In idea generation process all the team members should present their ideas without any hesitation or thinking about end results. The effectiveness of idea has to be evaluated after idea generation by various departments and should not have any impact during this productive idea generation stage. In general value for any product can be improved in following ways-

- By reducing the cost of the product without deteriorating the quality. For example in kart, if one component is unnecessary, it can be eliminated to reduce the cost of kart. This also reduces the weight of the kart which functions as another value addition process in kart.
- By improving functionality along with reduction of cost. If one specific part within kart can be removed and replaced with cheaper and much more efficiently functioning part, then it also serves as great value addition in it.
- Improving function with relatively little increased cost also acts as value addition process. Hence if someone presents idea which has potential to increase the performance of kart drastically with comparatively low investment, then it should be welcomed in value methodology.
- Another way which needs to be conveyed during workshop for value addition in the kart is by little reduction of functional aspects of the kart with great reduction of cost in manufacturing. Such ideas also significantly improve the value of final product i.e. kart.

In above ways team members can brainstorm and orient themselves so that they can productively generate the value addition Ideas during the workshop. In the workshop stage the effectiveness and number of ideas generated depend upon the functional analysis carried out and efficient benchmarking process. These two things play key role in the Value addition workshop.

Evaluation process-

In the evaluation phase ideas generated during the last stage needs to be evaluated. In that various departments formed during previous stages play a vital role in determining the practicability and efficacy of the ideas generated. Various departments evaluate the idea according to their perspectives and concerns. For that they can utilize different resources such as CAD modeling, simulation softwares and personal experience. The Evaluation stage can be implemented in the following way:

Evaluation phase by design department:

The design department is concerned with what impact the change suggested in the idea affects the current design aspects of the kart. For example; if the idea suggests removal of secondary members of the chassis which are cross members connecting the primary rods for weight reduction, design department will try to analyze the implications of this change. If the results after the elimination significantly reduce the strength of the chassis then they can reject this idea by representing the analysis results. Various ideas generated during previous stage should be given to the departments in the form of VAVE sheets. Following example represents the analysis done by design department on such various ideas;

Idea suggested – Dimension reduction of Rod from 1.5 inch OD (outer diameter) to 1 inch OD (outer diameter).

Evaluation by:

Design department-

- First the design department should calculate the approximate value of the forces acting on the geometry of the chassis and then analyzing whether the 1 inch OD rod can sustain those forces on the basis of theoretical calculations.
- After that they can use CAD modeling of different OD of rods and simulating the impact of forces and induced stresses on various simulation softwares such as ANSYS, Hypermesh etc. The induced stresses and deformations can be compared with the theoretical once.
- If the results of simulation after the change represented in the idea are desirable then the department can approve the idea for implementation.

- The following figure of simulation on ANSYS represents one such idea being rejected due to -concentration of stress at the rear end.

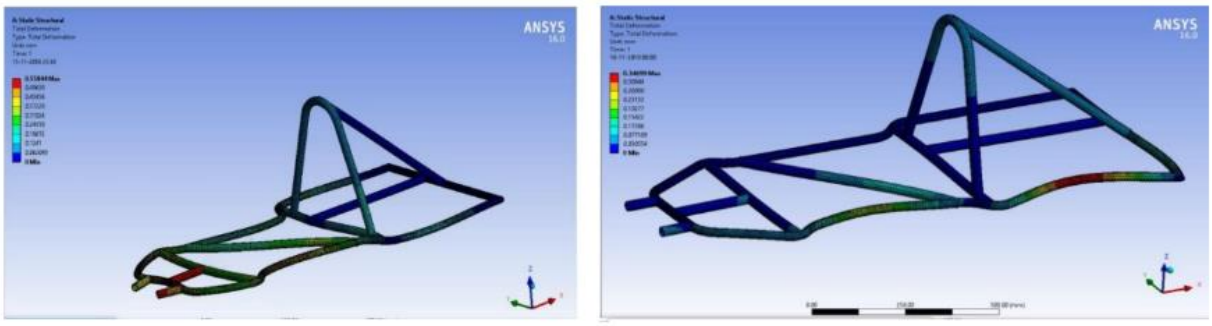

Fig. of simulation

Quality department

During evaluation stage of ideas, Quality department should consider the parameters which may get affected by change in the kart which is suggested in the idea. The parameters with which quality department is usually associated are Safety of the driver and kart structure, reliability and strength, Aesthetics and ergonomics and dimensional consistency. If the proposed idea adversely impacts the standards set by quality department then they can reject that specific idea by explaining specific reasons. For example, if idea is to reduce the thickness of floor pan metal sheet, quality department will evaluate the potential implications of the change, if all the factors mentioned above are met satisfactorily then the proposed idea is given a green signal by quality department.

Manufacturing Department

When it comes to manufacturing department for evaluation of proposed idea through VAVE sheet, they evaluate the practicability of the proposed idea. They check whether new idea requires some new processes to be carried out and if yes are those feasible to complete in given set up for manufacturing. If the idea demands for lot much change in manufacturing, making it really complex or costly then manufacturing department can suggest reconsidering the proposed idea. For instance, If idea suggests to use Gas tungsten arc welding or such costly welding process, though these welding process can increase strength of the kart and add value to it, but the cost of manufacturing makes it unfeasible. Hence in this case, manufacturing department can disapprove this idea.

Purchase department

Purchase department have their own concerns when it comes to evaluating the proposed ideas, such as availability of the specifically demanded part and its cost. If the idea suggests buying part for the kart which is less expensive than previous one, or reduces the weight of kart then purchase departments can work on evaluation of this idea. If they find the part in market easily or at low cost then they can approve the idea. If procuring part from market is going to cost more than the available budget then though potentially that part can reduce the overall eight of the kart, this idea will be disapproved by purchase department.

Technical assistance-

Purpose of manufacturing kart are always different, some manufacture it for personal use, some for various intercollege competition and many other international level racing also. Hence there has to be some department which gives concerns to the end users requirement, for example there is always one rule book for racing competitions which strictly needs to be followed by the kart manufacturers. For this technical assistance team will evaluate each manufacturing process, final designs etc. to assure that all the work meets the requirement of end user or rule book of competition. When VAVE idea is submitted technical assistance department can check whether the proposed change affects the area within their concerns as stated above. Accordingly they can take the decision for the acceptance.

In this way all the departments represent their decisions and views on the represented idea. All these VAVE sheets are processed further in post workshop phase as follows.

2.3 Post workshop

This phase comes after evaluation step of the workshop and it is the final stage. In this, all the team members take the final decision about the ideas. They analyze all the remarks given by various departments on VAVE sheet and take the final decision for the proposed idea by looking at overall scenario given by various departments. The ideas which are being finally approved need to be developed further so that its implementation can be carried out.

3.0 Implementation of Zero Defect Manufacturing

For the implementation of zero defect principles in the kart manufacturing process various documents need to be created and thoroughly evaluation of them is necessary. Following are the main documents which need to be created.

- Process Failure Mode And Effect Analysis (PFMEA)
- Control Plan.
- Work Instruction Sheet.

These documents are studied and a link is formed between them. This is useful for the prevention of the defects at the first place during manufacturing of product and also to rectify defects being occurred. The details of these documents are as follows.

3.1 PFMEA-

The Process Failure Mode and Effective Analysis is a compelling tool which is being extensively used by various industries for detecting potential failures with in the process. PFMEA gives us a proper idea about impact of failures through which we can identify and priorities the necessary actions required to reduce the risk of defects.

PFMEA

Op No.	Operation Description	Requirement	Potential Failure Mode	Potential effects of failure	Potential causes of failure	Process control prevention
1.	Manufacturing of chassis.	1 inch MS pipes	Cracking and Tearing During bending or welding	Strength is Reduced, Sudden Failure of structure.	Cracks in pipe Defects in raw material.	Use of Seamless pipes, Using appropriate pipes with diameter.
2.	Mounting of Steering column and steering mechanism	1 inch MS pipes UCP bearing Tie Rods, Tie Ends. Knuckles, Steering wheel, C clamps.	Over steering, under steering.	Bending of knuckles due to uneven stresses.	Deviation in C clamp angle, wrong ratio of pitman arm.	Doing proper alignment of steering mechanism.
3.	Assembly of 1 mm MS Sheet for belly pan.	1mm MS Sheets	Bending and tearing of belly pan,	Damping noise during dynamic action, Affecting aesthetics of kart.	Improper welding, weakening of welding spots.	Proper Welding at each point. Doing Nut Bolting where ever required
4.	Alignment And Mounting of Rear axle.	Bearings, Shafts with splines, Differential, chain sprocket, chain.	Miss Alignment of axle, differential stops working, loosening of chain tension	Differential stops working in dynamic conditions, Development of traction forces.	Miss Alignment of bearings, play in splines and differential fit, loose sprocket mounting.	Mount bearing properly in line, Maintaining proper tension in chain drive transmission.

The PFMEA gives the details about the operation to be performed, what are the specific requirements, form of potential failure mode etc. For example- In kart manufacturing the operation involved is welding of floor pan to the chassis then PFMEA gives what can be the potential failures in this process such as voids due to excessive welding, distortion of shape of floor pan. It also represents what are the causes and effects behind this failure and how to prevent this from happening. So the study of this document gives the person involved in manufacturing an insight about how to prevent certain defects during manufacturing and if they occur what measures to take to alleviate the occurred defects.

3.2 Work Instruction Sheet-

Work Instruction Sheet is another important tool which is used in the implementation of ZDM and which is useful to fulfill the aim of Zero Defect Manufacturing. As we move towards our goal of ZDM it is equally important to look after the safety of the workers, as they play a key role while implementing ZDM. The WIS is the tool which gives the operational sequence and also specifies the inspection method of the each operation, which helps in reducing the defects at each stage and hence contributes largely to the goal of ZDM. WIS decides the safety precaution to be implemented for each operation which helps largely to safeguard the workers in all the ways

Work Instruction Sheet

Sr. No	Operation Sequence	Method of Inspection	Safety key point	Quality Key Point	Safety Precautions	Reaction plan
1	Cutting and welding of MS pipes for chassis.	Virtually inspecting the weld joints and checking the joining symmetry.	Elimination of blow holes, warpages excess material occurred due to welding.	The dimensions of the final product should be as per the design specification and it should be in tolerance limit. There should not any holes or distortion.	Use glasses and safety hand gloves while welding or cutting.	The blow holes should me filled with filler material to give strength.
2	Mounting of motor	Check the alignment of the transmission chain to differential. Check base mounting of the motor using spirit level.	Mounting of motor should be in exact parallel to surface. Assembly should be strong to sustain the forces and traction.	The Motor Should be firmly mounted on supports. The supports should be welded strongly. Bolting should be done properly to avoid play in alignment.	Use sprit level to confirm proper alignment alignment. Chain Sprocket should be assembled properly with use of accurate key dimension Use glasses and safety hand gloves while welding or cutting	Proper alignment is established with calculated transmission angle by changing the levels of bearing mountings.
3	Assembly of Floor Pan.	The chassis should be fully covered. Bolts should be properly fixed tightly to avoid vibration.	Bolting should be done strongly. Tearing of sheet is avoided. Uniform thickness of M.S should be used.	The dimensions of the final product should be as per the design specification and it should be in tolerance limit. There should not any holes or distortion. It should be according to dimensions.	Do proper bolting and welding to do the assembly strong. See that floor pan supports the small mountings.	The blow holes should me filled with filler material to give strength. Bolts should fit in assembly with washers to avoid the play.

3.3 Control Plan-

If the defects occur or the manufacturing process deviates then the control plan should contain instructions for the operator. This document can also be used in conjunction with work station check sheet.

Control plan also ensures that if defect occurs due to manufacturing team members fault, it can be easily inspected and monitored.

But the control plan needs to be updated periodically. There are many chances for waste reduction in kart manufacturing process and control plan helps to eliminate such waste causing methodologies. The control plan helps in improving the quality of manufactured kart through reduction of variations in the processes. Control plan focuses on kart characteristics which end customers' demands

Op No	Operation Name, Description.	Name of Machine, Jig Fixture, Tools.	Product and process specification	Gauges Used	Error Prediction	Control Method	Reaction Plan
1	Mounting of Rear axle	Radial Drilling Machine, Cutting Machine, Arc welding machine.	The rear axle should be mounted co-axially to for efficient transmission.	Spirit Level, Measuring tape, L angle.	Miss - alignment can cause oblong moment of transmission assembly.	Mounting of bearing on same plane using measuring instruments.	A platform is made which is datum to take reference, bearing are mounted in alignment. Finally the rear axle alignment is made.
2	Assembly and mounting of firewall.	Riveting Machine, Cutting Machine, Welding Machine.	Firstly a rigid firewall structure is assembled and then insulating material is used for coating.	Measuring Tape, L angle.	Less gap between sea and firewall, Some areas of firewall can be kept without insulation.	There should be gap of 2 inch between seat and firewall, Firewall should be fully insulated.	The mounting should be done properly. Fire wall should be completely insulated.
3	Steering Assembly.	Radial Drilling Machine, Cutting Machine, Arc welding machine, Grinding machine, Vice for holding job.	The steering is mounted according to calculated angles and measurnments.	Measuring Tape, L angle, Angle Dekkor	Error in pitman arm dimensions, Error in angles during mounting.	Cutting And Drilling is done exactly in pitman arm.	Firstly markings are done according to calculations. Pitman arm manufacturing should done after experimenting on a dummy. Wheel must alignment is checked.

The above tools are used to achieve the goal of the Zero Defect Manufacturing. In the manufacturing phase all the above ZDS tools such as Control Plan, Work Instruction Sheet, and PFMEA are used. The very first step to implement the zero defect principal is make these documents through listing out manufacturing process required and referring the designs and drawing of kart. Once PFMEA, WIS, control plans are prepared, they can be referred at each and every phase of manufacturing by team members so that all the processes are carried out in efficient way. Team members can refer process failure mode and effect analysis documents in order to verify that the manufacturing of kart is going properly; if any errors are occurring during process they can go to these documents and analyze them so that necessary steps can be taken to overcome those errors. One person can also supervise during manufacturing to ensure all the processes are being done as per the work instruction sheet and control plan. So overall link formed by studying these documents can be utilized to make the manufacturing of kart defect free.

4.0 Conclusion-

Implementation of the value analysis and value engineering principles in the kart manufacturing process leads to remarkable improvements in overall quality of the kart. Value addition ideas suggested by team members are utilized to improve the functional aspects such as kart performance, stability and speed. Considering zero defect manufacturing results, its implementation also helped to reduce the defects which had potential to cause considerable manufacturing error. So this activity also helped to eliminate the waste caused due to defects in the manufacturing.

Hence we can conclude that these management based tools have potential to bring the much needed positive change in any product with complex subassembly in their design and manufacturing stages.. Hence it is plausible to posit that these core industrial engineering concepts can certainly bring great results in design and manufacturing process of product hence should be implemented wherever possible.

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