DESIGN, DEVELOPMENT AND VALUE ANALYSIS OF PNEUMATIC MANUAL FLOW CONTROL VALVE

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Abstract: Customer is the key ingredient of success story for any organization. With rapid change of technology and awareness of customer it's very much important to make success story of product by increasing customer satisfaction. Best ways to achieve customer satisfaction by providing the value for their money with add on facilities. This paper has in depth detailing of design and manufacturing of product apart from value analysis part which also ensures the needs of customer. With advent of new material and technological upgradation of manufacturing process makes it simple for organization to provide value added product to customer. Design and manufacturing play the active role in product development whereas value engineering gives the critical analysis of product design and manufacturing part a novel dimension. Design, Development and value analysis of pneumatic manual flow control valve can be taken as reference for new era in Indian manufacturing sector with all its intricacy.

***Keywords*–Embodiment design, Material selection, Manufacturing process, Value engineering (VE).**

I. INTRODUCTION

In current scenario of industrial development key to success for any organization is to understand the genuine requirements of customer. Basic requirements like performance, feature, durability, maintenance can be satisfied by using different design process and activity based on general and specific requirement. Producibility and cost of manufacturing is also very much important to penetrate in market in case of new product and to grow as well as retain own market share for existing process. Best way to achieve the success is to analyze own work (design and manufacturing process) to avoid any kind of disadvantages in competition. One of the proven methods is value engineer as a tool for every stages of product development as well as for existing product. Design consists of different stages of conceptual design embodiment design and detail design is used for design process. Iteration of design is basis of upgradation of design output. Selection of manufacturing process is very important because of its recurrence cost. Precision of work as well as aesthetic is salient feature of successful product. Value can be given as the relationship between function and cost of product: Value = Function / Cost.In order to increase the value, the organization has to improve the function: cost ratio. When the function of product is provided at high cost, the value may be low. This value can be increased by using technique like Value Analysis. Value Analysis is the process of minimizing costs in a development project. This process is achieved by assessing materials, processes, function of products and offering alternatives. The outcome results in minimized cost but without compromising the quality and functionality of the design.

II. LITERATURE SURVEY

Amit Kumar Kundu et al. [1] developed new product of wall plastering semi-automatic spray gun by using systematic and morphological design theory. This paper can be used as reference how an Indian organization is using rational design, empirical design, industrial design, design by experiment etc. in product development (PD). **Agarwal Yash Pratap [2]** has discussed about an analysis of product development activities of an Indian venture by synchronization of design processes with its activities. **Run-jie Lu et al. [3]** have presented a product design based on interaction design and axiomatic design (AD) theory. With the help of developed technology personalized design of product and self-fulfillment are now a day very important to attract customer. **Chanchal Kumar Salode et al. [4]** has applied value analysis concept on Wall plastering semi-automatic spray gun. By value analysis of part (Hooper), material of hopper changed from SS304 to SS201 with reducing cost and no compromising with quality of product. **Marjan Leber et al. [5]** discussed the development of new product on the basis of value analysis and conjoint analysis. Implementation of such methods resulted in strong reduction in cost inside a company.

III. DESIGN, MANUFACTURING AND VALUE ANALYSIS METHODOLOGY

Design:

Design of product is an iterative process. In basic form of design following three major steps to be followed.

- Conceptual design
  - Customer need identification
  - Information collection
  - Concept generation
  - Concept selection
- Embodiment design

- Product architecture
- Configuration design
- Parametric Design

➢ Detail design

In this pneumatic manual flow control valve design simple mechanism of obstruction of flow is used with the help of cantilever mechanism with guided barrier (pin with O-ring) and for return helical type compression spring is used. As this one is manual type product and not used for precision work therefore cost can be major factor in embodiment design stage which provide product shape, size, required interface, selection of material and design calculations for flow of energy, material and information. This product does not modularity 35C8 (Known as Mild steel) is used for maximum part for following advantages

➢ Cheap
➢ Availability
➢ Machinability
➢ Weldability

For Pin material EN-9 is used for its specific requirement of hardness to reduce wear and tear, scratches and friction. In value analysis material selection has been justified.

Size and shape as per easy grip of working personnel and taking care safety by avoiding sharp corner and extensions.

Standard tolerance has been used as per required following fitment type

➢ Clearance fit
➢ Transition Fit
➢ Interference fit

Following are the type of tolerances used with nominal size to reduce cost of the product during manufacturing stage.

- Unilateral
- Bilateral

For detail design stage following details have been made

➢ Drawing of assembly and component
➢ Bill of Material
➢ Prototype
➢ Cost sheet
➢ Final Product specifications

Development

The different processes are used to complete the product (for complete manufacturing of parts and finished goods) are as following

➢ Cutting
➢ Turning
➢ Threading
➢ Tapping
➢ Shaping
➢ Drilling
➢ Heat treatment
➢ Grinding
➢ Welding
➢ Fitting

Following machines will be required (or facilities) to complete the product as per under

➢ Power hacksaw (Cutting)
➢ Lathe (Turning, threading, drilling)
➢ Bench vice (Tapping and fitting)
➢ Shaper/Milling (Shaping)
➢ MIG welder (Welding)
➢ Cylindrical Grinder (Grinding)

All the above process is very common in production and manufacturing industry hence no special tooling is required. All the facilities can be outsourced in very economical rate. Costing of manufacturing will be minimal due to simple use of conventional machines and operation. In case assembly of the product manual skill is required with basic simple readily available tools. Only fitment (Non-permanent type) is required with specific degree of freedom (DOF) to exercise different functions.

Value Analysis

The analysis of design and manufacturing can be done by using value engineering. Comparative analysis of design regarding selection of material as well as their respective functions can be done using various prescribed table. Functionality and value of key function is the prime criteria to make comparative study. Graphical charts (Line graph, bar graph etc.) can be very useful for better way to visualize the outcome of analysis. The VA job plan divides the task being studied into functions. The methodology generally planned in such way that the team leader can have overall control over it. It is executed in eight sequential phases as follows:

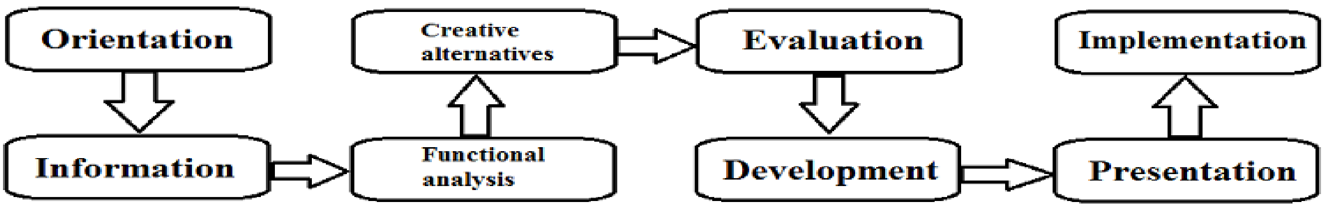

Figure 1 Value analysis methodology

I Orientation Phase: The methodology of Orientation Phase as follows:

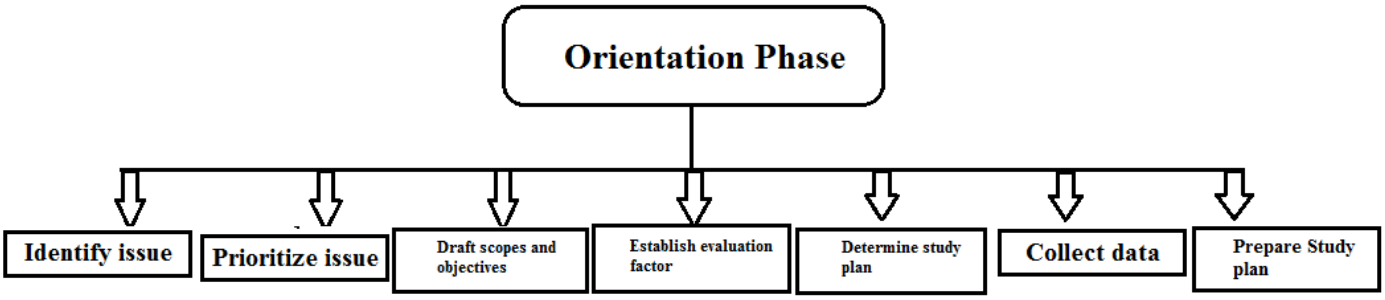

Figure 2 Constituents Orientation Phase

ii. Information Phase: Decide the scope of the issues to be addressed, goals, and related factors while building cohesion among team members.
iii. Function Analysis Phase: Determine the most constructive areas for study.
iv. Creative Phase: Alternatives for all functions can be prepared by using Scamper's check list.
v. Evaluation Phase: Analyze and select the best ideas for development into specific value-improvement recommendations.
vi. Development Phase: Optimize the "best" alternatives for presentation to the decision-maker.
vii. Presentation Phase: Obtain a commitment to follow a course of action for initiating an alternative.
viii. Implementation Phase: Obtain final approval of the proposal and facilitate its implementation.[3]

Value analysis tools and techniques applied on Pneumatic Manual Flow Control Valve-
3.1 Functional analysis worksheet is prepared for the different parts of the product

Part Name	Sub-part/ Description	Qty	Function		Part		Assembly	
			Verb	Noun	Basic	Secondary	Basic	Secondary
Pneumatic Manual Flow Control Valve	Valve Body	1	Hold	Job	X		X	
	Spring Pin	1	Guide	Spring	X		X	
	Top Flat	1	Hold	Lever		X		X
	Bush	1	Sliding	Pin		X		X
	Lever	1	Pressing	O-ring	X			X
	O Ring	1	Flow	Air	X		X	
	Spring	1	Release	Energy		X		X

Table 1 Functional analysis worksheet of Pneumatic Manual Flow Control Valve

Costing of different units

Sr. No.	Unit	Part	Quantity	Cost in Rs.
A	**Pneumatic Manual Flow Control Valve**	Valve Body	1	610
B		Spring Pin	1	210
C		Top Flat	1	130
D		Bush	1	65
E		Lever	1	95
F		O Ring	1	10
G		Helical Spring	1	100
Total				1220

Table 2 Costing of different units

3.2 Functional Evaluation of each part is done

A	A3	A3	A3	A3	A2	A3	17	18
	B	B2	B2	B2	B2	B3	11	12
		C	C1	C1	C3	C2	7	8
			D	D1	D3	D2	6	7
				E	E2	E1	3	4
					F	F2	2	3
						G	0	1

Unit	Key Letter	Part	Function	Weight	%Cost
Pneumatic Manual Flow Control Valve	A	Valve Body	Hold Job	18	50%
	B	Spring Pin	Guide Spring	12	17.21%
	C	Top Flat	Hold Lever	8	10.65%
	D	Bush	Sliding Pin	7	5.32%
	E	Lever	Pressing O-ring	4	7.78%
	F	O Ring	Flow Air	3	0.81%
	G	Spring	Release Energy	1	8.12%

Table 3 Functional Evaluation of each part is done

3.3 Creative phase-

Comparitive analysis of Mechanical properties-

Grade	UTS (N/mm^2)	Yield Strength (N/mm^2)	Hardness	Elongation (%)	Impact KVC(J)
EN-9	700	355	201	_	_
EN-24	850	700	248	9	
EN-8	550	280	152	_	_
EN3A	430	215	126	_	_

Table 4 Comparitive analysis of Mechanical properties

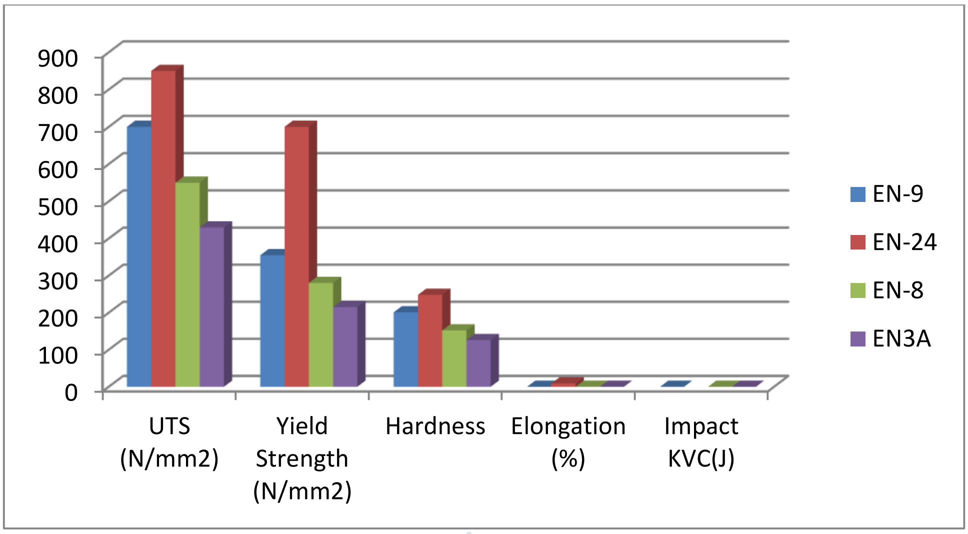

Figure 3 Comparitive analysis of Mechanical properties

Comparitive analysis of Chemical properties-

Grade	C	Si	Mn	P	S	Mo	Cr	Ni
EN-9	0.6	0.4	0.9	0.05	0.05	-	-	-
EN-24	0.44	0.4	0.7	0.035	0.04	0.35	1.4	1.7
EN-8	0.44	0.4	1	0.05	0.05	-	-	-
EN3A	0.24	0.4	0.9	0.05	0.05	-	-	-

Table 5 Comparitive analysis of Chemical properties

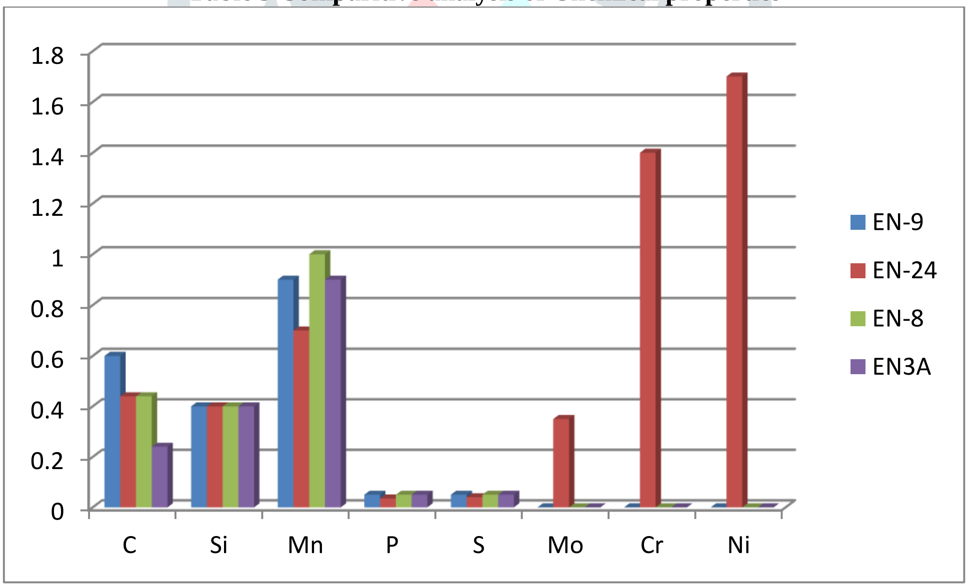

Figure 4 Comparitive analysis of Chemical properties

- **Comparison between Cost of material**

Material	EN-9	EN-24	EN-8	EN3A
Cost (per kg) in Rs.	60	120	50	80

Table 6 Comparison between Costs of material

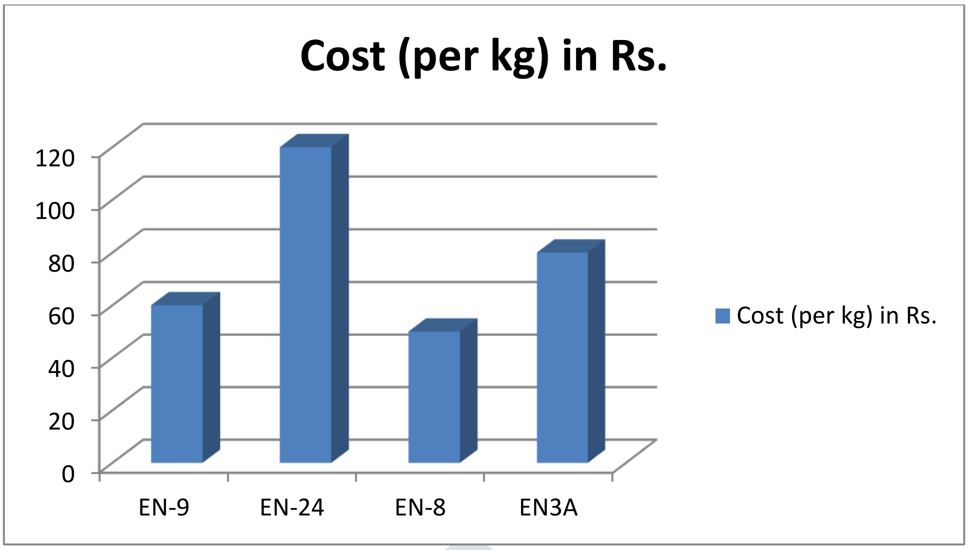

Figure 5 Comparison between Costs of material

Comparitive analysis of 35C8-Maximum component is manufactured by using this material. The material is to be analysed critically for costing reason as well as relevancy of function of product. Following properties are identified (As per importance) to compare material suitability for the product:

- Mechanical properties
- Chemical properties
- Cost

Mechanical Properties

Sample code	YS (MPa)	TS (MPa)	% Elongation	Hardness (HV)	CIE (J)
35C8, Normal air cooled	406.1	649.8	20.0	184	106.8
35C8, Forced air cooled	449.3	666.8	12.2	216	97.0
35C8, Oil quenched	519.1	722.7	9.6	264	72.5
38MnSiVS5, Normal air cooled	524.9	775.4	22.8	266	93.1
38MnSiVS5, Forced air cooled	590.6	847.4	20.5	285	68.6
38MnSiVS5, Oil quenched	789.4	1050.5	9.6	430	28.9

Table 7 Comparison between Mechanical properties of Handle material

Comparitive analysis of 35C8 & 38MnSiVS5 (Normal air cooled)

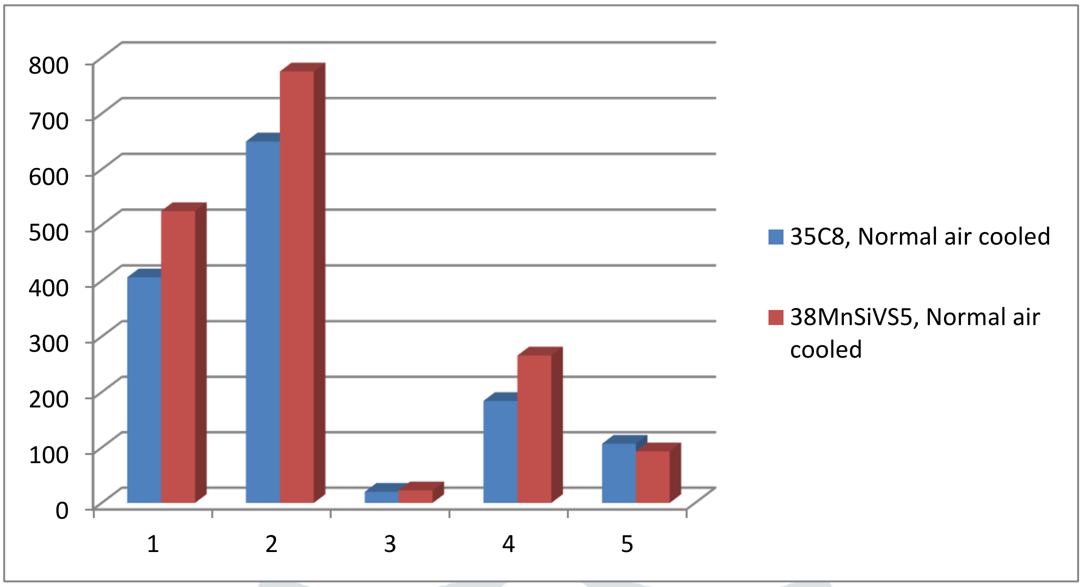

Figure 6 Comparative analysis of 35C8 & 38MnSiVS5 (Normal air cooled)

Comparitive analysis of 35C8 & 38MnSiVS5 (Forced air cooled)

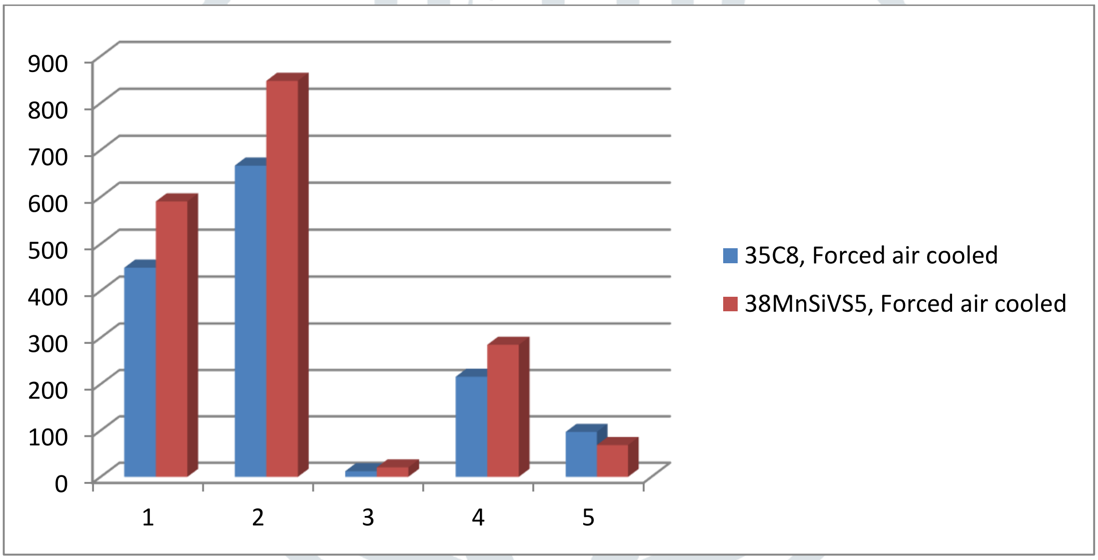

Figure 7 Comparitive analysis of 35C8 & 38MnSiVS5 (Forced air cooled)

Comparitive analysis of 35C8 & 38MnSiVS5 (Oil quenched)

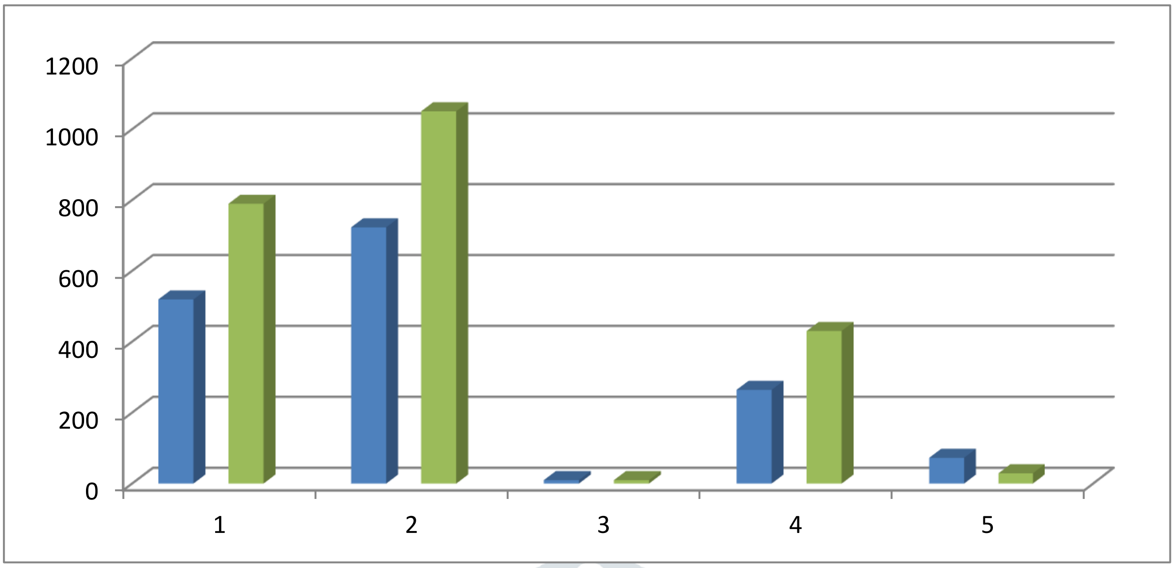

Figure 8 Comparitive analysis of 35C8 & 38MnSiVS5 (Oil quenched)

1	2	3	4	5
YS (MPa)	TS (MPa)	% Elongation	Hardness (HV)	CIE (J)

- **Chemical composition of the experimental steels (wt %)-**

Steels	C	Mn	Si	S	P	V	N
35C8	0.32	0.79	0.89	0.01	0.021	–	–
38MnSiVS5	0.40	1.21	0.19	0.02	0.017	0.085	0.0058

Table 8 Comparison between Chemical compositions of Handle material

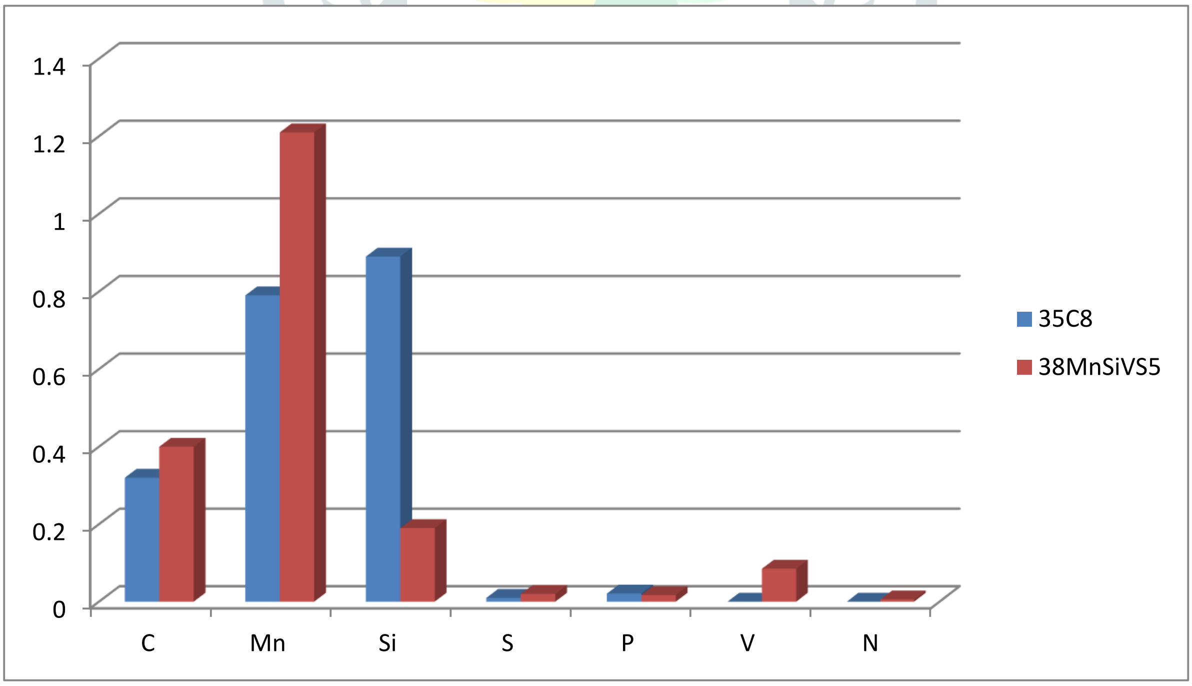

Figure 9 Comparison between Chemical compositions of Handle material

- **Comparison between Cost of material**

Material	35C8	38MnSiVS5
Cost per kg (in Rs.)	110	100

Table 9 Comparison between Cost of Handle material

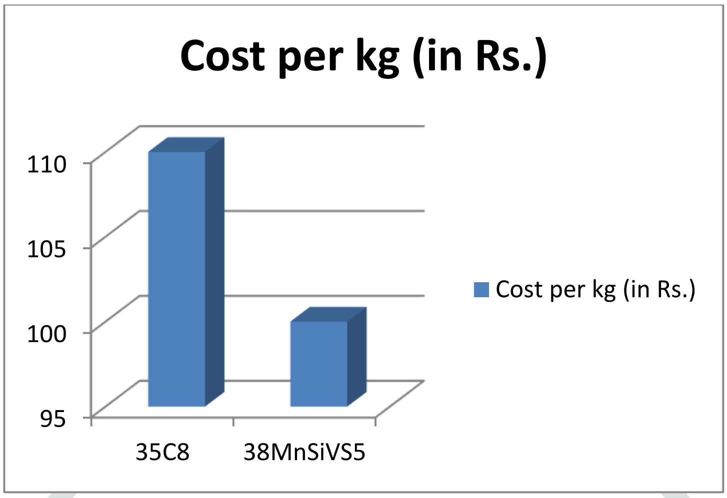

Figure 10 Comparison between Costs of Handle material

3.4 Function- Cost -Worth -Analysis –

Sr. No.	Function	Existing Product				New Product (Value analyzed)			value gap	% value gap
	Part name	Qty	Mat.	Cost per unit	Total Cost	Mat.	Cost per unit	Total Cost		
1	Valve Body	1	35C8	610	610	38MnSiVS5	554	554	56	9.18%
2	Spring Pin	1	EN-9	210	210	EN-9	210	210	00	00
3	Top Flat	1	35C8	130	130	38MnSiVS5	118	118	12	9.18%
4	Bush	1	GM	65	65	GM	65	65	00	00
5	Lever	1	35C8	95	95	38MnSiVS5	86	86	09	00
6	O Ring	1	STD	10	10	STD	10	10	00	00
7	Helical Spring	1	STD	100	100	STD	100	100	00	00
Total					1220	1143			77	

Table 10 Function- Cost -Worth -Analysis

3.5 Evaluation phase-

Parameters
a) Rigidity b) Light weight c) Durability d) Appearance

- Alternative I- Change material 35C8 to 38MnSiVS5 of different components of product

	B	**C**	**D**	**RAW SCORE**	**FINAL SCORE**
A	**A3**	**A2**	**A2**	**07**	**7**
	B	**B2**	**B2**	**04**	**4**
		C	**C1**	**01**	**1**
			D	**01**	**1**

Parameter Weight-age Alternative	Rigidity 7	Light Weight 4	Durability 1	Appearance 1	Total
Existing	4 28	3 12	3 3	3 3	46

Alternative-I	5 35	4 16	4 4	3 3	58

5	4	3	2	1
Excellent	Very Good	Good	Fair	Poor

Table 11 Evaluation phase

3.6 Recommendation Phase

Sr. No.	Parameter	Existing	Alternative-I
1	Valve Body	610	554
2	Spring Pin	210	210
3	Top Flat	130	118
4	Bush	65	65
5	Lever	95	86
6	O Ring	10	10
7	Spring	100	100
	Total (in Rs.)	1220	1143

Table 12 Recommendation Phase

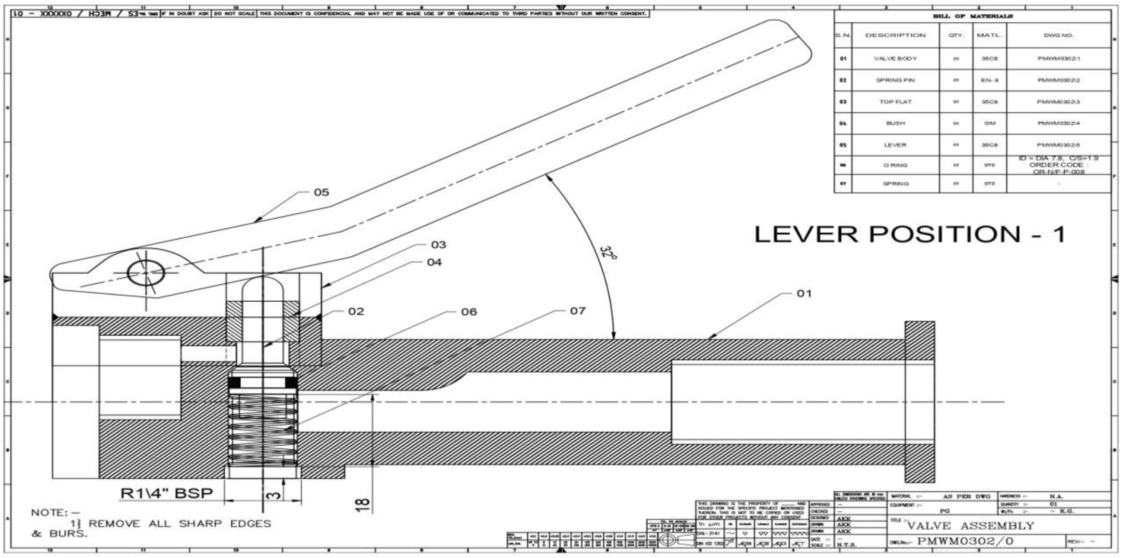

Figure 11 Sample Product drawing: Pneumatic manual flow control valve (M/s Lakshmi Machine Tools, Indore)

3.7Conclusion and Future Scope-

1. Value engineering was employed for the cost reduction without the change in the product design and manufacturing process.
2. The total saving incurred per product by implementation of above recommendations are 9.81% for alternative I.
3. In future,pneumatic manual flow control valve can be made by using advance higher quality material having more strength to weight ratio.
4. Other Industrial Engineering techniques for manufacturing can be used for further improvement in production process to reduce cost and time.

IV. Acknowledgment

We are very grateful to management of M/s Lakshmi Machine Tools, Indore for their co-operation and Support for providing organizational information for this analysis.

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