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Design using Reverse Engineering and Analysis of Garden Tiller

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Abstract

Garden tiller is used to plow the garden. Tiller means lifting up the soil, breaking apart the clods of dirt. This study is aimed at design of tiller blades using reverse engineering, fabrication of garden tiller and Analysis of tiller blade using ANSYS. The reverse engineering process is used to get the dimension of existing products, it's nothing but reproduction of manufactured product. Co-ordinate measuring machine (CMM) is used to extract point data of the surface of the model generated by measuring it surface. The main work of CMM it to acquire data acquisition system, data preprocessing, surface fitting and finally developing a CAD model. Tiller blades with different dimension were developed by using co-ordinate measuring machine (CMM). Appropriate blade tip and length, the main dimension of blade is designed which reduce the energy requirement for tiller blade. Based on the dimension of tiller blades are fabricated and static analysis is done by using ANSYS software to get optimum results. In the present work static analysis evaluate the effect of steady loading (i.e., initial torque) on a blade whose dimensions were modified. By applying initial torque static analysis is used to evaluate the stresses, deflection and reaction force on a blade

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I. INTRODUCTION

Garden tiller is mainly used in agriculture for loosening soil and more efficient trash mixing. The garden tillers are mainly designed to break up the soil for new vegetable gardens or lawns, create a new seed bed. It is an mechanical device to plough the gardens by series of blades are arranged and it will be used to lifting up the soil, breaking apart the colds of dirt loosening of an upper layer of soil of an earth. .A garden tiller is simply known as roto tiller, rotovator, power tiller, or rotary plough. The garden tiller is an important role in agriculture.it has main advantage of functioned by weed cleaning, soil loosening, land leveling of an seed bed. It is motorized cultivator that works on the soil by means of rotating tines or blades. These tillers are used in the domestic gardens. The design optimization and manufacturing errors can be minimized by its components design analysis and optimization. The blades and transmission elements having operating forces so control to stress distribution is important for designers, manufacturers. The main aim of design and optimization of tiller to reduce the weight and cost of the tiller and it will be improving ploughing performance of a blade.

II. METHODOLOGY OF REVERSE ENGINEERING

The main process of reverse engineering is to develop the shape and size of an existing model. Developing the dimensions of existing components is done by scanning the surfaces and edges of the object and after scanning converting the scan surface into 3-D surface solid model. Now days in

Competitive global market, in shorten tie span new product have to be developed for product development reverse engineering is a technological tool.

By using R.E technological tool cost of product design and manufacturing will reduce. This helps manufacturer to produce new product in market in short time. R.E helps to known the inter-relationship between the components and also develops damaged surface of the components. 3main steps of the 3-D scanning system are:-

1) Pre-processing:- Which includes the physical preparation of the object to scan and CAD software setup.

2) Data acquisition system:- Which extracts the point, line, edges and surfaces of the model.

3) Post-processing:- A stereolythgraphic (STL) file format is generated which is future digitized model smoothen to enhance the 3D model.

In this study JATEN-QVS-4030 -3D scanning machine model is used which can measure a dimension range 400*300*200 mm.

In the above machine white light 3D scanner is used instead of classic laser 3D scanner [1].

Optical vision measuring machine system for the acquisition of image data, followed by the processing and interpretation of this data by computer for some useful application the operation of machine vision system divided into three functions:-

1. Senseing and digitizing image data:- It can be measure point, line, circle, arc, oval, rectangular.

2. Image processing and analysis:- It can be improve the product accuracy with the multi-point positioning function.

3. Interpretation:- Image interpretation is the manipulations of images using computer algorithms to enhance, restore and understand the information contained in them.

The measuring data acquisition can be directly converted into Word, Excel, and AutoCAD.

III. DIMENSION OF TILLER BLADE

The garden tiller has number of blades which are connected together and forms a blade assembly. Assemble blade set is influenced under uneven forces of soil components. This uneven force of a blade assembly affects the strength and life of blade. The tiller blade is generated by 3D CMM machine in Auto cad [2].

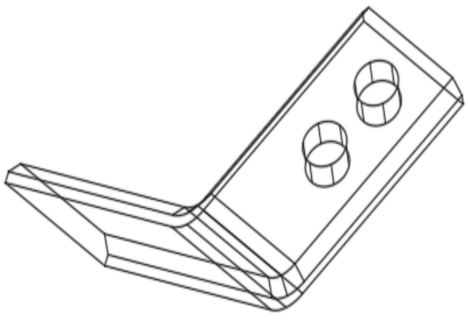

Fig. 1.blade exerted by CMM

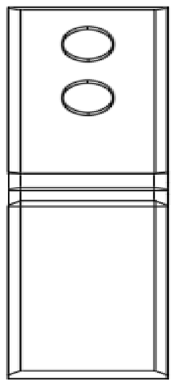

Fig. 2.Elevation of the blade exerted from CAD

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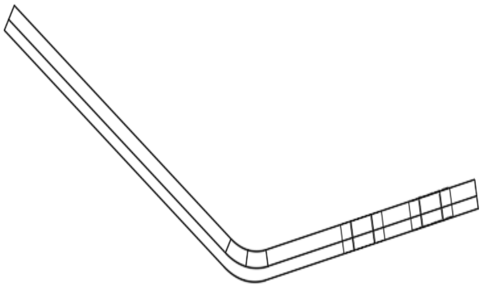

Fig. 3.End view of the blade exerted from CAD

The tiller blade generated by CMM was modified in catia and the dimension is as shown below. Dimensions were modified to get optimum power output [3]

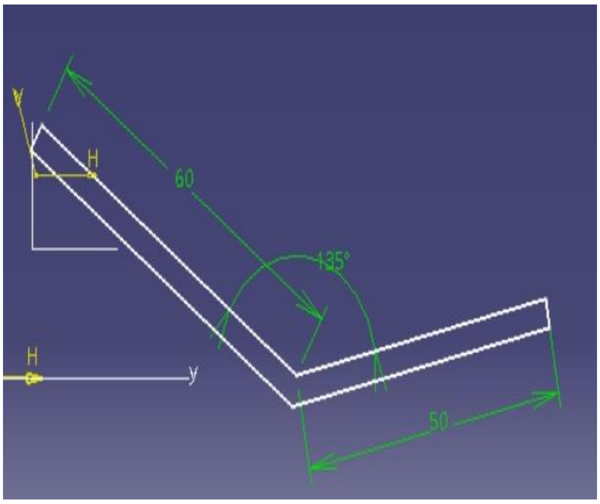

Fig. 4.Modified dimensions of blade by using CATIA

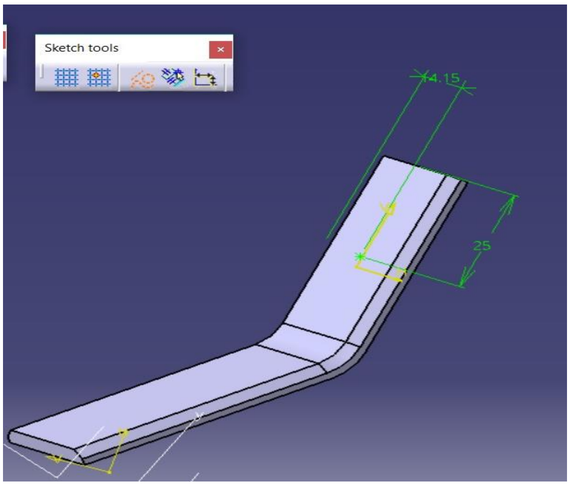

Fig.5. Modified dimensions and 3-D view of tiller blade by using CATIA

Table.I. Dimensions of Tiller Blade

S.No	Notations	Parameters	Units	Dimensions
1	Length of the blade attached to the plate	L	mm	50
2	Width of the cutting edge	W	mm	60
3	Thickness of the blade	T	mm	3.9
4	Chamfer of and blade	CH	mm	6.5*45°
5	Blade effective angle	α	deg (°)	45°

IV. DETAILS OF TILLER BLADES

Three types of blades are available, which are assembled to get desired output. The popular shapes of blades are L, C and J for different operating condition to break soil. L shaped blades have better performance then C or J type of blades. L shaped blade brake up soil much faster and in less time. For Indian soil L shaped blades are popular for farmers. A set for tiller blades is mounted on a flange and there are 6 flanges mounted on the shaft of a garden tiller.

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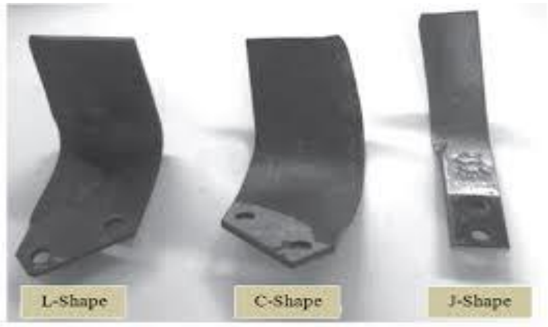

Fig.6. Types blades available in market [2]

All blades and flanges are mounted rotating shaft, the garden tillers are mostly used in land leveling, and loosening of the soil and fully trash mixing, before planting. These garden tillers are used in agriculture production in India.

V. MATERIAL PROPERTIES

Blade of garden tiller is pressed on the soil surface (ground surface) and rotary motion of blades on flange will lift the soil and soil break up process is initiated. While breaking up soil the blade rotates and back wheel (which support the tiller on ground) drive to move the tiller forward. As the surface of the blades are in continuous in contact with the soil, soil exert load on the surface this loads develop stresses and continuously wear the blade tip. In order to avoid wear different material were used with sufficient wear resistance. Wear rate is reduced to develop life span of tiller blade. The profile of the blade is designed to resist the wear and plough the garden in a specified area. In present work blade is designed by reverse engineering process and modeled by using CAD (CATIA). Blade model is modified in catia software to produce optimum result. The dimension modified in blade is cutting tip and thickness of blade. This model was analyzed through ANSYS. The selection of material is based on their properties and having good wear resistance characteristic. Dimension of blade is shown in Table I and the figure of the blade shown in Fig.5. Analysis of blade is developed by changing the different material of the blade in ANSYS workbench mode. The materials used for the proposed model are AISI D3, EN 31, STAINLESS STEEL, STRUCTURAL STEEL; it is shown in Table II for the details of a materials and properties of a blade. The various material properties for these steels will be tabulated below. These materials were chosen based their tensile strength and elastic module.

Table.II. Properties of Tiller Blades

	AISI D3	**EN 31**	**STANLESS STEEL**	**STRUCTURAL STEEL**
Density	$7.7*10^3$ kg/m^3	7.81 g/cm^2	7.85 g/cm^3	7850 kg/m^3
Tensile strength	1386Mpa	1234 Mpa	505Mpa	550Mpa
Poisson's ratio	0.27	0.29	0.29	0.30
Elastic module	200Gpa	200 Gpa	198Gpa	205Gpa

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March - April 2020
ISSN: 0193-4120 Page No. 9043 - 9051

The main aim to design tiller blade reduction of cost, and also at improving its field performance, strength of the blade so as to obtain higher soil mixing efficiency.

VI. CALCULATION OF ENERGY

Specific energy is an important parameter to judge the performance of the garden tiller. The factor on which the specific energy depends are volume of soil removed by tiller, forward speed of tiller, speed of tiller blade, depth of soil to cut, rotor radius, angle of rotation, width of soil cut, specific soil resistance. The higher value of specific energy lowers the soil volume tilled and the soil volume tilled is optimum for operation cost.

$$\text{Specific energy} = \frac{P_p + P_c + P_{mf} + P_{th}}{V_{so}} \qquad (1)$$

Where

P_p= Pushing power in KW,

P_c= soil cutting power in KW

P_{mf} = Power to overcome friction with soil in KW

P_{Th} = Cut soil throw in KW,

V_{so} = Soil Volume after tilled in m^3

Table.III. Calculated value of total specific energy

α	β	B_w	R	L_d	V_f	N	P_e	V_{so}
37.65	10.05	0.0283	0.235	0.05	0.3	300	5	1260 x10^{-6}

$$P_p = \frac{7161.96\,(\text{Vf Pe})\eta c\, \eta z}{\text{RN}\cos(\beta 1)}\,[\sin(\alpha)\cos(\beta_1) + \cos(\alpha)\sin(\beta_1)] \qquad (2)$$

$$= \frac{7161.96 \text{ x } (0.3 \text{ x } 5) \text{x } 0.9 \text{ x } 0.75}{0.235 \text{x} 300 \text{x} \cos 10.05}\,[\sin 37.65 \text{ x } \cos 10.05 + \sin 10.05 \text{ x } \cos 37.65]$$

$$= \frac{7251.445\, x 0.73963}{69.41}$$

P_p= 77.26 KW

$$P_c = K_{SP}\, B_W L_d V_f \qquad (3)$$

= 5000 x 0.0283 x0.05 x 0.3

= 2.122 KW

$$P_{mf} = L_d R V_f B_w\, S_{PW}\, \mu_K \quad (4)$$

= 0.05 x 0.235 x0.3 x 0.0283 x 1700 x 0.40

= 0.0678 KW

$$P_{Th} = \frac{0.219 \text{ RN Ld Vf Bw SPW}(3\text{R}-\text{Ld})}{\text{GZ}} (5)$$

$$\frac{0.219\, x\, 0.235\, x\, 300\, x\, 0.05\, x\, 0.3\, x\, 0.0283\, x\, 1700\, x\, (3\, x 0.}{9.81\, x 24}$$

= 0.02626KW

Equation 2, 3, 4 and 5 are substiturte in equation 1

$$\text{S.E} = \frac{7.26 + 2.122 + 0.0678 + 0.02626}{1260 \text{ x} 10^{-6}}$$

= 63076.23

= 63.077KW

Where

V_f= machine forward velocity, m/s f V

P_e= engine power, hp e P

n_{cn} = prime mover's efficiency [0.9 for power tiller]

n_z = coefficient (=0.75; Bernacki*et al.*, 1972);

R= rotor radius, m R

N= rotational speed, rpm N

α= the angle of direction (α= 420, Sineokov, 1977)

$Ø_1$= the angle of periphery, (Sineokov, 1977).

VII. RESULTS AND DISCUSSION

ANSYS analysis result of L type blade is shown in below. The power applied on the blade as per the above calculation is

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3.7285 KW. The initail torque is applied is to calculated in these formula $P=\frac{2\pi NT}{60}$

$$T=\frac{P\,x60}{2\pi N}=\frac{3.7285\,x\,1000\,x60}{2\pi 300}$$

T = 118.63 N-m

The above initial torque is applied on blade with taking into consideration different materials. That Different material is chosen as per their cost and availability in market. In ansys software same torque is applied but for each analysis material properties were changed to get the optimum result.

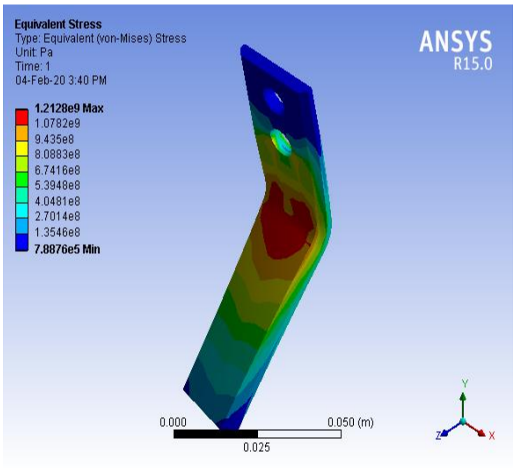

Fig.7.Static structural Analysis stress result of AISI D3 Steel material.

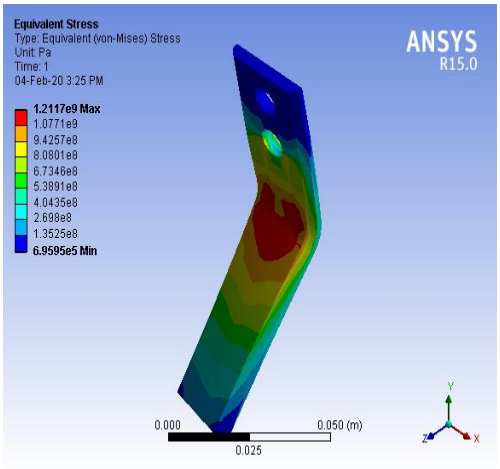

Fig.8. Static structural Analysis stress result of EN31 Steel material.

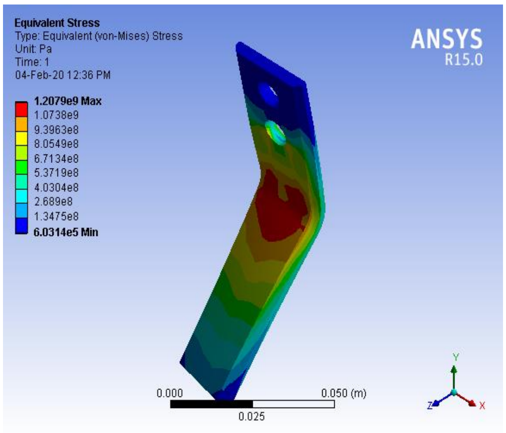

Fig.9.Static structural Analysis stress result Stainless Steel material.

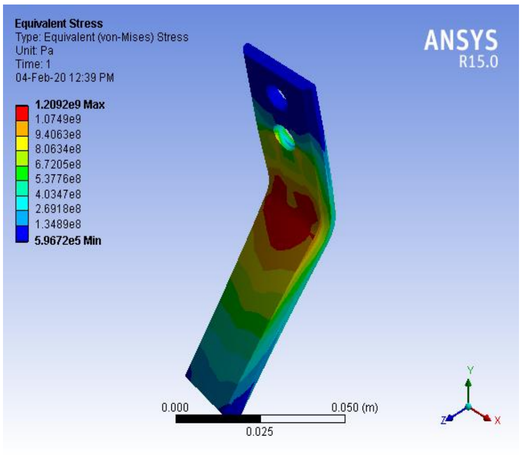

Fig.10.Static structural Analysis stress result of Structural Steel material.

From the above figures it appears that the developed blade shows some good characteristics of load of a various materials.

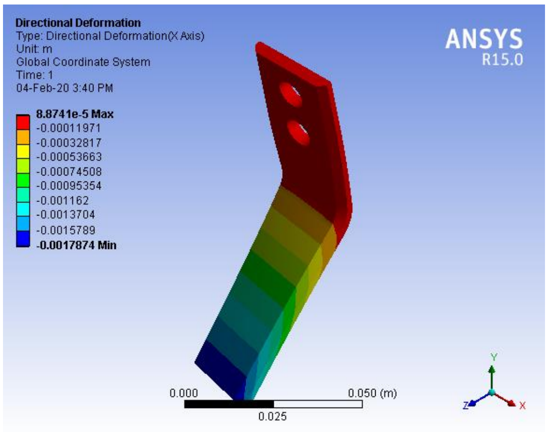

Fig.11.Static structural Analysis deformation result of AISI D3 material

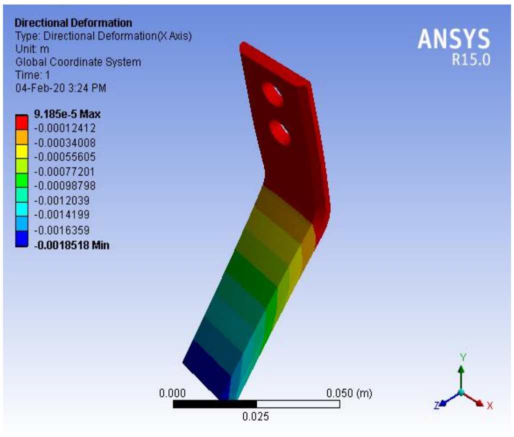

Fig.12. Static structural Analysis deformation result of EN31 material

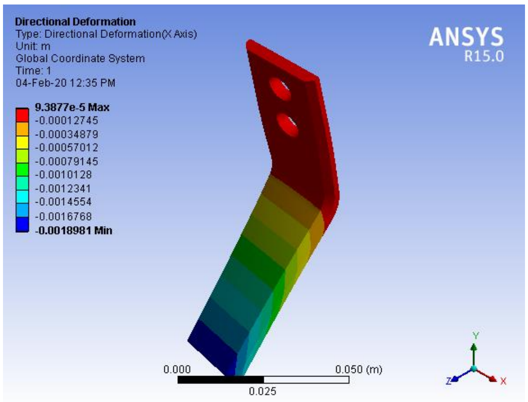

Fig.13. Static structural Analysis deformation result of Stainless Steel material

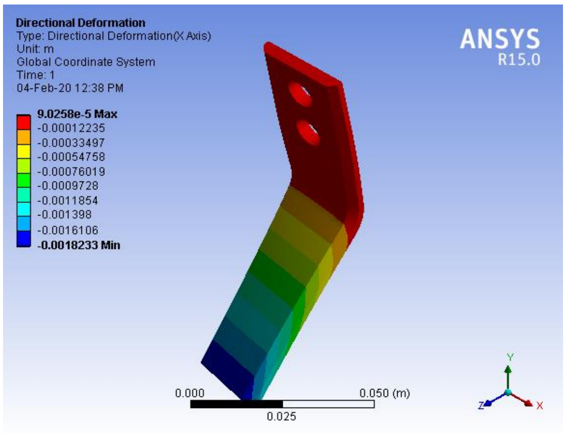

Fig.14. Static structural Analysis deformation result of Structural Steel material

The figures shown above depict the total deformation and equivalent stress acting on the blades which we are made out of the different materials.

Table.IV. Properties of various materials

S.NO	MATERIAL	STRESS (Pa)	DEFORMATION (m)
1	AISI D3	1.2128	8.8741
2	EN31	1.2117	9.185
3	STAINLESS STEEL	1.2079	9.3877
4	STRUCTURAL STEEL	1.2007	9.0258

A blade was developed in CATIA software and exported to the ANSYS 15.0 package. The next main process is meshing and applying loading and boundary conditions in the pre-processor so that simulation can be run to get a solution and generate results in the post-processor. The minimum and maximum stress of the blade was indicated in the colour chart from blue to red respectively. The colour indicated from blue to red is the minimum and maximum value for all the deflection and stresses on the blade respectively.

Fig.15 and Fig.16 shows the examination results for deformations and stress various materials.

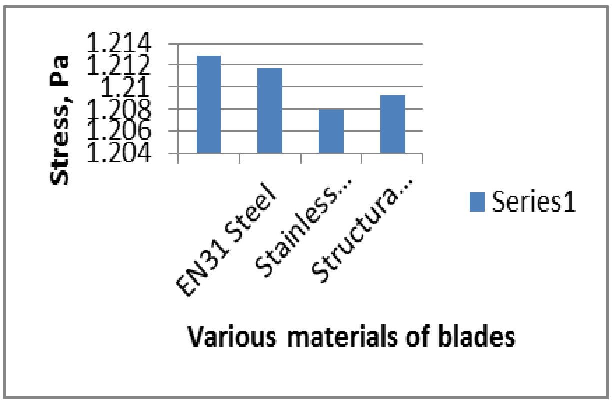

Fig.15. Examination results for stress of a various materials.

TEST Engineering & Management
March - April 2020
ISSN: 0193-4120 Page No. 9043 - 9051

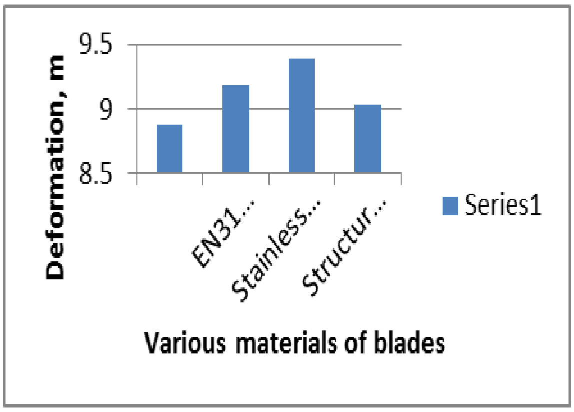

Fig.16. Examination results for deformation of a various materials

We considered the AISI D3, EN31,structural steel and Stainless Steel materials for the project. These materials are selected in ANSYS workbench and their required properties are provided manually. Simulation is done for the garden tiller blade by considering different materials and the solutions are obtained.

The material properties are not automatically selected by the software. Hence, the above-mentioned material properties are manually given to the software. The required solutions are selected like, Von-Misesstresses, strain, deformation and the solutions are obtained. To find out these solutions for other materials, just the material for the garden tiller is changed and the solutions for the other materials are obtained. Best used material for garden till from the above graph is ANSI D3 steel

VIII. CONCLUSION

The different dimensions of the blade were observed and a suitable dimension is considered for optimum result. To obtain less wear and more strength analysis using ANASYS software is performed. Different material (i.e. AISID3, EN31, Structural steel and stainless steel) properties were taken for analysis with same loading condition for existing design. The result of stress and deformation is shown in table IV.

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