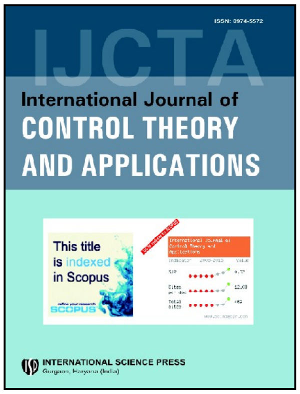

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Design and Development of Turbine Driven Wood Turning Lathe for Rural Development

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Abstract: The growing need of power and also increase in productivity has lead to look for alternatives in the field of power generation for product making. One of such development is the turbine driven wood turning lathe. As there is uncertainty and fluctuations in power supply in rural areas and the need to reduce the dependability on Government Electricity boards, the design of wood turning lathe would meet the requirements. This paper gives the detailed design of the lathe which is modeled using CATIA V5 R17 and the fabricated method. The indigenous fabrication method is adopted and parts such as casing plates, tool post, and carriage are detailed and assembled. The designed specifications and bearing life are also mentioned according to the capacity of lathe. This developed lathe is used for different pattern and product making by making use of steam driven turbine and gear systems design which also gives speed variation modules in lathe.

Keywords: Turbine, Wood, Lathe, Turning, CATIA V5 R 17

I. INTRODUCTION

India has raised its installed power capacity from 1437MW in the year 1947 to 2,50,000MW in the year 2016, but still 5,00,000 villages and tribal areas are away from the access to electric energy. The major challenges in electrification of these villages and tribal areas are lack of transmission facilities and huge amount of transmission losses which can account up to almost 40%. Due to non-accessibility to electricity, no industries could come up in these areas. As a result no employment opportunities are developed. Development of Tribal areas and villages in the country is slow due to lack of industries and electricity. It is easy to develop furniture industry in tribal areas and villages where man power and raw materials are locally available. Conventional furniture processing machines like wood lathe, cutting machines etc., requires electricity which is scarcity in villages and tribal areas. To overcome this difficulty, developing a turbine driven lathe machine which requires steam, which can be produced from combustion of biological wastes like tree branches, wood chips, dry leafs, etc would accomplish the need [4][5]. Direct consumption of energy resources reduces pollution [6][7]. The production and distribution of mechanical power rapidly evolved from water and steam as prime movers coupled to shaft and belt drive systems and in turn to electric motors will drive individual machines [3]. The energy consumption during machining is an important factor in production costs and environmental aspects [1].

II. METHODOLOGY

2.1. Need

The need of the lathe is to reduce the power shortages in tribal areas by generating power and to make use of available resources like wood, dry leaves and waste from tree branches from which the steam can be generated. This can be achieved through the installation of furniture industry where wood and wood waste i.e., Saw dust are available.

2.2. Selection of Materials/ Materials used

The trend in selection of the material in design and manufacturing differ between small and large turbines. Small machines tend to use lighter weight castings in an effort to reduce costs. Many parts are die cast aluminium in small turbines, while in large machines steel castings or forgings are needed to meet strength and structural fatigue requirements [2]. Aluminium and Mild Steel are used for the development of Turbine driven wood turning lathe, where these material satisfies the required conditions. Due to direct continuous interaction with the steam or heat, presence of water particles aid to form rust in the turbine. Aluminum is used for the fabrication of Turbine and blades where it directly interacts with the steam generated from waste heat boiler. Aluminium is a non-ferrous, light weight metal compared to the ferrous materials and also it resists the corrosion.. Mild steel is used for making of all remaining parts used in the fabrication such as tool post, lathe bed etc. because it possesses good mechanical properties like strength, ductility and good load bearing capabilities in static and dynamic motion.

2.3. Equipments and Tools used

The design and modeling of turbine driven wood turning lathe is done by CATIA V5. Various machines tools are used for the fabrication of turbine driven wood turning lathe. 1) Lathe machine is used for the fabrication of the Rotor from the Aluminium disc and by performing various machining operations like facing, turning and threading. 2) Hand Cutting/Grinding machine is used for cutting of blades from the length of Aluminium pipe of 50mm diameter and grinding at the cutting edges.3) Gas Welding Machine is used for welding of Aluminium

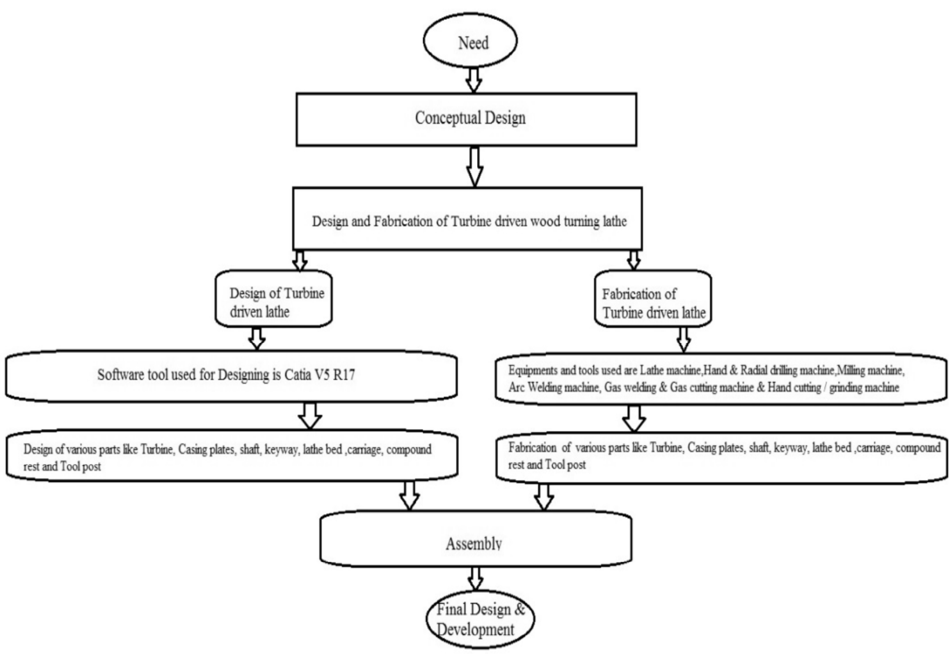

Figure 1: Flow Chart of Methodology

blades to the Rotor in a circular way as shown in design view of turbine. 4) Hand and Radial Drilling machines are used to make holes as per requirement of fabrication. 5) Milling machine is used to make keyway on the shaft and turbine to restrict the individual speeds of the shaft and turbine (Rotor) and to transmit the generated power from rotor to shaft.6) Gas Cutting machine is used to cut the ring for fabrication of turbine casing. 7) Arc Welding Machine is used for welding to make various lathe parts like Carriage, Compound rest and tool post at the necessary positions as per the design. The whole methodology is explained in below figure 1 by means of a flow chart.

2.4. Design

The design and modeling is carried out by using CATIA V5. The modeling of the various parts is made by making use of geometric details in sketch module and exit work bench module and some other modules are used for modification. The geometrical details used for designing and design models of various parts like Turbine Fig 2a & 2b, Casing plates of Turbine (front and rear) Fig 3a, 3b, 4a & Fig 4b, shaft Fig 5a & 5b, keyway Fig 6a & 6b, longitudinal and traverse rods Fig 7a, 7b, 8a and 8b, carriage Fig 9a & 9b, Compound rest Fig 10a, 10b and tool post Fig 11a, 11b are shown in below figures which are 2D and solid models.

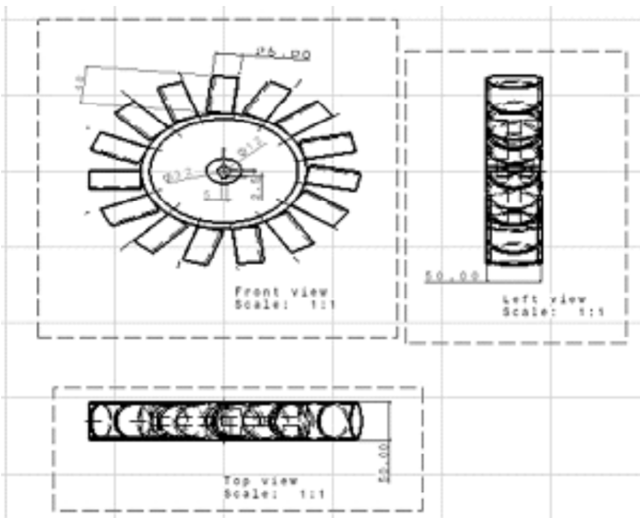

Figure 2 a): Geometrical Details of Turbine

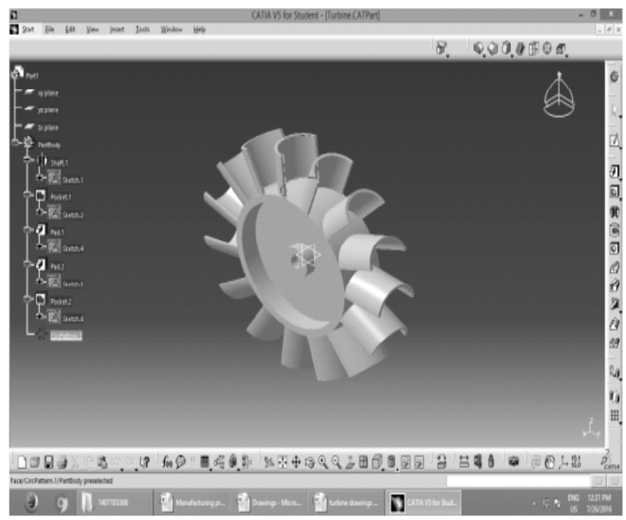

Figure 2 b): Design of Turbine

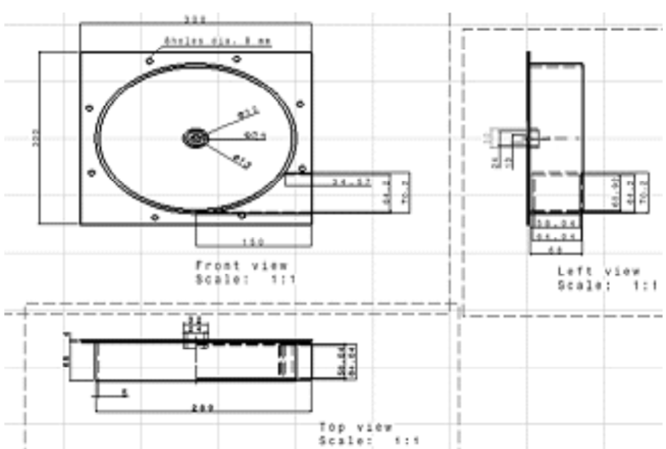

Figure 3 a): Geometrical Details of Casing Plate 1

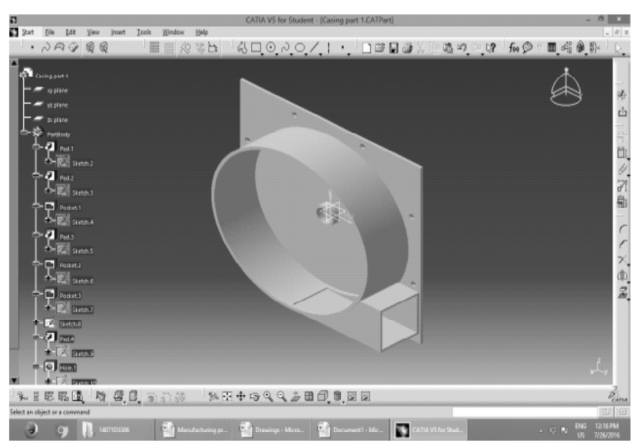

Figure 3 b): Design Model of Casing Plate 1

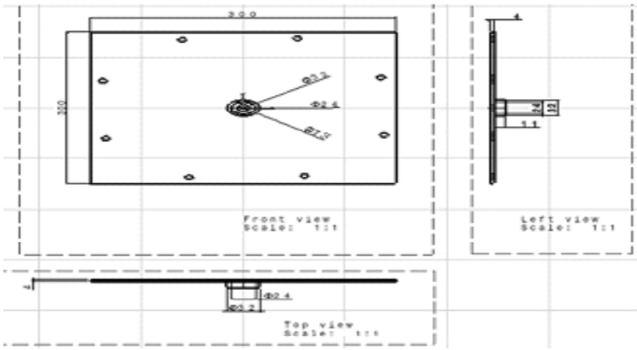

Figure 4 a): Geometrical Details of Casing Plate 2

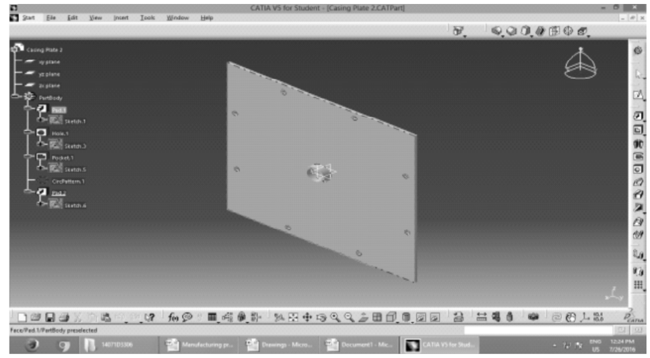

Figure 4 b): Design Model of Casing Plate 2

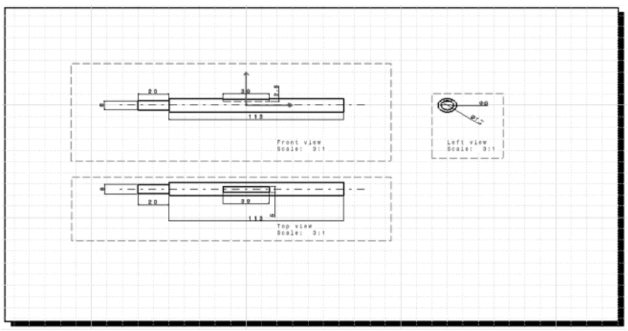

Figure 5 a): Geometrical Details of shaft

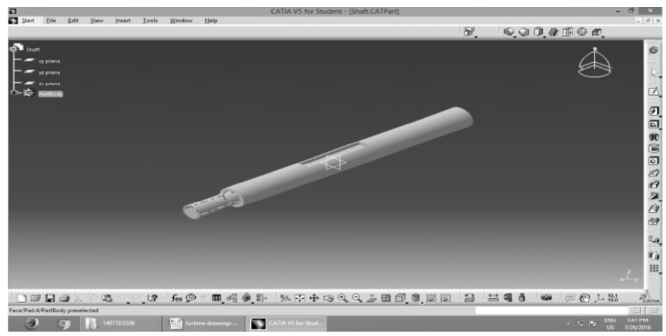

Figure 5 b): Design Model of shaft

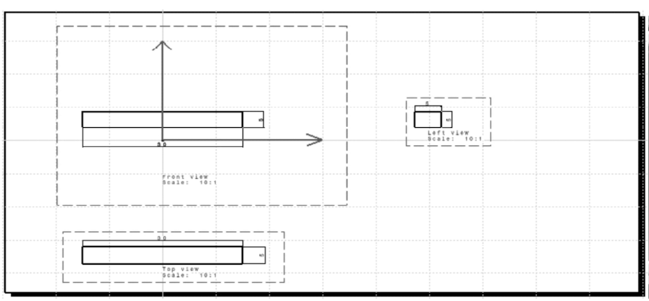

Figure 6 a): Geometrical Details of keyway

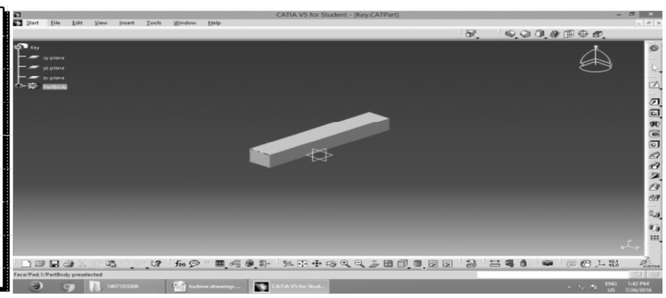

Figure 6 b): Design Model of keyway

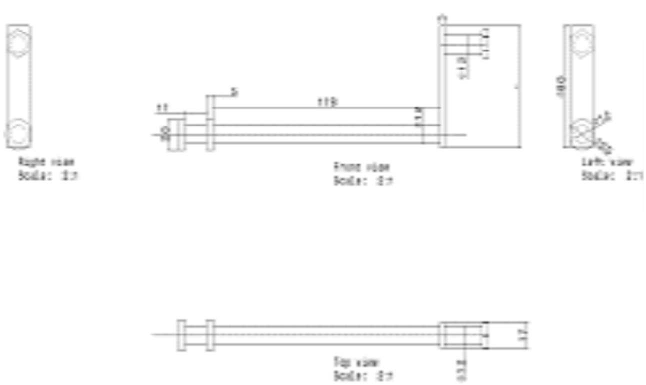

Figure 7 a): Geometrical Details of Longitudinal feed rod

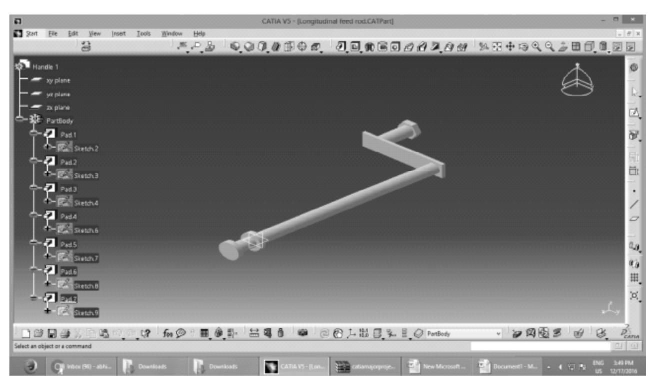

Figure 7 b): Design Model of Longitudinal feed rod

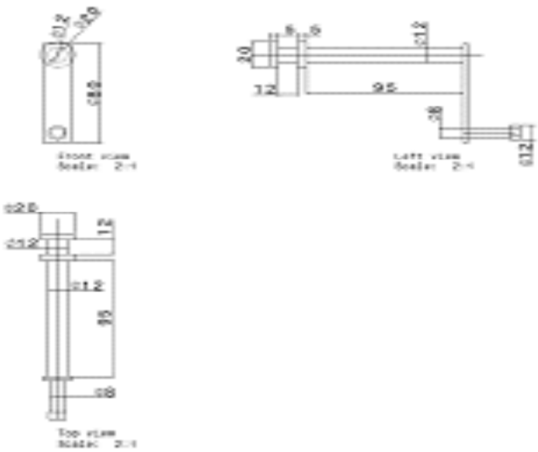

Figure 8 a): Geometrical Details of Transverse feed rod

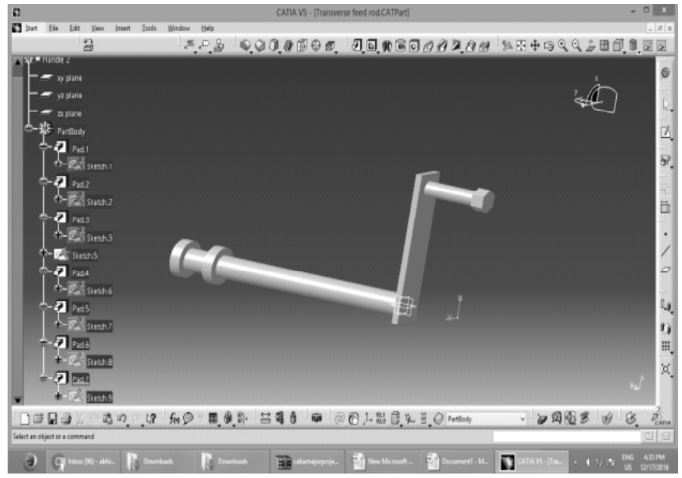

Figure 8 b): Design Model of Transverse feed rod

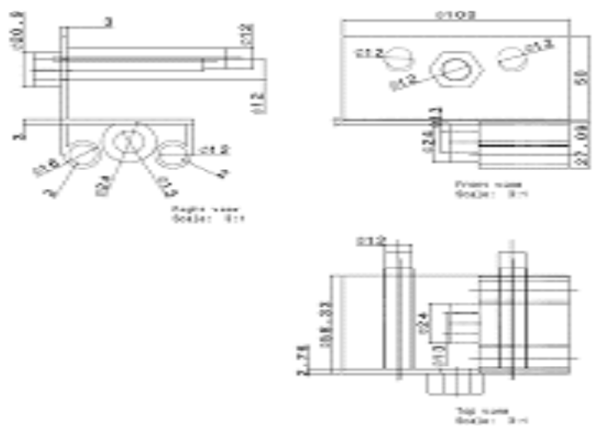

Figure 9 a): Geometrical Details of Carriage

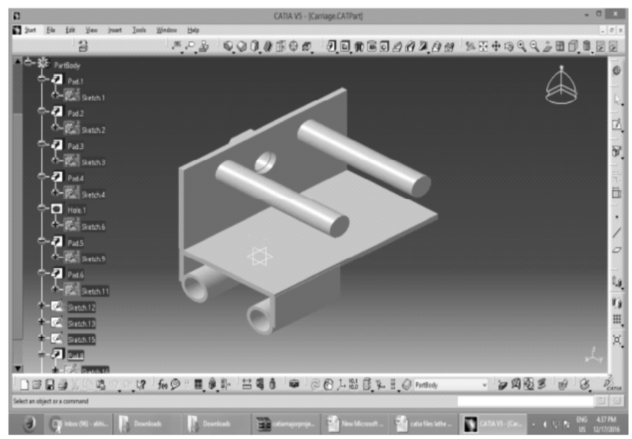

Figure 9 b): Design Model of Carriage

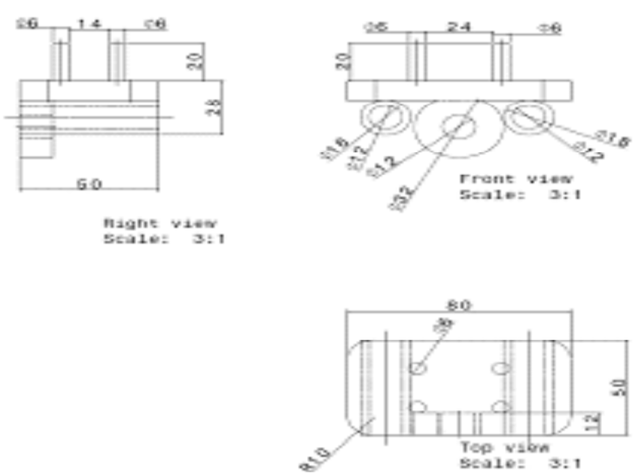

Figure 10 a): Geometrical Details of Compound rest

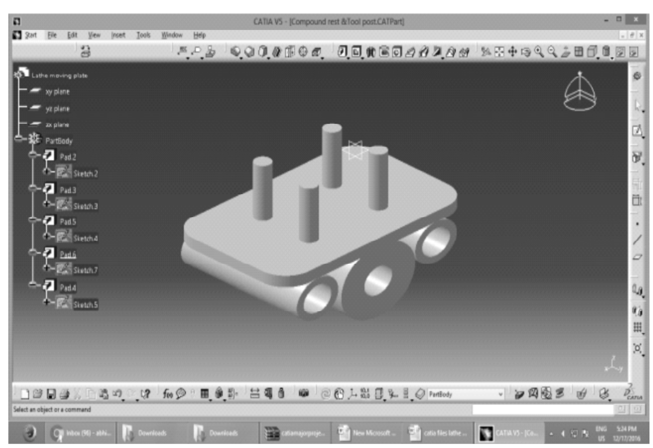

Figure 10 b): Design Model of Compound rest

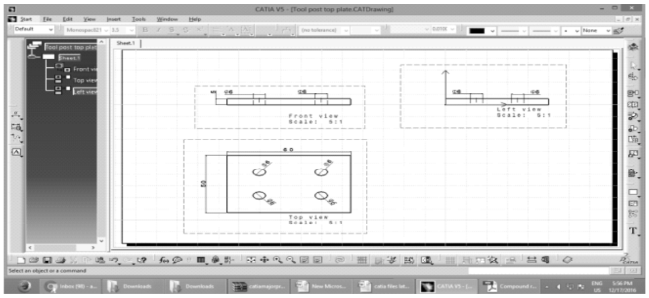

Figure 11 a): Geometrical Details of Tool post top plate

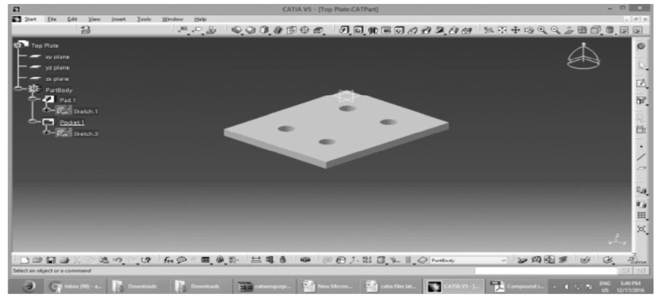

Figure 11 b): Design Model of Tool post top plate

2.5. Fabrication

1) The proposed design for turbine which is modeled in CATIA V5 R17 is fabricated with aluminium material. The disc of the turbine shown in Fig 12 also called Rotor is fabricated according to the design and later blades are welded over it by gas welding. The finishing operation was performed by grinding. 2) Lathe bed shown in Fig 13 with guide ways made of mild steel is manufactured with respect to specifications of the work piece size to be accommodated, capacity, power and speed.3) Carriage along with tool post made of mild steel shown in Fig 14 is fabricated as per the lathe specification. 4) The longitudinal and transverse motion of the cutting tool is achieved with the arrangement of Longitudinal and transverse feed rods which are fabricated.

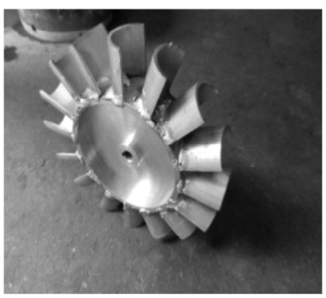

Figure 12: Turbine

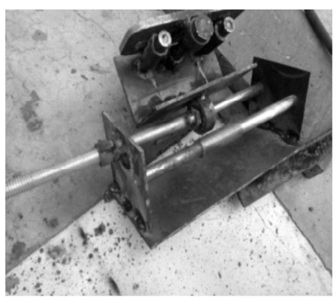

Figure 13: Lathe bed

Figure 14: Carriage

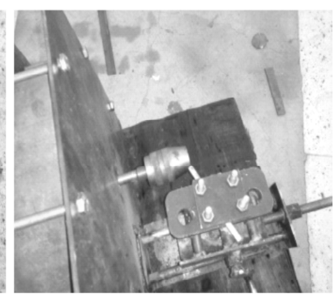

Figure 15: Tool Post

2.6. Assembly

The assembly plays a key role, while operating a machine without any geometrical errors. Assembly also helps in achieving the efficient and effective production in manufacturing which in turn leads to rise in the production capacity. The turbine is coupled to the shaft by keyway, where one end of the shaft is assembled with the chuck for holding the work piece while machining. The shaft is supported by the bearings provided in the bearing sleeves for turbine casing supporting plates. The steam intended to rotate the turbine and also shaft. This rotation is achieved by the provision of keyway between shaft and turbine, which restricts the motion and allowed to rotate with same speed. The clearance is provided in between turbine casing and Turbine, to rotate the turbine without any motion restriction. The casing supporting plates of Turbine are guided to rotate the turbine without any errors. The assembly of turbine and turbine casing is done with nuts and bolts. Later the total lathe is built by assembling various parts like guide ways, carriage, Compound rest and Tool post to turbine lathe bed assembly. The below figures lathe unit Fig 16, Assembly view Fig 17 and final assembly are modeled and represented in CATIA V5 R17 are shown. Fig 19 represents the Functional prototype.

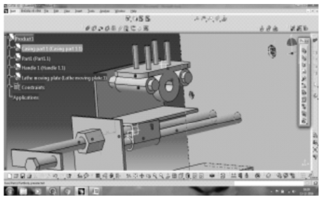

Figure 16: Lathe unit

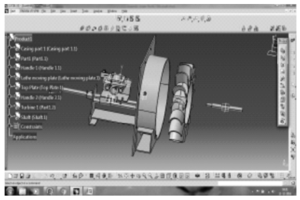

Figure 17: Assembly view

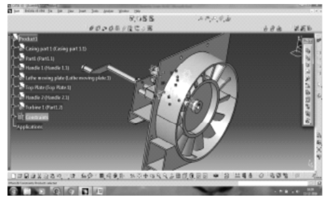

Figure 18: Final Assembly

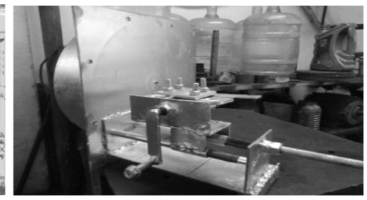

Figure 19: Functional Prototype

2.7. Design Specifications

Table 1
Turbine blade thickness calculations

Inner radius	*Ri*	*m*	*0.022*
Maximum Pressure Considered	P	MPa	1.5
Poissons ratio	μ		0.33
Yield point stress	σ_y	MPa	324
Tensile stress	σ_t	MPa	259.2
Required Thickness of blade	T	m	0.002906
Required Thickness of blade	T	mm	2.90622
Thickness chosen	**T**	**mm**	**3**

Table 2
Bearing Calculations

Mass of Rotor	Kg	2
Load of the Turbine	N	19.62
Load on Each bearing	N	9.81
Margin due to unforeseen forces	%	20
Load on each bearing including margin	N	11.772
Bearing selected		
Bearing Dynamic Capacity – C	N	787
Equivalent Dynamic Bearing Load – P	N	11.772
Bearing Life in millions of Revolutions=(C/P)^3=	Nos.	298795.1
Bearing /Shaft speed	rpm	3000
Calculated Bearing Life in hrs = [Life in million rev. x 10^6/(60 x RPM)]	hrs	1659973
Hence bearing selected is suitable for 60,000hrs operation		

III. EXPERIMENTATION AND RESULTS

The Experimental results i.e., Power Calculations of the lathe and Turbine are shown in Table 3. and Table 4.

In Table 3. We can see that the actual cutting power required for performing the turning operation on the maximum diameter 12mm of the work piece is approximately 34 Watts. In Table 4. We can see that the net generated power from Turbine is approximately 45 watts. The designed project can be developed and successfully implemented in the tribal areas based on the comparison of power between turbine and lathe.

Table 3
Lathe Power calculations

Depth of cut	a_p	mm	1
Feed per Revolution	f	mm/rev	1
Max. dia of work piece	D	mm	12
Turbine speed	S	rpm	1500
Cutting Speed	Vc	m/min	56.52
Specific cutting force	kC	Mpa	2500
Efficiency	¯„		70
Actual cutting Power	Pc	kW	0.033643
Actual cutting power	Pc	W	33.64286

Table 4
Turbine Power Calculations

Temperature of Steam at inlet		°C	200
Pressure of steam at inlet		bar	2
Enthalpy of Steam at inlet,	X1	kCal/kg	685.4067
Temperature of steam at outlet		°C	100
Pressure of Steam at outlet		bar	1
Enthalpy of Steam at outlet,	X2	kCal/kg	639.9522
Flow		kg/hr	1
Energy converted into mechanical energy, P= X1– X2		kWhr	52.85412
Leakage Losses		%	5
Friction losses		%	3
Inertia losses		%	8
Net Power Generated		%	44.80867

Note: Pn= P×(100-5)%×(100-3)%×(100-8)%

IV. CONCLUSION

The design of turbine driven wood turning lathe is modeled and parts are fabricated accordingly and later assembled.

The lathe when run is working successfully and is able to turn wood under different speed modules. This design and development of a prototype can be successfully implemented to fabricate a commercial wood turning lathe. As this lathe is turbine driven through the steam and the energy consumption is independent of government power grids, it can be installed in remote areas such as villages; rural areas etc., where biological waste such as waste wood, dry leaves and saw dust etc., can be easily available. This can be implemented in villages and tribal areas where there is no access for electricity.

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