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PROCESS FOR MAKING TURBINE PROPELLER SHAFT USING ST.37 LOW CARBON STEEL MATERIALS AT THE INDONESIAN INSTITUTE OF KNOWLEDGE (LIPI)

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Abstract
The shaft is a rotating stationary member, usually spherical in cross section, the shaft may receive bending loads, tensile loads, compressive loads or torsional loads acting alone or in combination with one another. The propeller turbine shaft is made using a conventional lathe from the Indonesian Institute of Sciences (LIPI). The shafts made have stratified diameters with diameters of 8 mm, 10 mm, 15 mm and 24 mm with an overall length of 595 mm and has a thread in one part of the shaft. The axle uses ST.37 material, dural rod material and for the outside of the shaft (casing) using aluminum. Dural is a high strength aluminum based alloy with the addition of copper, magnesium and manganese.

Keywords: *Shaft, Turbine Propeller, Conventional Lathe*

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Introduction

Indonesia's electricity consumption continues to increase every year in line with the increase in national economic growth. The increase in electricity demand is estimated to grow by an average of 6.5%/year until 2020 (Muchlis, 2003). In addition, in this digital era, more and more community activities are assisted by electronic goods.

With current technological advances and also the potential for power generation in remote areas, especially from the abundant potential of water, a small-scale power plant called the Micro Hydro Power Plant (PLTMH) is developed which is expected to be able to supply electrical energy to residents' homes.

With this PLTMH it is hoped that the community will be able to improve their welfare, carry out several activities easily both for agricultural, economic, social needs and so on. The ability of the government, which is hindered by the high cost of expanding the electricity grid, can make Microhydro provide an economic alternative to the grid. This is because an independent Micro-hydro scheme can save money from the transmission network, because such network expansion schemes usually require expensive equipment and staff costs. The potential for abundant water resources in Indonesia is due to the fact that there are many tropical rain forests, forcing us to develop this potential, because water is a renewable and natural source of energy. If this can continue to be explored, the conversion of water into electrical energy will be very profitable for this country.

As the first, largest and best research institute in Indonesia, the Indonesian Institute of Sciences (LIPI) has several activities including research programs and the utilization of science and technology.

LIPI makes and develops a 250 Watt capacity PLTMH using a propeller turbine. The Kaplan turbine is a propeller type water turbine which has adjustable blades and generator. The turbine was developed in 1913 by Austrian professor Viktor Kaplan, who combined an automatically adjustable propeller with wicket gates to achieve efficiency over varying water rates and flows. Likewise in turbine construction, in this case a water turbine, there is a shaft that functions as a successor to power and rotation resulting from changes in potential energy from falling water, so careful planning is needed to plan the shaft. The strength factor is the main factor in the design of this turbine shaft and resistance to corrosion is a factor that cannot be ignored, because the water turbine shaft will be exposed to or submerged in water.

Research Method

Work on the research and manufacture of this shaft with a flow chart can be seen in the following figure:

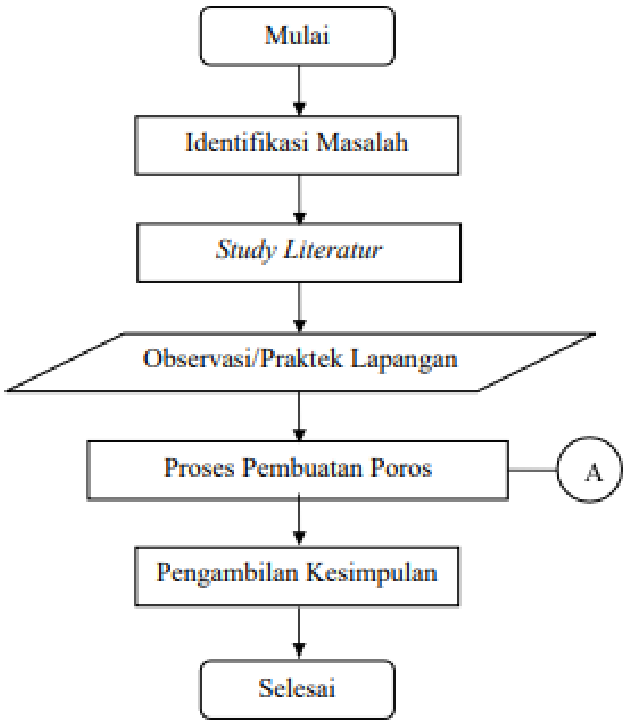


Figure 1 Research Flowchart

Results and Discussion

Manufacturing Process of Propeller Turbine Shaft

The propeller turbine shaft is made using a conventional lathe at LIPI Bandung, the material used for the ST 37 inner shaft, dural rod material and for the outer shaft (casing) uses aluminum. Dural is a high strength aluminum based alloy with the addition of copper, magnesium and manganese.

Shaft Cutting Process

The shaft cutting process uses a sawing machine with the size according to the working drawings of the material used, namely ST.37 diameter ø 24 mm and a length of 595 mm.

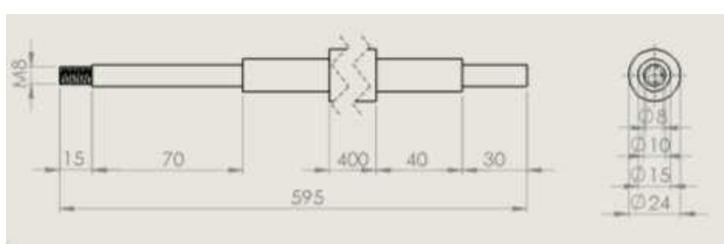
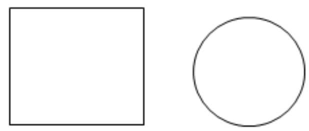
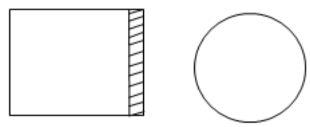
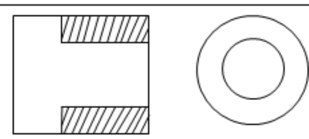
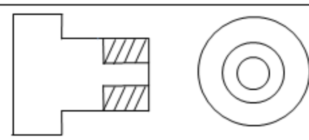


Figure 3 Size of the workpiece

Turbine Propeller Shaft Manufacturing Process

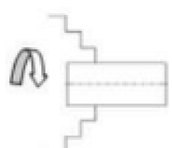
Machining SOPs

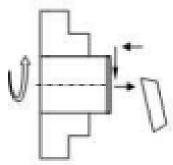
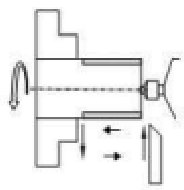
Table 4.1 Machining SOP

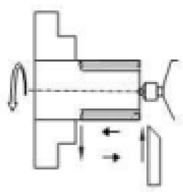
Gambar proses	Keterangan
	- Bahan ST.37 - Panjang 600 mm - Diameter 30 mm
	Proses bubut *face* - Pahat HSS Rata Kanan - Tebal 2.5 mm
	Proses bubut luar - Pahat HSS Rata Kanan - Tebal 4.5 mm - Panjang 40 mm
	Proses bubut bor - Pahat HSS Rata Kanan - Panjang 70 dan 30 mm - Tebal 2.5 mm

Shaft Turning Process

Table 4.2 Standard Operational Production (SOP) for Making Turbun propeller Shafts

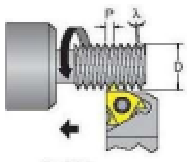
No	Jenis Pekerjaan dan Gambar	Alat dan Mesin	Parameter Pemesinan	Langkah Pembuatan	Keselamatan Kerja
1		• Mesin bubut Konvensional EC0CA • Kunci chuck • Kunci tool post		1. Persiapan pembubutan : a. Mempersiapkan peralatan dan perlengkapan mesin bubut b. Menyetting pahat bubut setinggi senter c. Mengatur putaran mesin 2. Memasang benda kerja pada mesin bubut dan mengencangkan chuck	• Jangan terlalu panjang benda kerja pada pencekaman • Kunci benda kerja ke chuck dengan kuat

2	Bubut *Facing* 	• Mesin bubut konvensional EC0CA • Pahat HSS rata kanan • Kunci L8 dan L12 • Senter kepala lepas • Jangka sorong	V = 21 mm/menit (**Tabel 2.1**) d =30 mm $n = \frac{V.1000}{\pi.d}$… (**Pers. 2.2**) $n = \frac{21.1000}{3,14.30}$ $n = \frac{21000}{94,2}$ $n = 222,92$ $n = 223\ Rpm$	3. Pembubutan *facing* dengan tebal pemakanan 2,5 mm 4. Lakukan pembubutan 2 kali pemakanan dengan tebal 2,5 mm dan membalikan benda kerja	• Jangan mengubah putaran mesin pada saat mesin berputar • Jangan meninggalkan mesin saat masih hidup
3	Bubut Rata 	• Mesin bubut konvensional EC0CA • Pahat HSS rata kanan • Kunci L8 dan L12	V = 21 mm/menit d = 24 mm $n = \frac{V.1000}{\pi.d}$ $n = \frac{21.1000}{3,14.24}$ $n = \frac{21000}{75,36}$ $n = 278.67$	5. Memasang senter kepala lepas agar putaran benda kerja stabil 6. Mengatur putaran mesin bubut menjadi 279 rpm 7. Jepit benda kerja pada dua senter	• Gunakan air pendingin pada saat pembubutan • Jangan mengubah putaran mesin pada saat mesin berputar • Jangan
		• Senter kepala lepas • Jangka sorong	$n = 279\ Rpm$ D1 = 30 mm, d2 = 24 mm a = 0,5 mm (tabel 2.) L = 595 mm $a = \frac{D-d}{2.i}$… (**Pers. 2.5**) $i = \frac{D-d}{2.a}$ $i = \frac{30-24}{2.0,5}$ $i = \frac{6}{1}$ i = 6 kali $t_h = \frac{L}{a.n}$… (**Pers. 2.4**) $t_h = \frac{595}{0,5.279}$ $t_h = \frac{595}{139,5}$	8. Lakukan pembubutan lurus dari diameter 30 mm-24 mm dengan panjang bubutan 595 mm. Kedalaman pemotongan (a) 0,5mm, Kecepatan sayat (s) 0,2	meninggalkan mesin saat masih hidup

			t_h = 4,26 menit		
4	Bubut Rata Bertingkat 	• Mesin bubut konvensional EC0CA • Pahat HSS rata kanan • Kunci L8 dan L12 • Senter kepala lepas • Jangka sorong	V = 21 mm/menit d = 15 mm $n = \frac{V.1000}{\pi.d}$ $n = \frac{21.1000}{3,14.15}$ $n = \frac{21000}{47,1}$ $n = 445,85$ $n = 446\ Rpm$ D1 = 24 mm, d2 = 15 mm L = 70 mm a = 0,5 mm $a = \frac{D-d}{2.i}$ … (Pers. 2.) $i = \frac{D-d}{2.a}$	9. Mengatur putaran mesin bubut menjadi 446 rpm 10. Lakukan pembubutan lurus bertingkat dari diameter 24-15 mm dengan panjang bubutan 70 mm. Kedalaman pemotongan (a) 0,5mm, Kecepatan sayat (s) 0,2 11. Lakukan bubut bertingkat pada diameter awal D1 15- d2 10 mm dengan panjang L = 30 mm 12. Balikan posisi benda kerja	• Gunakan air pendingin pada saat pembubutan • Jangan mengubah putaran mesin pada saat mesin berputar • Jangan meninggalkan mesin saat masih hidup
			$i = \frac{24-15}{2.0,5}$ $i = \frac{9}{1}$ i = 9 kali $t_h = \frac{L}{a.n}$ $t_h = \frac{70}{0,5.446}$ $t_h = \frac{70}{223}$ t_h = 0,31 menit Bertingkat (Ø10) $n = \frac{V.1000}{\pi.d}$ $n = \frac{21.1000}{3,14.10}$ $n = \frac{21000}{31,4}$ $n = 668,78$ $n = 669\ Rpm$ D1 = 15 mm, d2 = 10 mm L = 30 mm	13. Lakukan bubut bertingkat pada diameter 24-15 mm dengan L = 125 mm 14. Bubut rata bertingkat pada D1 15 mm – d2 10 mm dengan L = 85 mm 15. Bubut rata bertingkat pada D1 10 mm – d2 8 mm dengan L = 15 mm	

			$a = \frac{D-d}{2.l}$ … (Pers. 2.) $i = \frac{D-d}{2.a}$ $i = \frac{15-10}{2.0,5}$ $i = \frac{5}{1}$ i = 5 kali $t_h = \frac{L}{a.n}$ $t_h = \frac{30}{0,5.669}$ $t_h = \frac{30}{334,5}$ t_h = 0,08 menit Bertingkat (Ø8) $n = \frac{V.1000}{\pi.d}$ $n = \frac{21.1000}{3,14.8}$ $n = \frac{21000}{25,12}$ $n = 835,98$		

			$n = 836\ Rpm$ D1 = 10 mm, d2 = 8 mm L = 15 mm $a = \frac{D-d}{2.l}$ … (Pers. 2.) $i = \frac{D-d}{2.a}$ $i = \frac{10-8}{2.0,5}$ $i = \frac{2}{1}$ i = 2 kali $t_h = \frac{L}{a.n}$ $t_h = \frac{15}{0,5.836}$ $t_h = \frac{15}{418}$ t_h = 0,035 menit		

5	Bubut Ulir 	• Mesin bubut konvensional EC0CA • Pahat ulir Matrik • Kunci L8 dan L12 • Senter kepala lepas • Jangka sorong	D = 8 mm d2 = 7,188 mm d3 = 6,47 L = 15 mm M = M8 P = 1,25 mm α = 60°	16. Majukan pahat pada diameter luar ulir 17. Seting ukuran pada eretan atas menjadi 0 mm 18. Tarik pahat ke luar diameter benda kerja, sehingga pahat di luar benda kerja dengan jarak bebas sekitar 10 mm 19. Atur handel kisar menurut tabel kisar yang ada di mesin bubut, geser hanel gerakan eretan bawah untuk pembuatan ulir. 20. Masukan pahat dengan kedalaman potong sekitar 0,1 mm	• Gunakan air pendingin pada saat pembubutan • Jangan mengubah putaran mesin pada saat mesin berputar • Jangan meninggalkan mesin saat masih hidup
				21. Jalankan mesin sampai panjang ulir 15 mm yang dibuat terdapat goresan pahat, kemudain 22. hentikan mesin dan tarik pahat keluar.	

Material = ST Steel. 37

Workpiece Size = ∅30 mm, Length = 600mm

Turning results:

Flat lathe = initial diameter D1 =∅ 30 mm, d2 ∅ 24 mm length 595 mm with depth of cut a = 0.5 mm, 6 revolutions, in 4.26 minutes = 6 x 4.26 minutes = 25.56 minutes

Lathe Lathe = (∅ 15 mm) length 70 mm with a depth of cut a = 0.5 mm, 9 revolutions, in 0.31 minutes = 9 x 0.31 minutes = 2.79 minutes, and vice versa with L = 125mm.= (∅ 10) mm length 30 mm with ap depth of cut a = 0.5 mm, 5 rounds, in 0.08 minutes = 5 x 0.08 minutes = 0.4 minutes, and vice versa with L = 85mm. = (∅ 8) mm length 15 mm with depth of cut a = 0.5 mm, 2 turns, in 0.032 minutes = 2 x 0.032 minutes = 0.064 minutes Lathe Thread = Initial diameter (D) = 8 mm, pitch diameter (d2) = 7.188 mm, smallest diameter (d3) = 6.47 mm, thread length (L) = 15 mm, matrix code (M) = M8, pitch distance (P) = 1.25 mm, pitch angle (α) = 60°.

Conclusion

Dalam pembuatan poros turbin propeller dilakukan dengan menggunakan mesin gergaji sebagai alat pemotong benda kerja dan mesin bubut konvensional sebagai mesin pembuatan poros turbin propeller. Pembubutan poros turbin propeller menggunakan mesin bubut konvensional pengoprasian pertama dengan membaca gambar kerja yang akan dibubut dan membuat Standart Operational Production (SOP) Pembuatan Poros Turbun propeller sehingga didapat waktu dalam pembuatan turbin dibutuhkan 32, 004 menit menggunakan mesin bubut konvensional EC0CA.

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