$$\lambda = \frac{2*\Pi*42}{12*11}$$

$$\lambda = 2$$

$$\boldsymbol{\lambda=2}$$

Similarly for different values of tip speed ratio (λ=2, 4, 6, 8, 10, 12, 14) the wind power and coefficient of power are calculated by using the above formulas.

Table 1: calculated values of wind power and coefficient of power

B	ϒ	Cp(λ,β)	Pm(MW)
0	2.1505	1.4051*10-3	0.006374
2	2.1782	1.543*10-3	0.006529
4	2.3229	2.5681*10-3	0.0116
6	2.4809	4.149*10-3	0.0188
8	2.6404	6.2808*10-3	0.02849
10	2.9601	0.01219	0.40705
12	2.9601	0.0121	0.00005
14	3.1201	0.0158	0.000071
16	3.28009	0.0198	0.000009

Similarly for different values of tip speed ratio (λ=2, 4, 6, 8, 10, 12, 14) the wind power and coefficient of power are calculated by using the above formulas.

3. Planetary Gear Box

The gearbox is used in the 2.1MW machine is planetary system which is the effective system for the maximum power generation. Planetary gearboxes are look like to the solar system. The components of a planetary gear box include a sun gear, ring gear and planetary gears. The sun gear is the central gear which is fixed in the center, ring gear which is the outer ring, and the planetary gears which rotate around the sun gears and mesh with both the sun gear and ring gear.[7]

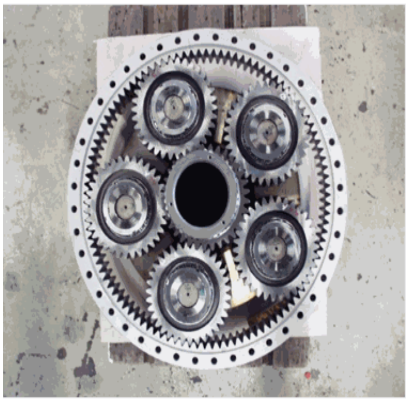

Figure 2: Planetary Gear Box

Gear Ratio:

The gear ratio of an epicyclic gearing system is mainly three basic components are:

- Sun: central gear
- Planet carrier: it is meshed with the sun gear
- Ring gear: an outer ring with inward facing teeth that mesh with the gears

The overall gear ratio of planetary gear can be calculated using the below two equations, representing the sun-planet and ring- planet interactions respectively.

$$N_s W_s + N_p W_p - (N_s + N_p) W_c = 0$$

$$N_a W_a - N_p W_p - (N_a - N_p) W_c = 0$$

Where,

W_s, W_a, W_c, W_p, is the angular velocity of the sun gear, annulus, planet carrier, and planet gears respectively, and N_s, N_a, N_p is the number of teeth of the sun gear, annulus, planet gears respectively.

The gear ratio of a gear train, also known as its speed ratio, the gear ratio is the ratio of the angular velocity of the input gear to the angular velocity of the output gear. The gear ratio can be calculated directly from the number of teeth on the gears in the gear train. [7]

$$\text{Gear Ratio} = \frac{\text{velocity of driver}}{\text{velocity of driven}} \qquad (10)$$

$$= \frac{V_1}{V_2}$$

Where

V1= velocity of driver
V2= velocity of driven
Gear ratio=v1/v2
Gear ratio= 0.6
V1=14 to 25 m/s

Velocity of driven is calculated by using the above formula

V2=v1/G.R (11)

At velocity of driver 14 m/s

V2=v1/G.R
=14/0.6
V2 = 23.33 m/s

Similar calculations are done from 14 to 25 m/s the results are tabulated:

Gear Ratio = 0.6

Table 2: Calculations of velocity of driven

Velocity of driver(v1) m/s	Velocity of driven(v2) m/s
14	23.33
15	25
16	26.6
17	28.3
18	30
19	31.66
20	33.33
21	35
22	36.66
23	38.33
24	40
25	41.66

Gear Ratio = v1/v2
V1=14 m/s
G.R= v1/v2

At angular velocity of driver 14 m/s

G.R=14/23.33
G.R= 0.6

Similar calculations are done from 23.3to 41.6 m/s the results are tabulated:

Table 3: Calculations of gear ratio

Angular velocity of driven(v2)m/s	Gear Ratio(G.R)
23.33	0.6
25	0.56
26.6	0.526
28.3	0.494
30	0.466
31.66	0.442
33.33	0.42
35	0.4
36.66	0.38
38.33	0.365
40	0.35
41.66	0.336

4. Results

Graphical Representations:

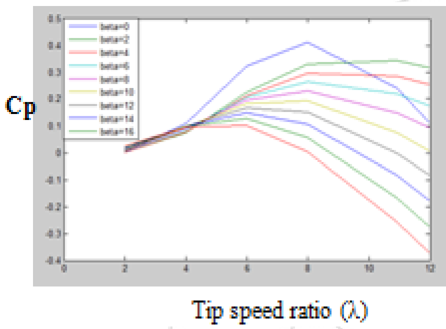

Figure 3: C_p verses λ with different pitch angles

The performance characteristic of the wind turbines is relationship between the coefficients of power verses tip speed ratio graphically shows. Increasing the pitch angle the coefficient of power is gradually decreasing. That means the coefficient of power depends on the pitch angle and tip speed ratio. The tip speed ratio is increases and then coefficient of power is also increases, but up to certain points only increases. The maximum coefficient of power is 0.41 at tip speed ratio 8 and then coefficient of power is decreasing gradually.

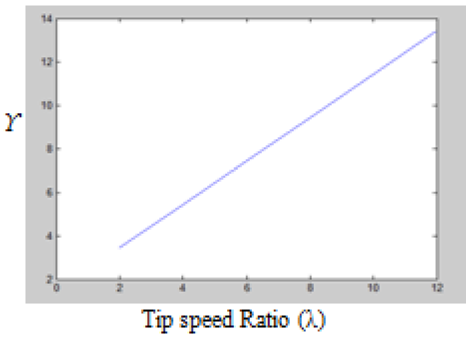

Figure 4: Υ verses λ with different pitch angles

The performance characteristic of the wind turbines is relationship between the gamma verses tip speed ratio graphically shows. Increasing the pitch angle the gamma is gradually decreasing. That means the gamma depends on the pitch angle and tip speed ratio. Gamma increases with increasing of tip speed ratio.

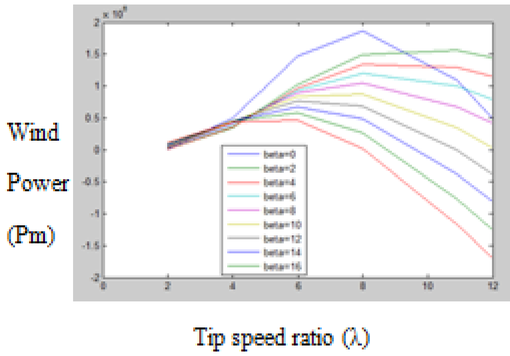

Figure 5: P_m verses λ with different pitch angles

The performance characteristic of the wind turbines is relationship between the wind power verses tip speed ratio graphically shows. Increasing the pitch angle the wind power is gradually decreasing. That means the wind power depends on the pitch angle and tip speed ratio. The tip speed ratio is increases and then wind power is also increases, but up to certain points only increases. The maximum wind power is 1.86MW at tip speed ratio is 8 and then wind power is decreasing gradually.

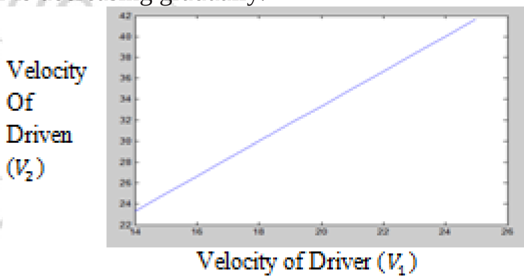

Figure 6: velocity of driven verses velocity of driver at fixed velocity of driver.

The performance characteristics are drawn between the angular velocity of driven and angular velocity of driver by fixed gear ratio. The gear ratio is fixed at 0.6, the angular velocity of driver increases gradually then angular velocity of driven also increases.

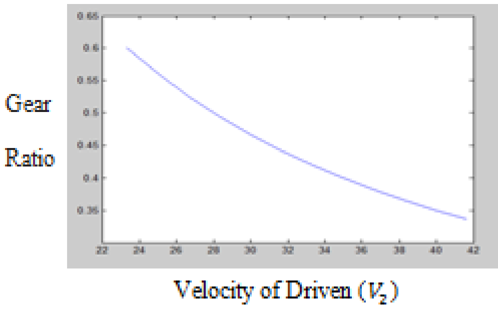

Figure 7: gear ratio verses velocity of driven at fixed velocity of driver

The performance characteristics are drawn in between the angular velocity of the driven and gear ratio at fixed angular velocity of driver at 14 m/s. Angular velocity of driver at14m/s is fixed, the angular velocity of driven is increasing gradually the gear ratio value is gradually decreasing state. Hence the gear ratio is inversely proportional to the angular velocity of driven.

5. Conclusion

The effect of variations in pitch angles on wind turbines and gearbox are analyzed. The graphical results of the coefficient of power vs tip speed ratios, wind power vs tip speed ratio, gamma vs tip speed ratio by varying the pitch angles are obtained from MATLAB programming. And gear ratio is also calculated by using the velocity of driver to velocity of driven. The performance characteristics of the wind turbines and gear box are analyzed and graphically shown by using the MATLAB. The maximum coefficient of power is 0.41 at tip speed ratio 8 and then coefficient of power is decreasing gradually. Gamma is increased with increasing of tip speed ratio. The maximum wind power obtained in this work is 1.86MW at tip speed ratio 8 and then wind power is decreasing gradually. Angular velocity of driven is increased gradually with increasing in angular velocity of driver. The gear ratio is inversely proportional to the angular velocity of driven.

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