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Designing, Modeling and Structural Analysis of Spur Gear System by Using Polymers

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ABSTRACT

This work elaborates more on the creep nature of metallic spur gear results in the deficiency because of the deformation of teeth when pressure angle of 20° acting on it. At the replacing points of tooth between driving and driven the disturbances such as in-evitable random noise, elastic deformation and manufacturing error, alignment error in assembly all these together causes the high level of gear vibration and noise and leads to loss in efficiency. The main motto is to reduce the deformation of teeth, by replacing the metallic cast iron gear with Nylon gear and proved that the deformation of Nylon gear is less compared to metallic and polycarbonate. Since the deformation is less the loss in efficiency is also less compared to metallic gear. The modeling of spur gear has been done in PRO-E and the structural and modal analysis of spur gear analyzed through ANSYS software.

Keywords : Shaft Deign, Optimization, MATLAB, Graphical User Interface

I. INTRODUCTION

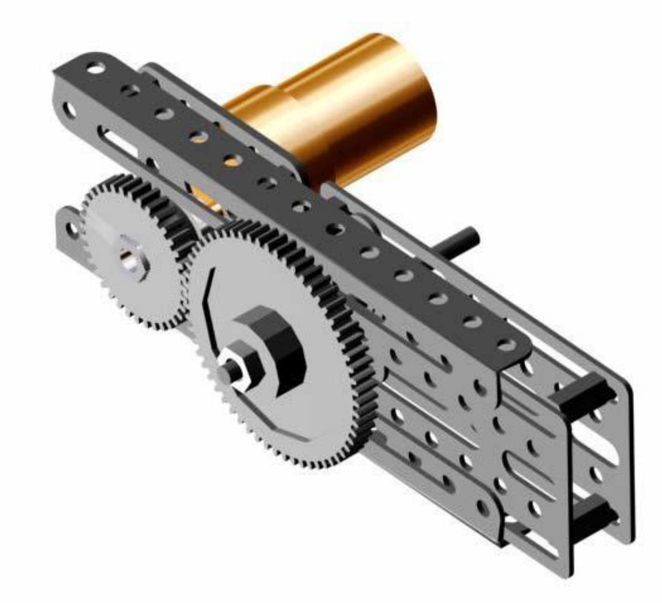
A gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque, in most cases with teeth on the one gear of identical shape, and often also with that shape (or at least width) on the other gear. Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine.

1.1 GEAR TERMS AND TYPES

Spur gears have been used since ancient time's illustration of the two-man drive system that System that Leonardo Davinci designed to power his vision of a helicopter like device. The device never flew, but the gear system works. Modern gears are a refinement of the wheel and axle. Gear wheels have projections called teeth that are designed to intersect the teeth of another gear. Whengear teeth fittogetherorinterlock in this manner they are said to be in mesh. Gears in mesh are capable of transmittingforce and motion alternately from one gear to another. The gear transmitting the force or motionis called the drive gear and the gear connected to the drive gear is called the driven gear.

Gears are used to Control Power Transmission in These Ways

1. Changing the direction through which power is transmitted (i.e., parallel, right angles,
Rotating, linear etc.)
2. Changing the amount of force or torque
3. Changing RPM



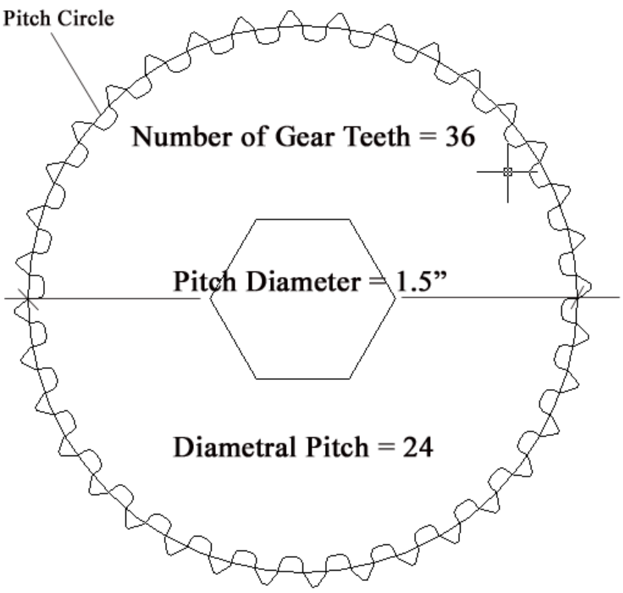
1.2 GEAR TERMS AND CONCEPTS

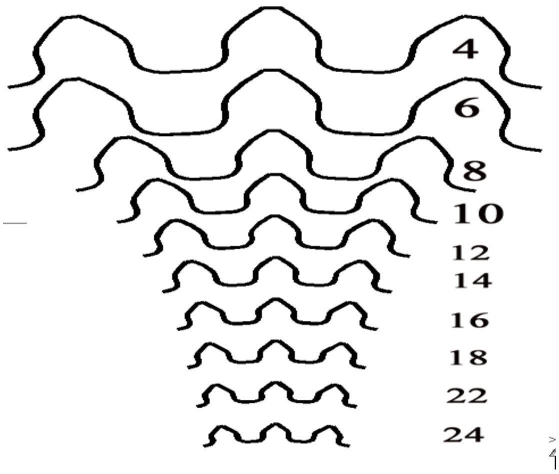
1.3

Spur Gears are cogged wheels whose cogs or teeth project radially and stand parallel to the axis.

Diametric Pitch (DP)

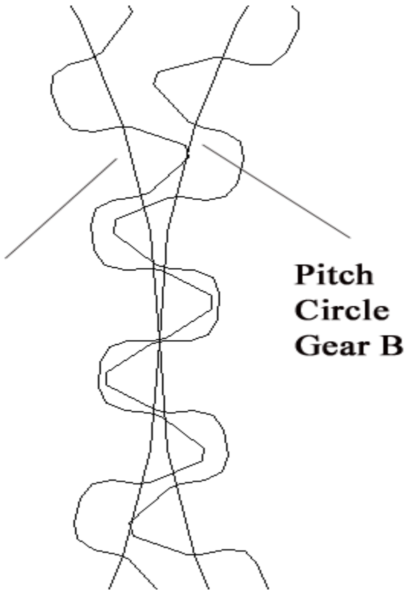
The Diametric Pitch describes the gear tooth size. The Diametric Pitch is expressed as the number of teeth per inch of Pitch Diameter. Larger gears have fewer teeth per inch of Diametric Pitch. Another way of saying this; Gear teeth size varies inversely with Diametric Pitch.





I. The Pitch Circle

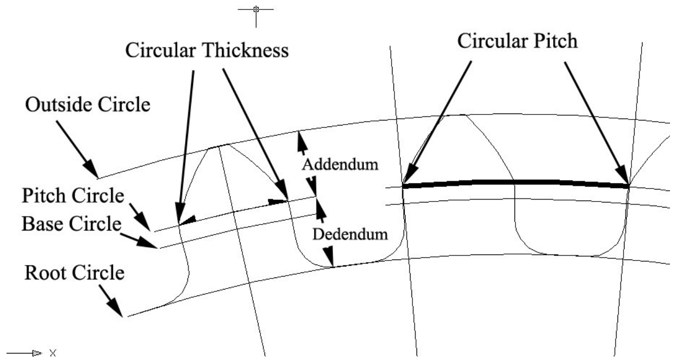
The pitch circle is the geometrical starting point for designing gears and gear trains. Gear trainsrefer to systems of two or more meshing gears. The pitch circle is an imaginary circle that contacts the pitch circle of any other gear with which it is in mesh.



The pitch circle centers are used to ensure accurate center-to-center spacing of meshing gears. The following example explains how the center distances of meshing gears is determined using the pitch circle geometry.

Calculate the center-to-center spacing for the 2gears specified below.
Gears: Gear #1) 36 tooth, 24 Pitch Drive Gear
Gear# 2) 60 tooth, 24 Pitch Driven Gear
Pitch Diameter (D) of gear #1 is: D= N/P = 36/24 =1.5"
Pitch Diameter (d) of gear#2 is: D= N/P = 60/24= 2.5"

Add the two diameters and divide by 2.
Pitch Dia. of gear #1 = 1.5"
Pitch Dia. Of gear #2 = + 2.5"
Sum of both gear diameters = 4.0"
Divide by 2 Sum of both gear diameters = 4.0"/2 = center to center distance = 2"
(This is necessary since the gear centers are separated by a distance equal to the sum of their - respective radii.)
A simple formula for calculating the center-to-center distances of two gears can be written;
Center-to-Center Distance =(D + D) / 2

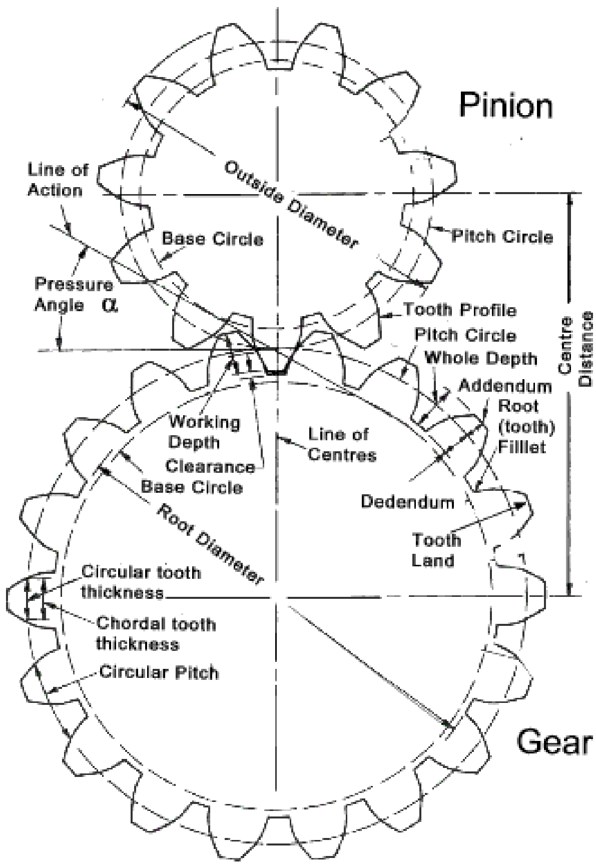


II. TERMINOLOGY - SPUR GEARS

TERMINOLOGY AND DEFNITIONS

- **DIETRAL PITCH (D P)** - The number of teeth per one inch of pitch circle diameter.
- **MODULE. (M)** - The length in mm of the pitch circle diameter per tooth.
- **CIRCULAR PITCH (P)** - The distance between adjacent teeth measured along the arc at the pitch circle diameter
- **ADDENDUM (H A)** - The height of the tooth above the pitch circle diameter.
- **CENTRE DISTANCE (A)** - The distance between the axesoftwo gears in mesh.
- **CIRCULAR TOOTH THICKNESS (CTT)** - The width of a tooth measured along the arc at the pitch circle diameter.
- **DEDENDUM (H F)**-The depth of the tooth below the pitch circle diameter.
- **OUTSIDE DIAMETER (D O)** - The outside diameter of the gear.
- **BASE CIRCLE DIAMETER (D B)** - The diameter on which the involutes teeth profile is based.
- **PITCH CIRCLE DIA (P)**- The diameter of the pitch circle.

- **PITCH POINT**-The point at which the pitch circle diameters of two gears in mesh coincide.
- **PITCH TO BACK** - The distance on a rack between the pitch circle diameter line and the rear face of the rack.
- **PRESSURE ANGLE** - The angle between the tooth profile at the pitch circle diameter and a radial line passing through the same point.
- **WHOLE DEPTH** -The total depth of the space between adjacent teeth.



III. EQUATIONS FOR BASIC GEAR RELATIONSHIPS

It is acceptable to marginally modify these relationships e.g to modify the addendum /dedendum to allow Centre Distance adjustments. Any changes modifications will affect the gear performance in good and bad ways...

Addendum(h a) = m = 0.3183 p

Base Circle diameter (Db) = d.cos α

Centre distance (a) = (d g + d p) / 2

Circular pitch (p) = m.π

Circular tooth thickness (ctt) = p/2

Dedendum (h f) = h - a = 1,25m = 0,3979 p

Module (m) = d /z

Number of teeth (z) = d / m

Outside diameter (D o) = (z + 2) x m

Pitch circle diameter (d) = z .m ... (d g = gear & d p = pinion)

Whole depth(min)h = 2.25. m

Top land width(min) (t o) = 0,25 . m

SPUR GEAR STRENGTH AND DURABILITY CALCULATIONS:

Designing spur gears is normally done in accordance with standards the two most popular series are listed under standards above

Bending

The basic bending stress for gear teeth is obtained by using the Lewis formula

$\sigma = F_t / (b_a . m. Y)$

- F_t = Tangential force on tooth
- σ = Tooth Bending stress (MPa)
- b_a = Face width (mm)
- Y = Lewis Form Factor
- m = Module (mm)

Note: The Lewis formula is often expressed as $\sigma = F_t / (b_a . p. y)$

Where y = Y/π and p = circular pitch

When a gear wheel is rotating the gear teeth come into contact with some degree of impact. To allow for this a velocity factor (K_v) is introduced into the equation. This is given by the Barth equation.

For cut or milled gears $K_v = \frac{6,1 + V}{6,1}$

For cast iron , cast gears $K_v = \frac{3,05 + V}{3,05}$

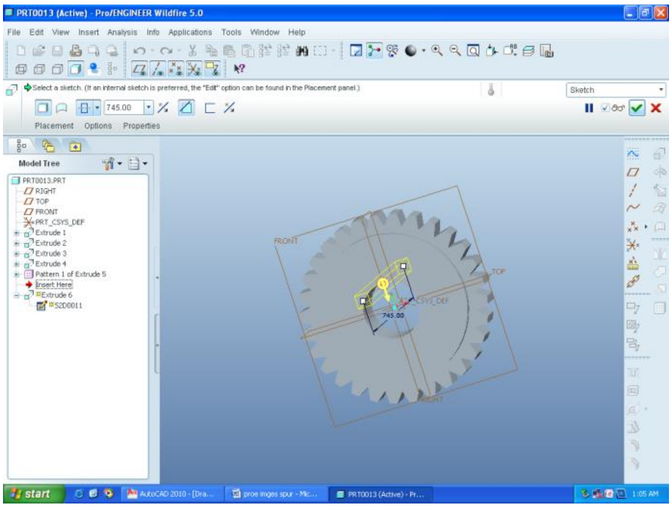
For hobbed or shaped gears $K_v = \frac{3,56 + \sqrt{V}}{3,56}$

For shaved or ground gears $K_v = \sqrt{\frac{5,56 + \sqrt{V}}{5,56}}$

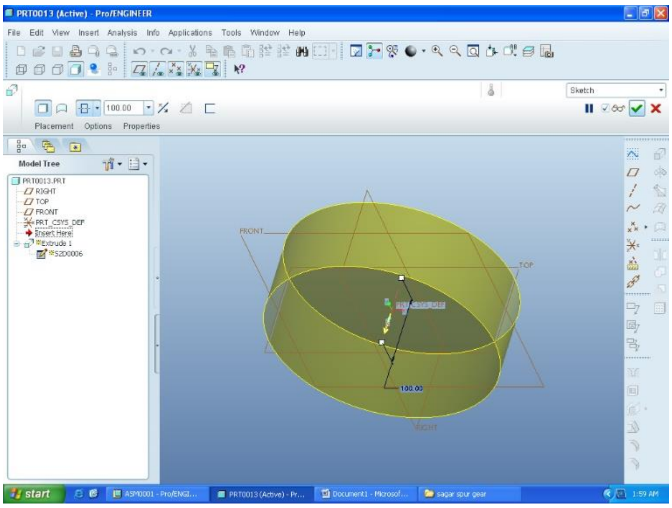
The Lewis formula is thus modified as follows

$\sigma = K_v . F_t / (b_a . m. Y)$

IV. MATERIAL PROPERTIESOF CAST IRON, NYLON AND POLYCARBONATE



MODELLING OF SPUR GEAR IN PRO-E



Material property	Cast Iron	Nylon	polycarbonate
Young's modules	1.65e5	2.1e5	2.75e5
Poisions Ratio	0.25	0.39	0.38
Density (kg/mm)	7.2e-6	1.13e-6	1.1e-6
Co-efficient of Friction	1.1	0.15-0.25	0.31
Ultimate Tensile strength	320-350	55-83	55-70

V. ANALYSIS OF SPUR GEAR

CONVERTING THE PRO-E MODEL INTO IGES FORMAT

After the completion of modeling of Spur gear we need to convert it into the IGES format in which ANSYS recognizes our model and can be imported easily in the suggested way.

GO TO FILE---- CLICK SAVE COPY---- Change files type to IGES ---CLICK SOLID MODEL and give File Name --- SAVE in PRO-E

SATIC ANALYSIS HAS BEEN DONE TO FIND OUT THE DEFORMATION OF TEETHS

We have to follow certain procedure to analyze the results in ANSYS.

Procedure steps:

1) IMPORT THE MODEL
2) MESHING
3) CONSTRAINING THE DEGRESS OF FREEDOM

4) APPLY LOADS

5) SOLVE

PREFERENCE --- STRUCTURAL

PRE-PROCESSER---ELEMENT TYPE---ADD ELEMENT---TET10NODE 187-- Click OK

IMPORTING THE MODEL

Click File--- click on Import---IGES---Browse---OK

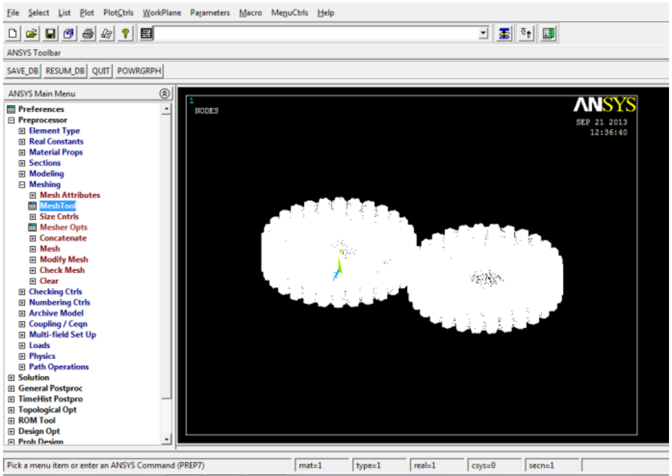
Spur Gears will be displayed on the ANSYS working Window

MESHING

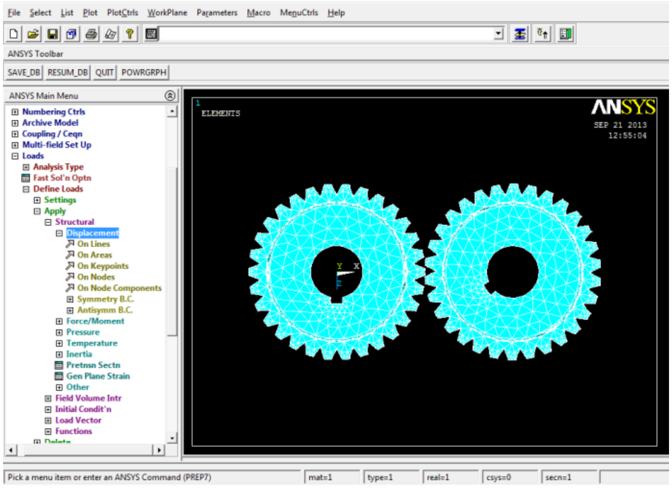
MESH---MESH TOOL--- CHANGE TO VOLUMES---CLICK--- FREE MESH---CLICK THEE SPUR GEARS VOLUMES---OK and then CLICK ON MESH.

A very fine mesh view of spur gear is displayed below.

(MESHED USING TET10NODE187- ELEMENT USED)

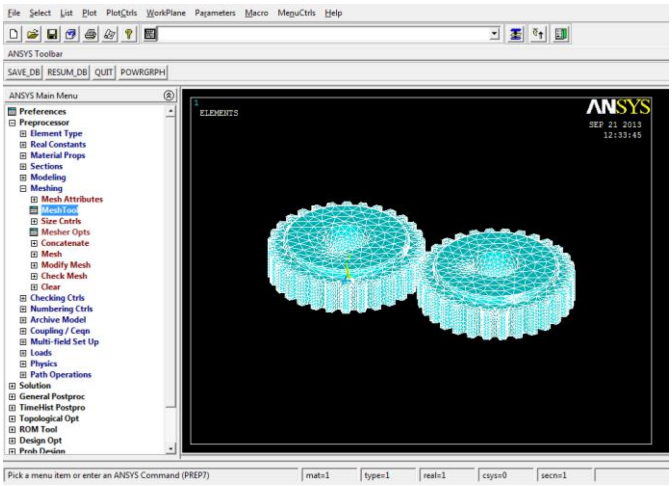


(MESH VIEW OF SPUR GEAR)

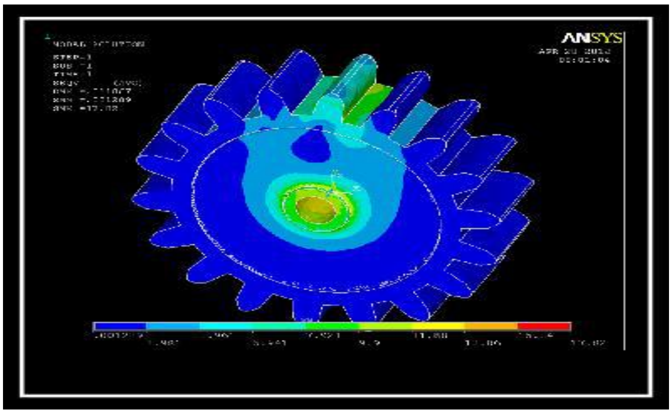


(ELEMENTS OF SPUR GEAR)

(CONTACT TEETHS OF SPUR GEAR)



LOADS AND BOUNDARY CONDITIONS OF GEAR



VI. RESULTS

From the static analysis using ANSYS the deflections and Vonmises stress and strain values for the cast iron, Nylon and polycarbonate are obtained as following below tables.

VII. CONCLUSION

As per results given by ansys the deflections of nylon gear is less, Since the deflections are less the efficiency of nylon spur gear is more than the cast iron spur gear, results in less noise and long life, The metallic gear results is more deflection compared to nylon and polycarbonate, the cost price and life of nylon is also good. When we replace the metallic spur gear with nylon gear there would be better results we can find in the automobile, robotic and in medical fields where the need of nylon gear is there.

FOR CAST IRON SPUR GEAR

Pressure (N/mm2)	Vonmise Stress (N/mm2)	Deflection (mm)	Strain
1	3.832	0.002905	2.21e-4
2	7.665	0.005811	4.41e-4
3	11.497	0.008716	6.62e-4
4	15.33	0.011622	8.82e-4
5	19.078	0.014488	1.14e-3

FOR NYLON SPUR GEAR

For Nylon Spur gear: Pressure (N/mm2)	Vonmise Stress (N/mm2)	Deflection (mm)	Strain
1	3.582	0.002381	2.19e-4
2	7.163	0.004762	4.37e-4
3	10.745	0.007143	6.56e-4
4	14.327	0.009524	8.74e-4
5	17.82	0.011867	1.29e-3

FOR POLYCARBONATE SPUR GEAR

Pressure (N/mm2)	Vonmise Stress (N/mm2)	Deflection (mm)	Strain
1	3.615	0.001817	2.20e-4
2	7.863	0.003635	4.45e-4
3	10.846	0.005452	6.61e-4
4	14.462	0.007274	8.82e-4
5	17.989	0.009059	1.38e-3

VIII. REFERENCES

1) D. W. Dudley, ed., Gear Handbook (1962); H. J. Watson, Modern Gear Production (1970); R. J. Drago, Fundamentals of Gear Design (1988).

2) Darle W. Dudley, Practical Gear Design, McGraw-Hill Book Company, 1954

3) Peter R.N. Childs, Mechanical Design, Second edition, Elsevier Butterworth-Heineman, 2004.

4) Mekala P., Kunuthur M.R., Chandramohana Reddy B. (2019) Evaluation of the Mechanical Properties of Recycled Jute Fiber–Reinforced Polymer Matrix Composites. In: Vasudevan H., Kottur V., Raina A. (eds) Proceedings of International Conference on Intelligent

Manufacturing and Automation. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-13-2490-1_26

5) Rapid Start up Analysis of a Natural Circulation HRSG Boiler with a Vertical Steam Separator Design by M.J. Albrecht, W.A. Arnold, R. Jain and J.G. DeVitto,
6) Design and analysis of the prototype of boiler for steam pressure control 1Akanksha Bhoursae, 2 Jalpa Shah, 3Nishith Bhatt Institute of Technology, Nirma University, SG highway, Ahmedabad-382481,India 3Essar steels limited,Hazira,Surat-394270,India
7) Pullareddy. M, Shabeera Sheik, Sk Md Imran, Kavitha. K, Chanikya. K, Lavanya. G, Jayasree. K, Shahanaaz, Anitha. C, Manmohan. S, "Experimental Investigation on Al 7075, TiB2, TiC, Metal Matrix Composites to find Power Consumption and MRR while Machining", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 2 Issue 2, pp. 1329-1337, March-April 2016. Journal URL : https://ijsrset.com/IJSRSET1622450
8) Kunuthur M.R., Reddy B.C. (2019) Investigation of Moisture Absorption in Jute Fiber Polymer Matrix Composites. In: Vasudevan H., Kottur V., Raina A. (eds) Proceedings of International Conference on Intelligent Manufacturing and Automation. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-13-2490-1_34
9) Lou Roussinos, P. E., "Boiler Design and Efficiency" [online], Available: http://www.forestprod.org/drying06williamson .pd f, Accessed: September 1, 2010.
10) Murdock, K. L., "3ds max 9 Bible, Wiley Publishing Inc. Indianapolis, Indiana, 2007.
11) Nagpal, G. R., 1998, Power Plant Engineering, Khanna, Delhi.
12) K. Manohar Reddy, B. Chandra Mohana Reddy, Mechanical characterization of chemically treated used jute fiber reinforced epoxy composite with SIC fillers, Materials Today: Proceedings, Volume 37, Part 2, 2021, Pages 917-921, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2020.06.055.
13) Steam Pressure Reduction: Opportunities and Issues by U.S Deportment of energy,
14) Technological investigations and efficiency analysis of a steam heat exchange condenser:
15) U. M. Basha et al., "Synthesis and Characterization and Properties Comparison of Epoxy Filled Filler Millet (Ragi) Filler and Treated Sacharun offinarum (Sugar Cane) Fiber Reinforced Composites", International Letters of Chemistry, Physics and Astronomy, Vol. 51, pp. 41-46, 2015
16) K. Manohar Reddy, D. Harsha Vardhan, Y. Santhosh Kumar Reddy, Gujjala Raghavendra, Ramesh Rudrapati, "Experimental Study of Thermal and Mechanical Behavi
17) Buckingham, E., 1949, "Analytical Mechanics of Gears", McGraw-Hill, New York.
18) Smith, J.D., 1999, Gear Noise and Vibration, Marcel-Dekker, New York.
19) Spotts, M.F., 1964, Mechanical Design Analysis, Prentice Hall, Englewood Cliffs, NJ.

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