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RESEARCH ARTICLE OPEN ACCESS

Design, Modeling, Application and Analysis of Bevel Gears

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ABSTRACT

Computer technology has touched all areas of today's life, impacting how we obtain railway tickets, shop online and receive medical advice from remote location. Computer-based design analysis is nowadays a common activity in most development projects. Traditionally, the design field has been identified with particular end products, e.g., mechanical design, electrical design, ship design. In these fields, design work is largely based on specific techniques to foster certain product characteristics and principles The scope of this work includes, to design, to model the bevel gear, to select gear materials , to detailed factor safety in design and to analysis bevel gears. Gears are toothed elements that transmit rotary motion from one shaft to another. Gears are generally rugged and durable and their power transmission efficiency is as high as 98%. Gears are usually more costly than chains and belts. **Bevel gears** are gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped. Bevel gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The pitch surface of bevel gears is a cone. Two bevel gears in mesh is known as bevel gearing. In bevel gearing, the pitch cone angles of the pinion and gear are to be determined from the shaft angle, i.e., the angle between the intersecting shafts. The bevel gear has many diverse applications such as locomotives, marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, railway track inspection machines, etc.

I. INTRODUCTION

The history of gears is probably as old as civilization itself. Still today, the importance of gears in the manufacturing industry is undiminished and even continues to grow**.**Gears are considered as one of the oldest piece of equipment known to mankind, so old in fact that their origin can be trace back to The Chinese South-Pointing Chariot in the 27th century B.C – a vehicle built on two wheels which bore a movable indicator that always pointed South no matter how the chariot turned. The chariot, allegedly designed by mechanical engin Ma Jun, possessed rotating wheels that were mechanically geared to keep the indicator pointing in a southern direction without the use of magnets**.** The earliest description of gears was written in the 4th century B.C. by Aristotle. He wrote that the "direction of rotation is reversed one gear wheel drives another gear wheel. In the 3rd century B.C., various Greek Inventors used gear in water wheels and clocks, and sketches of various types of gears of around this time were found in Leonardo da Vinci's notebooks on. For a long period after these discoveries, there were no major development concerning wheels until the 17th century, when the first attempts to provide constant velocity ratios (conjugate profiles) was recorded and there was mention of the utilization of the involute curve. The 19th century saw the first use of form cutters and rotating cutters and in 1835 English inventor Whitworth patented the first gear hobbing process. Various other patents followed until 1897 when Herman Pfauter of Germany invented the first hobbing machine capable of cutting both spur and helical gears. Through the 20th century various types of machines developed. But, the next major step came 1975 when the Pfauter Company in Germany introduced the first NC hobbing machine and in 1982 the Full 6 axis machine was introduced. The purpose of any gear mesh is to transmit rotary motion and torque from one location to another at a consistent rate.see fig 4

Simulation is a powerful approach to modeling manufacturing systems in that many complex and diverse systems can be represented. Can predict system performance measures that are difficult to assess without a model. It is a proven, successful tool and has been in use since the 1950s. The current languages take advantage of the capabilities of today's microprocessors and provide the user with the needed on-line support for model development, management, and analysis . CAD (computer-aided design) has its roots in interactive computer graphics. Before the CAD era, engineering drawings were prepared manually on paper using pencils and drafting instruments on a drafting table. The advent of interactive computer graphics replaced the drafting table with a computer monitor and the pencil with an input device such as a light pen or mouse. Instead of using physical drafting instruments, software commands and icons on the computer display are used.The drawing can be created, modified, copied, and transformed using the software tools. At the time,CAD stood for computer-aided drafting. Drafting was confined to 2D because of the paper limitation. With the computer, such limitation is removed. Three-dimensional CAD systems were developed in the 1960s. In 3D CAD, objects are modeled using 3D coordinates (x, y, and z) instead of 2D coordinates (x and y). The need for modeling parts and products with complex surfaces motivated the development of free-form surface modelers. Bevel gears are used in differential drives, which can transmit power to two axles spinning at different speeds, such as those on a cornering automobile.

The gears in a bevel gear planer permit minor adjustment during assembly and allow for some displacement due to deflection under operating loads without concentrating the load on the end of the tooth.

Spiral bevel gears are important components on rotorcraft drive systems. These components are required to operate at high speeds, high loads, and for a large number of load cycles. In this application, spiral bevel gears are used to redirect the shaft from the horizontal gas turbine engine to the vertical rotor.

II. GEAR DESIGNCONSIDERATIONS

Bevel and hypoid gears are suitable for transmitting power between shafts at practically any angle and speed. The load, speed, and special operating conditions must be defined as the first step in designing a gear set for a specific application. A basic load and a suitable factor encompassing protection from intermittent overloads, desired life, and safety are determined from

[1.] The power rating of the prime mover, its overload potential, and the uniformity
of its output torque
[2.] The normal output loading, peak loads and their duration, and the possibility of
stalling or severe loading at infrequent intervals
[3.] Inertia loads arising from acceleration or deceleration

The speed or speeds at which a gear set will operate must be known to determine inertia loads, velocity factor, type of gear required, accuracy requirements, design of mountings, and the type of lubrication. Special operating conditions include

[1.] Noise-level limitations
[2.] High ambient temperature
[3.] Presence of corrosive elements
[4.] Abnormal dust or abrasive atmosphere
[5.] Extreme, repetitive shock loading or reversing
[6]. Operating under variable alignment
[7.] Gearing exposed to weather
[8.] Other conditions that may affect the operation of the set

III. SELECTION OF TYPE OF GEAR

Straight-bevel gears are recommended for peripheral speeds up to 1000 feet per minute (ft/min) where maximum smoothness and quietness are not of prime importance. However, ground straight bevels have been successfully used at speeds up to 15 000 ft/min. Plain bearings may be used for radial and axial loads and usually result in a more compact and less expensive design. Since straight-bevel gears are the simplest to calculate, set up, and develop, they are ideal for small lots. Spiral-bevel gears are recommended where peripheral speeds are in excess of 1000 ft/min or 1000 revolutions per minute (r/min). Motion is transmitted more smoothly and quietly than with straight-bevel gears. So spiral-bevel gears are preferred also for some lower-speed applications. Spiral bevels have greater load sharing, resulting from more than one tooth being in contact. Zerol bevel gears have little axial thrust as compared to spiral-bevel gears and can be used in place of straight-bevel gears. The same qualities as defined under straight bevels apply to Zerol bevels. Because Zerol bevel gears are manufactured on the same equipment as spiral-bevel gears, Zerol bevel gears are preferred by some,They are more easily ground because of the availability of bevel grinding equipment. Hypoid gears are recommended where peripheral speeds are in excess of 1000 ft/min and the ultimate in smoothness and quietness is required. They are somewhat stronger than spiral bevels. Hypoids have lengthwise sliding action, which enhances the lapping operation but makes them slightly less efficient than spiral-bevel gears.

IV. MATERIALS USED IN GEAR MANUFACTURING PROCESS

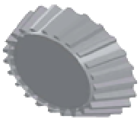
The various materials used for gears include a wide variety of cast irons, non ferrous material and non – metallic materials. The selection of the gear material depends upon: Type of service

Peripheral speed Degree of accuracy required Method of manufacture Required dimensions and weight of the drive Allowable stress Shock resistance Wear resistance. Some materials chosen include: Cast iron, which is popular due to its good wearing properties, excellent machinability and ease of producing complicated shapes by the casting method. It is suitable where large gears of complicated shapes are needed. Steel, which is sufficiently strong & highly resistant to wear by abrasion. Cast steel, which is used where stress on the gear is high and it is difficult to fabricate the gears. Plain carbon steels, which find application for industrial gears where high toughness combined with high strength. Alloy steels, which are used where high tooth strength and low tooth wear are required. Aluminum, which is used where low inertia of rotating mass is desired. Gears made of non–metallic materials give noiseless operation at high peripheral speeds.

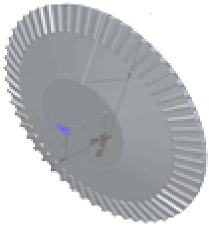
V. APPLYING COMPUTERS TO DESIGN

No other idea or device has impacted engineering as computer have. All engineering disciplines routinely use computer for calculation, analysis, design and simulation .Many of the individual tasks within the overall design process can be performed using a computer. As each of these tasks is made more efficient, the efficiency of the overall process increases as well. The computer is especially well suited to design in four areas, which correspond to the latter four stages of the general design process. Computers function in the design process through geometric modeling capabilities, engineering analysis calculations, automated testing procedures, and automated d

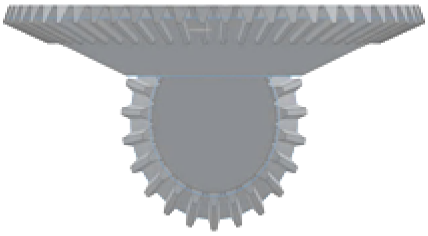
VI. DESIGN AND MODELING OF BEVEL GEAR



Fig;1 Gear 1



Fig; 2 gears 2



Fig; 3 Bevel Gear Mesh

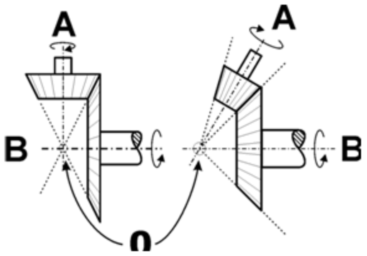


Fig 4 Bevel Gear Rotation

Fig 5 multiply views

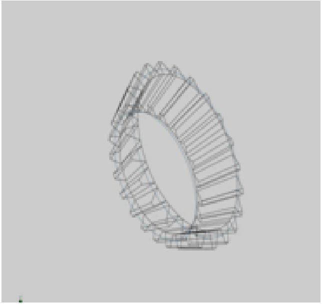
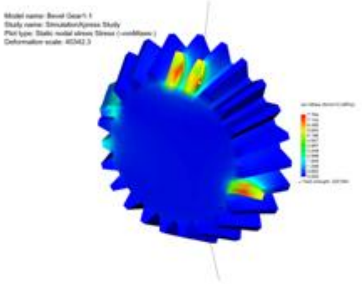


Fig 6 Wire Frame



Fig; 7 static nodal stresses

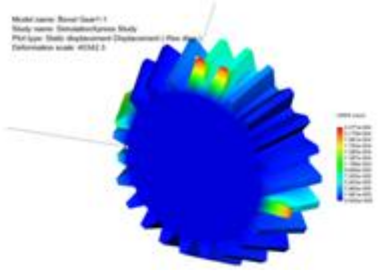


Fig 8 Static Displacement

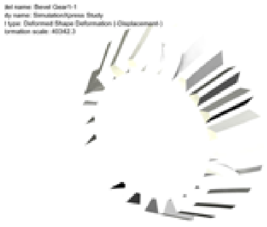


Fig 9 ; Deformed Shape

Fig 10 factor of safety

VII. DESIGN PROCESS

The ability to create something out of nothing makes design one of the most exciting aspects of engineering. To be successful, design engineer require abroad set of talents include knowledge creativity, people skill and planning ability .Engineers use CAD to create two− and three−dimensional drawings, such as those for automobile and airplane parts, floor plans, and maps and machine assembly. While it may be faster for an engineer to create an initial drawing by hand, it is much more efficient to change and adjust drawings by computer. In the design stage, drafting and computer graphics techniques are combined to produce models of different machines. Using a computer to perform the six−step'art−to−part' process: The first two steps in this process are the use of sketching software to capture the initial design ideas and to produce accurate engineering drawings. The third step is rendering an accurate image of what the part will look like. Next, engineers use analysis software to ensure that the part is strong enough .Step five is the production of a prototype, or model CAD began as an electronic drafting board, a replacement of the traditional paper and pencil drafting method. Over the years it has evolved into a sophisticated surface and solid modeling tool. Not only can products be represented precisely as solid models, factory shop floors can also be modeled and simulated in 3D shown in fig 7-10. It is an indispensable tool to modern engineers

VIII. MODELLING

Modeling is the process of producing a model; a model is a representation of the construction and working of some system of interest as shown in fig 3. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoff between realism and simplicity. Simulation practitioners recommend increasing the complexity of a model iteratively. An important issue in modeling is model validity. Model validation techniques include simulating the model under known input conditions and comparing model output with system output. Generally, a model intended for a simulation study is a mathematical model developed with the help of simulation software. Mathematical model classifications include deterministic (input and output variables are fixed values) or stochastic (at least one of the input or output variables is probabilistic); static (time is not taken into account) or dynamic (time-varying interactions among variables are taken into account). Typically, simulation models are stochastic and dynamic

Wire Frame The most basic functions of CAD are the 2D drafting functions. 2D geometry such as line, circles, and curves can be defined. A 2D profile can also be extruded into a 2½ D object. The extruded object is a wireframe of the object CAD also allows a 3D wire-frame to be defined.To cover the wire-frame model, faces can be added to the model. This creates a shell of the object. Hidden line/surface algorithms can be applied to create realistic pictures. Many menu functions are used to help simplify the design process. Annotation and dimensioning are also supported. Text and dimension symbols can be placed anywhere on the drawing, at any angle, and at any size.A sample drawing is shown in Fig; 6

Experimental Analysis involves fabricating a prototype and subjecting it to various experimental methods. Although this usually takes place in the later stages of design, CAD systems enable the designer to make more effective use of experimental data, especially where analytical methods are thought to be unreliable for the given model. CAD also provides a useful platform for incorporating experimental results into the design

Bevel Gears Component Generator

file:///C:/Users/ROMCHI~1/AppData/Local/Temp/DA/GEAR2/GEAR2.htm

Bevel Gears Component Generator (Version: 12.0 (Build 120254000, 254))

12/6/2015

⊞ **Project Info**

⊟ **Guide**

Unit Corrections Guide - Complex Proposal
Type of Load Calculation - Torque calculation for the specified power and speed
Type of Strength Calculation - Check Calculation
Method of Strength Calculation - According to ISO

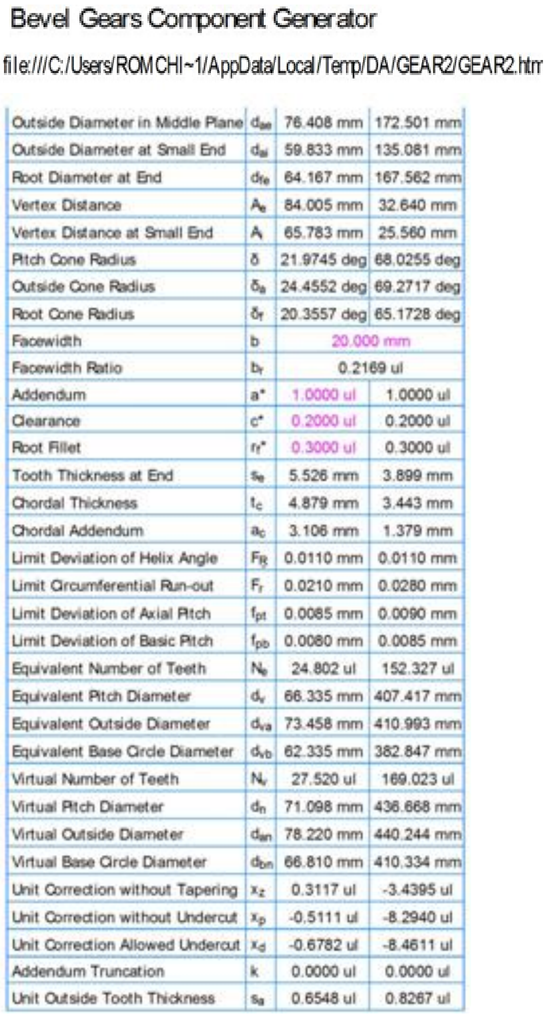
⊟ **Common Parameters**

Gear Ratio	i	2.4783 ul
Tangential Module	m_{et}	3.000 mm
Helix Angle	R	15.0000 deg
Tangential Pressure Angle	α_t	20.0000 deg
Shaft Angle	K	90.0000 deg
Normal Pressure Angle at End	α_{ne}	19.5015 deg
Normal Pressure Angle in Middle Plane	α_{nm}	19.3701 deg
Base Helix Angle	R_b	14.1327 deg
Helix Angle at End	R_e	13.3411 deg
Module	m	2.919 mm
Contact Ratio	ε	2.2081 ul
Transverse Contact Ratio	ε_α	1.6660 ul
Overlap Ratio	ε_R	0.5421 ul
Limit Deviation of Axis Parallelity	f_x	0.0110 mm
Limit Deviation of Axis Parallelity	f_y	0.0055 mm
Virtual Gear Ratio	i_v	6.142 cm
Virtual Center Distance	a_v	253.883 mm
Pitch Cone Radius	R_e	92.198 mm
Pitch Cone Radius in Middle Plane	R_m	82.198 mm
Whole Depth of Tooth	h_e	6.600 mm

⊟ **Gears**

		Gear 1	Gear 2
Type of model		Component	Component
Number of Teeth	N	23 ul	57 ul
Unit Correction	x	0.3314 ul	-0.3314 ul
Tangential Displacement	x_t	0.0298 ul	-0.0298 ul
Pitch Diameter at End	d_e	69.000 mm	171.000 mm
Pitch Diameter in Middle Plane	d_m	61.516 mm	152.453 mm

Current View of Bevel Gears

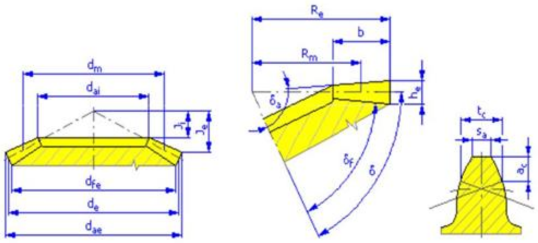


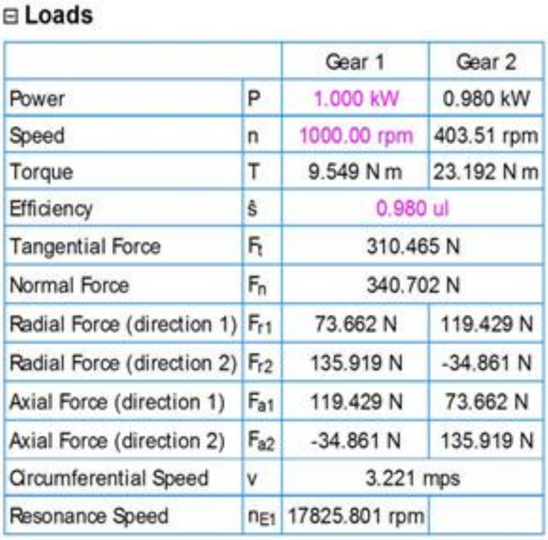
Bevel Gears Component Generator

file:///C:/Users/ROMCHI~1/AppData/Local/Temp/DA/GEAR2/GEAR2.htm

Outside Diameter in Middle Plane	d_{ae}	76.408 mm	172.501 mm
Outside Diameter at Small End	d_{ai}	59.833 mm	135.081 mm
Root Diameter at End	d_{fe}	64.167 mm	167.562 mm
Vertex Distance	A_e	84.005 mm	32.640 mm
Vertex Distance at Small End	A_i	65.783 mm	25.560 mm
Pitch Cone Radius	δ	21.9745 deg	68.0255 deg
Outside Cone Radius	δ_a	24.4552 deg	69.2717 deg
Root Cone Radius	δ_f	20.3557 deg	65.1728 deg
Facewidth	b	20.000 mm	
Facewidth Ratio	b_r	0.2169 ul	
Addendum	a^*	1.0000 ul	1.0000 ul
Clearance	c^*	0.2000 ul	0.2000 ul
Root Fillet	r_f^*	0.3000 ul	0.3000 ul
Tooth Thickness at End	s_e	5.526 mm	3.899 mm
Chordal Thickness	t_c	4.879 mm	3.443 mm
Chordal Addendum	a_c	3.106 mm	1.379 mm
Limit Deviation of Helix Angle	F_R	0.0110 mm	0.0110 mm
Limit Circumferential Run-out	F_r	0.0210 mm	0.0280 mm
Limit Deviation of Axial Pitch	f_{pt}	0.0085 mm	0.0090 mm
Limit Deviation of Basic Pitch	f_{pb}	0.0080 mm	0.0085 mm
Equivalent Number of Teeth	N_e	24.802 ul	152.327 ul
Equivalent Pitch Diameter	d_v	66.335 mm	407.417 mm
Equivalent Outside Diameter	d_{va}	73.458 mm	410.993 mm
Equivalent Base Circle Diameter	d_{vb}	62.335 mm	382.847 mm
Virtual Number of Teeth	N_v	27.520 ul	169.023 ul
Virtual Pitch Diameter	d_n	71.098 mm	436.668 mm
Virtual Outside Diameter	d_{an}	78.220 mm	440.244 mm
Virtual Base Circle Diameter	d_{bn}	66.810 mm	410.334 mm
Unit Correction without Tapering	x_z	0.3117 ul	-3.4395 ul
Unit Correction without Undercut	x_p	-0.5111 ul	-8.2940 ul
Unit Correction Allowed Undercut	x_d	-0.6782 ul	-8.4611 ul
Addendum Truncation	k	0.0000 ul	0.0000 ul
Unit Outside Tooth Thickness	s_a	0.6548 ul	0.8267 ul

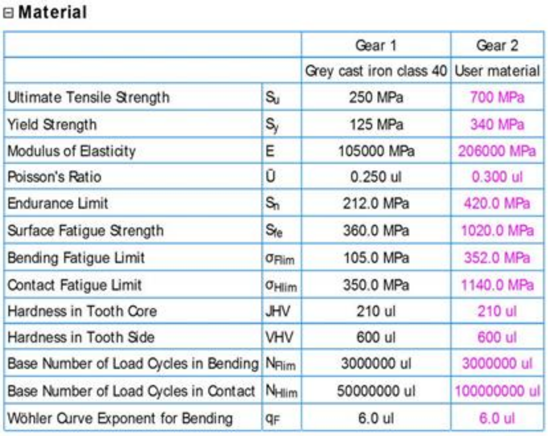
Top view

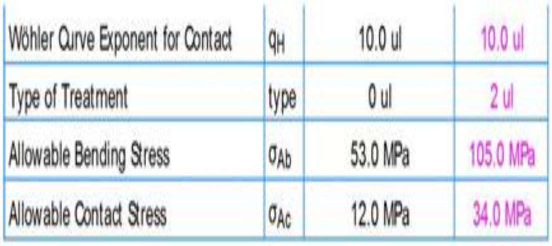




Loads

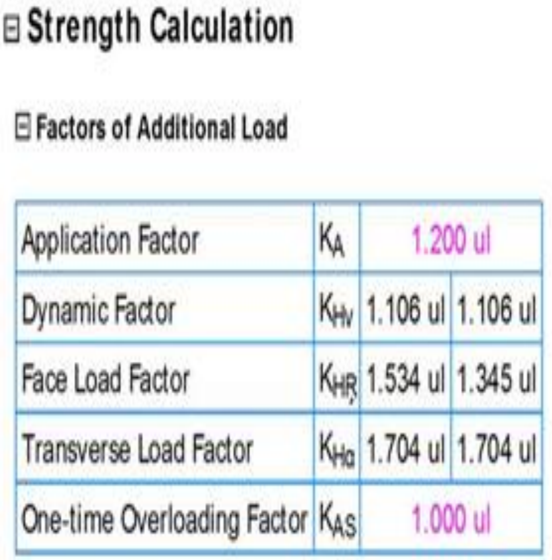
		Gear 1	Gear 2
Power	P	1.000 kW	0.980 kW
Speed	n	1000.00 rpm	403.51 rpm
Torque	T	9.549 N m	23.192 N m
Efficiency	ŝ	0.980 ul	
Tangential Force	F_t	310.465 N	
Normal Force	F_n	340.702 N	
Radial Force (direction 1)	F_{r1}	73.662 N	119.429 N
Radial Force (direction 2)	F_{r2}	135.919 N	-34.861 N
Axial Force (direction 1)	F_{a1}	119.429 N	73.662 N
Axial Force (direction 2)	F_{a2}	-34.861 N	135.919 N
Circumferential Speed	v	3.221 mps	
Resonance Speed	n_{E1}	17825.801 rpm	





Material

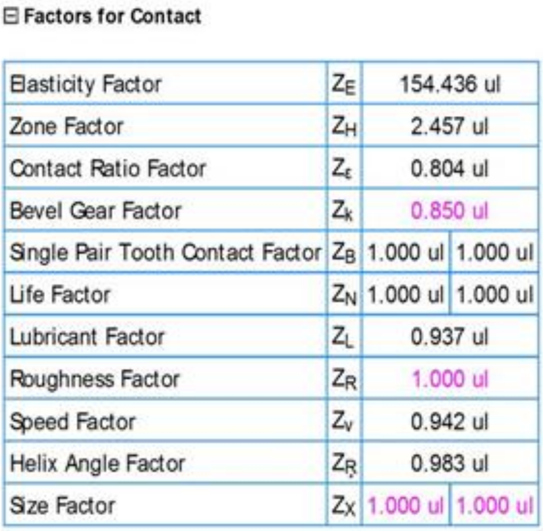
		Gear 1	Gear 2
		Grey cast iron class 40	User material
Ultimate Tensile Strength	S_u	250 MPa	700 MPa
Yield Strength	S_y	125 MPa	340 MPa
Modulus of Elasticity	E	105000 MPa	206000 MPa
Poisson's Ratio	Ū	0.250 ul	0.300 ul
Endurance Limit	S_n	212.0 MPa	420.0 MPa
Surface Fatigue Strength	S_{fe}	360.0 MPa	1020.0 MPa
Bending Fatigue Limit	σ_{Flim}	105.0 MPa	352.0 MPa
Contact Fatigue Limit	σ_{Hlim}	350.0 MPa	1140.0 MPa
Hardness in Tooth Core	JHV	210 ul	210 ul
Hardness in Tooth Side	VHV	600 ul	600 ul
Base Number of Load Cycles in Bending	N_{Flim}	3000000 ul	3000000 ul
Base Number of Load Cycles in Contact	N_{Hlim}	50000000 ul	100000000 ul
Wöhler Curve Exponent for Bending	q_F	6.0 ul	6.0 ul
Wöhler Curve Exponent for Contact	q_H	10.0 ul	10.0 ul
Type of Treatment	type	0 ul	2 ul
Allowable Bending Stress	σ_{Ab}	53.0 MPa	105.0 MPa
Allowable Contact Stress	σ_{Ac}	12.0 MPa	34.0 MPa



Strength Calculation

Factors of Additional Load

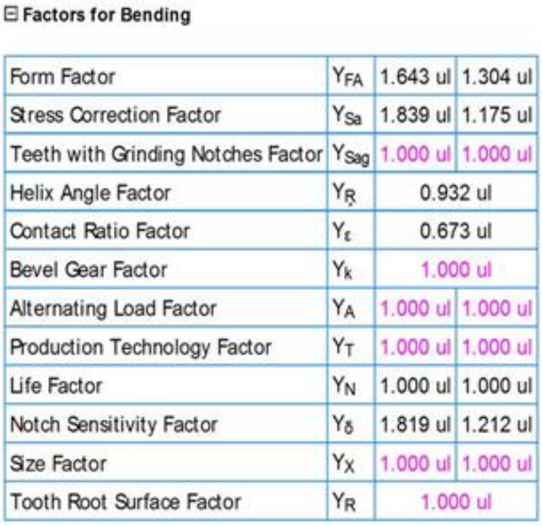
Application Factor	K_A	1.200 ul	
Dynamic Factor	K_{Hv}	1.106 ul	1.106 ul
Face Load Factor	K_{HR}	1.534 ul	1.345 ul
Transverse Load Factor	$K_{H\alpha}$	1.704 ul	1.704 ul
One-time Overloading Factor	K_{AS}	1.000 ul	



Factors for Contact

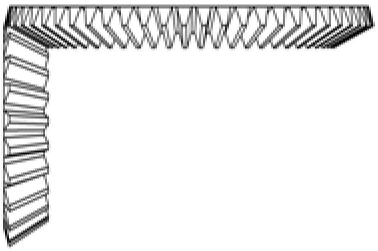
Elasticity Factor	Z_E	154.436 ul	
Zone Factor	Z_H	2.457 ul	
Contact Ratio Factor	Z_ε	0.804 ul	
Bevel Gear Factor	Z_k	0.850 ul	
Single Pair Tooth Contact Factor	Z_B	1.000 ul	1.000 ul
Life Factor	Z_N	1.000 ul	1.000 ul
Lubricant Factor	Z_L	0.937 ul	
Roughness Factor	Z_R	1.000 ul	
Speed Factor	Z_v	0.942 ul	
Helix Angle Factor	Z_R	0.983 ul	
Size Factor	Z_X	1.000 ul	1.000 ul

Bottom view



⊟ **Factors for Bending**

Form Factor	Y_{FA}	1.643 ul	1.304 ul
Stress Correction Factor	Y_{Sa}	1.839 ul	1.175 ul
Teeth with Grinding Notches Factor	Y_{Sag}	1.000 ul	1.000 ul
Helix Angle Factor	Y_R	0.932 ul	
Contact Ratio Factor	Y_{ε}	0.673 ul	
Bevel Gear Factor	Y_K	1.000 ul	
Alternating Load Factor	Y_A	1.000 ul	1.000 ul
Production Technology Factor	Y_T	1.000 ul	1.000 ul
Life Factor	Y_N	1.000 ul	1.000 ul
Notch Sensitivity Factor	Y_{δ}	1.819 ul	1.212 ul
Size Factor	Y_X	1.000 ul	1.000 ul
Tooth Root Surface Factor	Y_R	1.000 ul	



Left view

⊟ **Results**

Factor of Safety from Pitting	S_H	1.202 ul	3.915 ul
Factor of Safety from Tooth Breakage	S_F	5.510 ul	24.270 ul
Static Safety in Contact	S_{Hst}	1.362 ul	3.704 ul
Static Safety in Bending	S_{Fst}	7.572 ul	50.056 ul
Check Calculation		Positive	

⊟ **Summary of Messages**

8:02:34 PM Design: Calculation indicates design compliance!

Right View

Safety An engineer must always design products that are safe for the end user and the artisans who construct the product.it is impossible to design completely safe products because they would be too costly. Therefore, the engineer often must design to industry standards for similar product

Factor Of Safety is the ratio of ultimate strength of the material to allowable stress. The term was originated for determining allowable stress. The ultimate strength of a given material divided by an arbitrary factor of safety, dependent on material and the use to which it is to be put, gives the allowable stress. In present design practice, it is customary to use allowable stress as specified by recognized authorities or building codes rather than an arbitrary factor of safety. One reason for this is that the factor of safety is misleading, in that it implies a greater degree of safety than actually exists. For example, a factor of safety of 4 does not mean that a member can carry a load four times as great as that for which it was designed. It also should be clearly understood that, though each part of a machine is designed with the same factor of safety, the machine as a whole does not have that factor of safety. When one part is stressed beyond the proportional limit, or particularly the yield point, the load or stress distribution may be completely changed throughout the entire machine or structure, and its ability to function thus may be changed, even though no part has ruptured. Although no definite rules can be given, if a factor of safety is to be used, the following circumstances should be taken into account in its selection:

1. When the ultimate strength of the material is known within narrow limits, as for structural steel for which tests of samples have been made, when the load is entirely a steady one of a known amount and there is no reason to fear the deterioration of the metal by corrosion, the lowest factor that should be adopted is 3.

2. When the circumstances of (1) are modified by a portion of the load being variable, as in floors of warehouses, the factor should not be less than 4.

3. When the whole load, or nearly the whole, is likely to be alternately put on and taken off, as in suspension rods of floors of bridges, the factor should be 5 or 6.

4. When the stresses are reversed in direction from tension to compression, as in some bridge diagonalsand parts of machines, the factor should be not less than 6.

5. When the piece is subjected to repeated shocks, the factor should be not less than 10.

6. When the piece is subjected to deterioration from corrosion, the section should be sufficiently Increased to allow for a definite amount of corrosion before the piece is so far weakened by it as to require removal.

7. When the strength of the material or the amount of the load or both are uncertain, the factor should be increased by an allowance sufficient to cover the amount of the uncertainty.

8. When the strains are complex and of uncertain amount, such as those in the crankshaft of a reversing engine, a very high factor is necessary, possibly even as high as 40.

9. If the property loss caused by failure of the part may be large or if loss of life may result,

as in a derrick hoisting materials over a crowded street, the factor should be large.

IX. CONCLUSION

CAD combines the characteristic of designer and computer that are best applicable made CAD such as popular design tool. CAD Has allowed the designer to bypass much of the Manuel drafting and analysis. Simulation tools enable us to be creative and to quickly test new ideas that would be much more difficult, time-consuming, and expensive to test in the lab. (Jeffrey D. Wilson, Nasa Glenn Research Center) It also help us reduce cost and time-to-market by testing our designs on the computer rather than in the field. Many of the individual tasks within the overall design process can be performed using a computer. As each of these tasks is made more efficient, the efficiency of the overall process increases as well. The computer is well suited to design in four areas, which correspond to the latter four stages of the general design process; Computers function in the design process through geometric modeling capabilities, engineering analysis calculations, testing procedures, and automated drafting, From the result of the testing and the affordability in terms of cost, it can be concluded that the project is successful. Therefore software design should be encouraged in our institution of higher learning base on the following facts, long product development, countless trial and error, and accountability and limited profitability

REFERENCE

[1]. Dan B. Marghitu (2001)Mechanical Engineer'sHandbook published by Academic Press
[2]. Frank C. Uherek(2013)Gear Material Selection and Construction for Large Gears introduction to gears (2006) kohara gears Industry Co. LTD
[3]. bevel gear-wikipedia,the free encyclopedia

[4]. Childs,, T.H.C.; Maekawa, K.; Obikawa, T.; Yamane, Y. " Metal Machining - Theory and Applications", Elsevier Dec 7, 200, ISBN 0-340-69159-X
[5]. Holubář, P., Šíma, M., Zindulka, O., Technologie Úpravy Nástrojů Před Povlakováním, MM průmyslové spektrum, č. 9
[6]. OBERG, Erik; Jones, Franklin D.; Horton, Holbrook L,Ryffel, Henry H., Machinery's Handbook (87thEdition) & Guide to Machinery's Handbook, Industrial Press, Sep 19, 2005
[7]. Zetek, M.; Škarda, J.; Kříž, A.; Sosnová, M.; Hájek, J.; Podaný, P. New Types Of Thin
[8]. Layers And new trends in PVD technologies. In ICPM 2005. Wien : Abteilung Austauschbau und
[9]. Messtechnik, 2005. s. 337-343. ISBN 3-901-888-31-4
[10]. Law, A. M., and M. G. McComas. 1991. Secrets of Successful Simulation Studies, Proceedings of the1991 Winter Simul ation Conference, ed. J. M.Charnes, D. M. Morrice, D. T. Brunner, and J. J.Swain, 21−27. Institute of Electrical and Electroni cs Engineers, Piscataway, New Jersey
[11]. Mechanical Engineers' Handbook, 2nd ed., Edited By Kutz.
[12]. Ashok Kumar Gupta Dr.Vandana Somkuwar (2014) Spiral Gevel Gear And Development Generation And Simulation Of Meshing And Tooth Contact Analysis (Tca)
[13]. Mark T.Holtzapple W.Dan Reece "Fundamental of Engineering"Taxas A&M University
[14]. Industrial Engineering handBook fifth Edition Edited by KJELL B. zandian co-sponsores by JMA,INC.
[15]. Koya O.A and Faborode M.O(2005) Mathematic al modeling of palm fruit cracking based on Hertzs Theory˜Biosyst ems Engineering, Vol.91 No.4 pp 471− 7
[16]. Tugrul Özel and Taylan Altan(1998)Modeling Of High Speed Machining Processes For Predicting Tool Forces, And Temperatures Using Fem Simulations
[17]. www.digitalengineeringlibrary.com
[18]. http//www.smihq.org/public/publications/springsmag08_07a.html
[19]. http//www.allrite.com/history-of-spring-compression-extension-torsion
[20]. [20]http/,centuryspring.com/pdfs/12-228compressionpdf
[21]. Engr. Rufus O. Chime,Engr.Samuel .Ukwuaba,Engr.Engr. Ukwu Nwachukwu Design Modelling and Simulation of a Screw press Expeller for palm kernel oil extraction [International Engineering Conference, Exhibition and Annual General meeting] NSE Proceedings, 2013
[22]. http://www.en.wikipedia.org
[23]. Banks, J. 1994. Simulation software, paper presented as 1994 Winter Simulation Conference, Atlanta.
[24]. Banks, J., Burnette, B., Rose, J.D., and H. Kozloski. 1995. Siman V and Cinema V, John Wiley & Sons, New York.
[25]. Cox, S.W. 1992. Simulation Studio™, in Proceedings of the 1992 Winter Simulation Conference, J. J.
[26]. Swain, D. Goldman, R.C. Crain, and J.R. Wilson, Eds., Association for Computing Machinery, New York, 347–351.
[27]. Glavach, M.A. and Sturrock, D.T. 1993. Introduction to Siman/Cinema, in Proceedings of the 1993
[28]. Winter Simulation Conference, G.W. Evans, M. Mollaghasemi, E.C. Russell, and W.E. Biles, Eds.,Association for Computing Machinery, New York, 190–192.