THE UNIVERSITY OF UTAH

Name:

ID #:

Department of Mechanical Engineering
ME EN 7960 - Precision Machine Design

Problem Set 2 - Ball Screw Selection Tool

Assigned: Monday, October 9, 2006

Due: Monday, October 15, 2006, 4pm in 2110 MEB

Ballscrew Selection Tool

The selection of ballscrews is a multi-criteria problem that can be very time consuming and tedious. For this purpose, a tool that assists designers in making quick and reliable selections is an absolute must.

Problem 1

In this exercise you are asked to prepare an Excel spreadsheet that calculates all relevant selection criteria. Your spreadsheet should include the following THK ballscrew and nuts:

MDK Size 4 - 14, and BIF 16 - 50. The spreadsheet needs to have the following inputs:

Input Data

Parameter	Value	Units	Symbol	SI Value	SI Unit
Machining Data					
Machining force	650	N	F_m	650	N
Machining speed	0.3	m/min	v_m	0.005	m/s
Percentage of machining	75	percent	q_m	0.75	
Percentage of constant velocity	15	percent	q_uni	0.15	
Percentage of acceleration	10	percent	q_accl	0.1	
Rapid Motion	20	m/min	v_max	0.33333333	m/s
Acceleration time	0.1	s	t_ac	0.1	s
Table Data					
Mass	400	kg	m	400	kg
Incline angle	90	degrees	alpha	1.57079633	rad
Coefficient of friction	0.008		mu_bearing	0.008	
Length of ball screw	700	mm	L_axial	0.7	m
Gravity	9.81	m/s^2	g	9.81	m/s^2
Density	7850	kg/m^3	rho	7850	kg/m^3
Young's modulus	207	GPa	E	2.07E+11	Pa
Poison's ratio	0.3		poisons	0.3	
Shear modulus			G_modulus	7.96E+10	Pa
Ballscrew Data					
Mech. Efficiency	90	percent	eta	0.9	
Expected lifetime	40000	hr	life	40000	hr
Maximum allowable stress	147	Mpa	sigma_max	147000000	Pa
Safety Factors					
Safety against buckling	1.1		f_buckling	1.1	
Safety against brinelling	2		f_brinelling	2	
Safety against critical speed	1.1		f_critical_speed	1.1	
Safety against life	1.2		f_w	1.2	
Accuracy					
Rotary encoder resolution	4000	counts/rev	rot_resolution	4000	

The output should look similar to the one below.

MDK		
Type	**Unit**	**MDK 0401-3**
Motor		
Shaft speed during rapid motion	rpm	20000
Shaft speed during machining	rpm	300
Torque during rapid motion	Nm	0.93
Torque during machining	Nm	0.81
Ballscrew		
Equivalent stress < permissible stress?		No
Buckling load fixed-free > Fa?		No
Buckling load fixed-supp > Fa?		No
Buckling load fixed-fixed > Fa?		No
Safe against brinelling?		No
Critical speed > required speed fixed-free?		No
Critical speed > required speed fixed-supp?		No
Critical speed > required speed fixed-fixed?		No
DN value < 70000		No
Exceeds specified life?		No
Overall Stiffness		
Stiffness (fixed-free & fixed-supp)	N/micron	2.3
Stiffness (fixed-fixed)	N/micron	7.1
Accuracy		
Total error (fixed-free & fixed supp) with motor mount	micron	2090.3
Total error (fixed-fixed) with motor mount	micron	727.8
Total error (fixed-free & fixed supp) with free end mount	micron	2004.0
Total error (fixed-fixed) with free end mount	micron	641.5

Screw diameter	mm	4
Lead	mm	1
Root diameter	mm	3.4
Ballcircle diameter	mm	4.15
Dynamic load rating	kN	0.29
Static load rating	kN	0.42
Nut length	mm	13
Nut stiffness	N/micron	35
Support bearing stiffness	N/micron	27

Problem 2

Using the spreadsheet and the input parameters shown on the previous page, select the smallest (=least expensive) ballscrew that fulfills all relevant criteria as well as a required overall accuracy of 25 microns. What accuracy class will be required in this case?