Dynamic Analysis of Spur Gear Transmissions (DANST)

PC Version 3.00 User Manual

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DYNAMIC ANALYSIS OF SPUR GEAR TRANSMISSIONS (DANST)
PC Version 3.00 USER MANUAL

by

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SUMMARY

DANST is a FORTRAN computer program for static and dynamic analysis of spur gear systems. The program can be used for parametric studies to predict the static transmission error, dynamic load, tooth bending stress and other properties of spur gears as they are influenced by operating speed, torque, stiffness, damping, inertia, and tooth profile.

DANST performs geometric modeling and dynamic analysis for low- or high-contact-ratio spur gears. DANST can simulate gear systems with contact ratios ranging from one to three. It was designed to be easy to use and it is extensively documented in several previous reports and by comments in the source code. This report describes installing and using a new PC version of DANST, covers input data requirements and presents examples.

PROGRAM CAPABILITIES

Dynamic Analysis of Spur Gear Transmissions (DANST) is a computer program for spur gear systems. The program calculates the properties of system components and substitutes them into the governing equations to solve for dynamic tooth loads, tooth bending stresses and other engineering properties. DANST-PC runs on personal computers with the following minimum requirements: 386 or later, 640 Kb memory, co-processor, VGA graphics, DOS operating system.

DANST is based on a four-degree-of-freedom, lumped-mass model of a gear transmission. The model includes driving and driven gears, connecting shafts, motor, and load. The equations of motion were derived from basic gear geometry and elementary vibration principles. The dynamic solution is found by integrating the equations of motion. References 1-14 describe the model, method of solution and parametric studies performed using DANST.

DANST provides the user with many options including: (1) Materials, basic gear geometry, and operating conditions; (2) Various combinations of tooth profiles (including three standard forms of tip relief or user-digitized profile modifications); (3) Static and dynamic analysis; and (4) Various printed and plotted outputs.

DIFFERENCES FROM EARLIER VERSIONS

The previous versions (through DANST 2.0x) were for mainframe computers. DANST-PC runs on personal computers. DANST-PC improves modeling of tooth contact conditions by considering that tooth deflection under load extends the contact zone. (Contact extension can be suppressed for compatibility with previous versions. See the notes below for the input variable Isoln.) DANST-PC adds the ability to model non-standard tooth proportions and non-standard center distance. For optional user-digitized tooth profiles, an external preprocessor program is no longer needed. The input data format has changed considerably for DANST-PC.

INPUT DATA

The input data for DANST must be provided in an input data file. This file should provide 50 lines of data including nine "spacer" lines. The input data must be entered in the order shown. Data items can be separated by one or more spaces or by commas. All input data is in English customary units. In the table below, the data type is indicated as C=character, I=integer or R=real. Gear 1 (pinion) is the input and gear 2 is the output. Once the program reads the input data, the user can interactively change data items. If a user-digitized profile is chosen, then a separate file is required to specify the profile data .

```
 Line  Name         Type   Description

   1   jobID         C      Job Heading (up to 46 characters)
   2   (Spacer) ===> Cutter Geometry
   3   Icut,Wcut    I,R     Hob Offset Code; Offset amount (for pinion)
                            0 = None, 1 = Hob cutter offset
   4   DP,PhiDc      R      Diametral Pitch (1/In), Pressure Angle (degrees)
   5   NTc           I      Number of Cutter Teeth (on shaper cutter)
   6   Ac            R      Cutter Addendum Ratio: Pinion, Gear
   7   RCEG          R      Cutter Edge Radius Ratio: Pinion, Gear
Notes:
*  DANST models hob cutters.  (We may add shaper cutters as a future option.)
*  If Icut=0 then the offset value will not be used.  (You must supply a dummy
   value anyway.)  Any offset is used to cut the pinion.  A positive value means
   a withdrawn hob which increases the pinion addendum.  The gear offset is
   calculated from equations listed in Refs. 9 and 11.
*  DANST does not use NTc -- it is reserved for a future (shaper cutter) option.
   (You must supply a value anyway as a place holder.)
*  Ac is the normalized (divided by DP) addendum for the cutters.  Values are
   reqd. for both pinion and gear.  The tooth dedendum is the cutter addendum
   plus Cs*DP.  (See Cs description below.)
*  RCEG refers to the rounded edge on the tip of the cutter.  The ratio is the
   radius of the tip divided by the diametrial pitch.  In the example input
   files, RCEG=0.4 and DP=8, thus the cutter radius is 0.05".  The actual tooth
   fillet radius may range from about 100-170 percent of the cutter edge radius.

   8   (Spacer) ===> Gear Geometry
   9   NT            I      Number of Teeth: Pinion, Gear
  10   OD            R      Outside Diameter (in): Pinion, Gear
  11   Cs            R      Tooth Clearance Ratio: Pinion, Gear
  12   FW,BK         R      Face Width (in), Backlash (in)
Notes:
*  You can enter the outside diameter to control the gear addendum, or enter zero
   and DANST will calculate the OD for you per equations given in Ref. 9.
*  Cs is the normalized (multiplied by DP) tooth clearance ratio.  A typical
   value is 0.25
  13   (Spacer) ===> Center dist., Std. or spread cntr.
  14   IDC           I      Center Dist Design Code (0=Standard 1=Extended)
  15   CDd           R      Center Distance Extension (in)
Note:
*  CDd will be added to the standard center distance if IDC=1.  If IDC=0,
   then CDd is not used.  (You must supply a value as a place holder anyway.)
*  The center dist. and addenda are related by equations given in Ref. 9.
  16   (Spacer) ===> Gear Material Data
  17   E             R      Young's Modulus (psi): Pinion, Gear
  18   Poi           R      Poisson's Ratio: Pinion, Gear
```

```
19   (Spacer) ===> Operating Parameters
20   AT          R       Input (pinion) Torque (lb-in)
21   rpm1,rpm2   R       Pinion Starting Speed (rpm), Ending Speed (rpm)
22   rpmI        R       Speed Increment (rpm)
23   Ilube       I       Lubrication Code (1=Buckingham, 2=EHD)
24   Idamp       I       Damping Code (0=No Damping, 1=Damping & Friction)
25   psiG        R       Gear Mesh Damping Coefficient (decimal fraction)
```

Notes:
* If you run a single-speed analysis, then rpm1=rpm2 and rpmI is not used.
  (You must supply a value anyway as a place holder.) The max. number of
  increments is 200. This number is: 1+(rpm2-rpm1)/rpmI.
* The authors generally specify the Buckingham lubrication model for
  high-speed, jet lubricated gears. A typical damping coeff. is 0.05 to 0.15
  (5 to 15% of critical damping).

```
26   (Spacer) ===> Inertia and Stiffness Data
27   zJ(1),zJ(4) R       Inertia (lb-in-s^2): Input (motor) & Output (Load)
28   zJ(2),zJ(3) R       Inertia (lb-in-s^2): Gear-1 and Gear-2
29   Sstif       R       Torsional Stiffness (in-lb/rad): Input & Output Shafts
30   (Spacer) ===> Solution & Modif. Codes
31   Isoln       I       Solution Code (1=static,2=dynamic,negative=rigid)
32   Imod        I       Modification Code (-1 to 4 conv,none,lin,para1/2,digi)
33   Pmod        R       Modification Length (or Start): Pinion, Gear
34   Amod        R       Amount of Modification (in): Pinion, Gear
```

Notes:
* If Isoln=1, DANST-PC provides only a static solution (natural frequencies and
  static transmission error); 2 provides both static and dynamic solutions;
  Negative number (-1 or -2) suppresses modeling of contact extension due to
  tooth flexibility. This is for consistency with older versions of DANST.
* Conventional modification (Imod=-1) provides linear tip relief starting at
  the first transition point and extending to the tooth tip (ie: 100% length).
  The amount of relief at the tip is equal to the tooth deflection. No modif.,
  (Imod=0) means an involute profile. Other choices are Linear (Imod=1);
  Parabolic type-1 (Imod=2) in which the trace on a profile chart has zero
  slope (tangent to involute) at the start of modif.; Parabolic type-2 (Imod=3)
  in which the trace has infinite slope (vertical) at tooth tip; or user-
  digitized (Imod=4) profile. If user-digitized profile is chosen, the
  profile data must be entered in a separate file (see below). See Fig. 2 in
  ref. 13 for a comparison of modification types.
* You may specify Pmod in either of two ways: (1) as a percentage of the
  length from the first contact transition point to the tip. (For low-contact
  ratio gears, the first transition point is the high point of single tooth
  contact. For high contact-ratio gears, it is the highest point of double
  tooth contact.) As an alternative, (2) you may enter the roll angle at the
  start of modification (in degrees). If option (2) is chosen, enter the value
  as a NEGATIVE number.

```
35   (Spacer) ===> Plot Control Codes
36   IPmod        I       Profile Modification Chart
37   IPdef        I       Tooth Deflection Curves
38   IPteS        I       Static Transmission Error
39   IPteD        I       Dynamic Transmission Error
40   IPldS        I       Static Tooth Load
41   IPldD        I       Dynamic & Static Tooth Load
42   IPsfS        I       Static Tooth Stiffness
43   IPteFTS      I       FFT of Static Transmission Error
44   IPteFTD      I       FFT of Dynamic Tooth Load
45   IPcof        I       Friction Coefficient
46   IPtqf        I       Friction Torque
47   IPdyS        I       Dynamic Stress
48   IPspd        I       Dynamic Factor Speed Survey
```

Note:
* With any plot code, 0=no plot, 1=plot to device (specified below),
  2="plot" to ASCII file, 3=plot to both device and file.

```
49   (Spacer) ===> Plot Output Device Code
50   Idevice      I       Plot Output Device Code
```
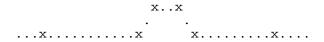
Note:
* Idevice specifies the device for plots requested above: 0=VGA screen;
  1=EPSON FX-8* printer; 2=HP LJ printer; 3=Post Script File, 4=Auto CAD File

USER-DIGITIZED PROFILE

DANST-PC requires data representing any deviations from a perfect involute profile for each of 121 tooth contact positions defining the zone of tooth contact. Actually, the program requires two sets of such data: (1) for undeformed teeth and (2) after the teeth deflect under the static load carried by the gears. (Deflection changes the contact points between the teeth.) Fortunately, you do not need to provide all of this data. DANST will calculate much of it for you.

If you specify one of the pre-defined profiles (conventional, involute, linear, parabolic-I, or parabolic-II), all the data required is in the standard input file described above. If your gears do not fit any of the standard profiles included in the program, you must enter profile data as "digitized" values from a separate file. You need not provide the actual 121 values needed by the program. You can provide a file giving only as many points needed to identify the profile. DANST will calculate the points it needs, using linear interpolation and extrapolation from the data you provide.

As a very simple example, consider the profile depicted below. This represents an involute with a "high spot". You can define this to DANST by providing data (roll angle and deviation) just for the six points marked "x". DANST will calculate the points it needs from this data by interpolating or, if needed, extrapolating. You can also use a "scale factor" -- for example, in test case III below, the authors measured profile deviations from an involute chart in millimeters and then determined the chart scale, 1.0 mm equals 72.46E-6 inches.

```
                        x..x
                       .    .
        ...x..........x      x.........x....
```

The profile modification data file must follow the format prescribed below. All roll angles are in degrees.
* First line: Scale factor for pinion (use 1.0 if data is in inches)
* Next lines: Pinion profile (min 2, max 121 lines, each containing roll angle and deviation)
* Next line: Indicator for end of pinion data (negative roll angle and "dummy" value)
* Next line: Scale factor for gear (use 1.0 if data is in inches)
* Next lines: Gear profile (min 2, max 121 lines, each containing roll angle and deviation)
* Last line: Indicator for end of gear data (negative roll angle and "dummy" value)

TEST CASES

To demonstrate how to use DANST, we present three test cases. Each involves gears tested on the NASA gear noise rig. The rig is powered by an electric motor driving through a speed- increasing belt drive and a soft coupling. A dynamometer produces resisting torque. Because of the soft coupling, we end our model at the coupling. Also, because of the very high dynamometer inertia and compliance of connecting shafts, we did not include the dynamometer in the model. Table 1 shows the mass and stiffness properties we used to model the system. Typical lubrication and damping parameters were used for this analysis. Sample data files for the three test cases are provided with DANST-PC.

TABLE 1 - Gear Noise Rig Parameters

Mass inertia, Input	0.100 lb-in-sec^2
Mass inertia, Output	0.124 lb-in-sec^2
Stiffness, driving shaft	150,000 lb-in/radian
Stiffness, driven shaft	150,000 lb-in/radian

Consider a pair of standard low-contact-ratio spur test gears with the parameters shown in Table 2. For this example, we applied a 0.006" correction for the edge break at the tip of the teeth by specifying an outside diameter 0.012" less than the nominal value. The gears have linear tip relief starting at a roll angle of 24.5 degrees with a total amount (at the tooth tip) of 0.0010". (The length of modification represents about 88% of the distance from tooth tip to high point of single tooth contact. We call this an "intermediate" relief zone.)

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TABLE 2 - Gear Data, Test Case I

Number of teeth	28 and 28
Diametrial pitch	8.00
Pressure angle	20.0 deg
Face width	0.250 in
Edge break	.006 in
Outside diameters	3.750 in each (reduced by 0.012" for edge break)
Backlash	0.007 in
Tooth addendum	1.00/DP
Young's modulus	$30*10^6$ psi
Poisson's ratio	0.3
Mass inertia	0.00594 lb-in-sec^2 (includes shaft inertia)
Lubrication model	Buckingham
Mesh damping coefficient	0.10 (10% of critical)

The input data file for this example is shown below. Comments at the end of each line (set off by exclamation marks) describe data items.

```
Test Case 1, Intermediate relief                      ! Job Identification
===> Cutter Geometry
0        0.0             ! Hob offset code (0=None, 1=Offset); Offset Amount
8.       20.0            ! Diametral Pitch, Pressure Angle (deg)
40                       ! Number of cutter teeth (Shaper cutter)
1.00     1.00            ! Cutter Addendum Ratio (A/DP)
0.40     0.40            ! Cutter edge radius ratio (RCEG/DP)
===> Gear Geometry
28       28              ! Number of teeth
3.738    3.738           ! Outside Diameters
0.25     0.25            ! Tooth Clearance Ratios (C/DP)
0.25     0.00700         ! Face Width (in), Backlash (in)
===> Center dist., Std. or spread cntr.
0                        ! Center Distance Code (0=Standard 1=Extended CD)
0.00                     ! Center Distance Extension (in)
===> Gear Material Data
30.E6    30.E6           ! Young's Modulus
0.3      0.3             ! Poisson's Ratio
===> Operating Parameters
700.00                   ! Input Torque (lb-in)
6000.    6000.           ! Starting Speed, Ending Speed (rpm)
2000.                    ! Speed Increment (rpm)
1                        ! Lubrication Code (1=Buckingham, 2=EHD)
1                        ! Damping Code (0=No Damping, 1=Damping & Friction)
0.1                      ! Gear Mesh Damping Coefficient
===> Inertia and Stiffness Data
.100     .124            ! Input and Output Inertia
0.00594  0.00594         ! Gear-1 and Gear-2 Inertia
150000.  150000.         ! Input and Output Shaft Torsional Stiffness
===> Solution & Modif. Codes (See Notes)
2                        ! Solution Code (1|2 static,dynamic,negative=rigid)
1                        ! Modification Code (-1 to 4 conv,none,lin,para1/2,digi)
-24.5    -24.5           ! Modification Length (Start) on Gear 1 & 2
0.0010   0.0010          ! Amount of Modification on Gear 1 & 2
===> Plot Control Codes (See Notes)
 0                       ! Profile Modification Chart
 0                       ! Tooth Deflection Curves
 1                       ! Static Transmission Error
 0                       ! Dynamic Transmission Error
```

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```
0                            ! Static Tooth Load
1                            ! Dynamic & Static Tooth Load
0                            ! Static Tooth Stiffness
0                            ! FFT of Static Transmission Error
0                            ! FFT of Dynamic Tooth Load
0                            ! Friction Coefficient
0                            ! Friction Torque
0                            ! Dynamic Stress
0                            ! Dynamic Factor Speed Survey
===> Printer-Plot Output Device Code
0          ! 0=VGA, 1=EPSON FX-8*, 2=HP LJ, 3=Post Script File, 4=Auto CAD File
```

The gears of Test Case I have a very low (0.0003") peak to peak transmission error at the specified torque (700 in-lb). Graphical output for Test Case I includes one plot of static transmission error, and one plot showing both static and dynamic loads. Figures 1 and 2 show the plots as produced by a laser printer.

Figure 1--Static transmission error for the gears of test case I

We also performed a study on the gears of Test Case I to show how the static transmission error varies with the torque. The input file above was used with a few changes: Isoln=1 (static analysis) and the torque was varied. (Torque or any other input data can be changed interactively after the program starts.) We "plotted" to a data file (by setting control codes to 2). These files were combined and re-arranged for an external plotting program so we could show "families" of curves representing various torque levels. Results of this study are shown in Fig. 3 as a "Harris Map". (Transmission error increases downwards, the opposite of Fig. 1.) This method of presenting transmission error is recommended by Munro (ref 15).

Test Case II: Long/short addendum gears
DANST-PC can simulate the effect of gears with non-standard tooth proportions. Consider gears with 20/36 teeth cut with a hob shift such that the pinion addendum is increased by 0.040" and the gear addendum decreased by the same amount. (The equal and opposite change allows the gears to operate at the standard center distance.) Other gear proportions are similar to those for Test Case I except the modification amount was reduced to 0.0008" and therefore the design torque was reduced to 500 in-lb. The calculated peak to peak transmission error is again quite low (0.00005"). The plot of static and dynamic load (similar to Fig. 2 for test case I) is shown in Fig. 4.

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DYNAMIC AND STATIC TOOTH LOAD

Test Case 1, Intermediate relief
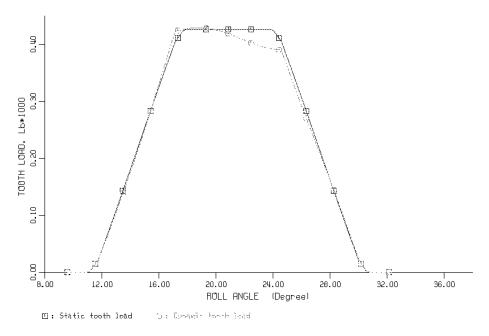
Speed = 6000.0 rpm   Torque = 700.0 Lb-in

Figure 2--Static and dynamic tooth loads for the gears of test case I
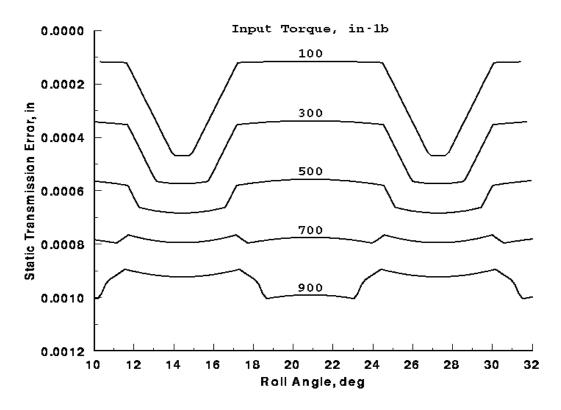

Figure 3--"Harris map" of static transmission error for the gears of test case I

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DYNAMIC AND STATIC TOOTH LOAD
Test Case 2, 20/36 teeth, Hob shift
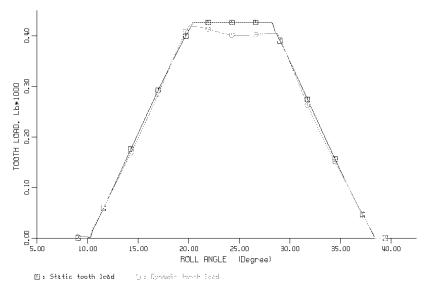Speed = 6000.0 rpm   Torque = 500.0 Lb-in

Figure 4--Static and dynamic tooth loads for the gears of test case II

Test Case III: 25:31 HCR gears, Digitized Profile

For this case we consider high-contact-ratio spur gears with dimensions shown in Table 3. These gears have long addenda (to produce a high contact ratio). The addenda of the pinion and gear are not equal (the gears were cut with a hob shift). We increased the cutter addendum ratio (line 6) to maintain the tooth proportions. To account for an edge break and tolerance on the outside diameter, we subtracted 0.0315" from the nominal outside diameter (line 10). To estimate the gear inertia, we assumed the gears to be solid steel disks equal to the pitch diameter. We subtracted a correction from the gear inertia to account for a web-rim structure but we made no allowance for gear shaft inertia.

TABLE 3 - Gear Data, Test Case III

Number of teeth	25 and 31
Diametrial pitch	8
Face width	1.25 in
Backlash	0.0075 in
Outside diameter	3.4905 and 4.2205 in (reduced by 0.0315")
Normalized addenda	1.462 and 1.382 in (or 1.422 each with 0.040 hob shift)
Young's modulus	$30*10^6$ psi
Poisson's ratio	0.3
Mass inertia	0.0161 and 0.0843 lb-in-sec^2
Lubrication model	Buckingham
Mesh damping coefficient	0.10 (10% of critical)

Test Case III gears have profile relief on both the addendum and dedendum and therefore do not fit any of the standard profiles included in DANST-PC. This means profile data must be entered as digital values in a separate input file. Profile values as estimated from the involute charts are listed in Table 4. (The manufacturer's chart for the pinion is reproduced in Fig 5.) The profile relief is very large for the torque specified, therefore the peak to peak transmission error of 0.00014" is much larger than in cases I and II. The plotted output (Fig. 6) is a "speed sweep" showing the normalized maximum dynamic load factor over speeds of 3000 to 8000 rpm. In this figure,

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the ordinate (Y-axis) is labeled "1/KV". This is the reciprocal of the AGMA dynamic factor K_v and is equal to the maximum dynamic load divided by the maximum static load.

TABLE 4 - Modification Data for Test Case III (estimated from profile charts)

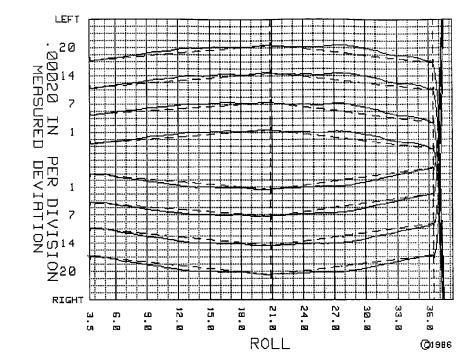| Pinion Roll Angle, deg	Pinion Mod., in	Pinion Roll Angle, deg	Pinion Mod., in	Gear Roll Angle, deg	Gear Mod., in	Gear Roll Angle, deg	Gear Mod., in
5	.00039	21	0.0	8	.00055	24	.00004
6	.00037	22	.00001	9	.00051	25	.00007
7	.00033	23	.00003	10	.00046	26	.00009
8	.00028	24	.00004	11	.00042	27	.00012
9	.00022	25	.00003	12	.00041	28	.00017
10	.00018	26	.00003	13	.00036	29	.00020
11	.00016	27	0.0	14	.00030	30	.00025
12	.00010	28	.00001	15	.00025	31	.00030
13	.00007	29	.00003	16	.00020	32	.00038
14	.00007	30	.00007	17	.00016	32.5	.00040
15	.00007	31	.00014	18	.00007		
16	.00006	32	.00024	19	.00001		
17	.00005	33	.00029	20	0.0		
18	.00005	34	.00032	20.85	0.0		
19	.00004	35	.00036	21	.00001		
20	.00002	36	.00046	22	.00001		
20.85	0.0			23	.00004		

Figure 5--Profile chart for the pinion of test case III

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SPEED SURVEY OF DYNAMIC TOOTH LOAD
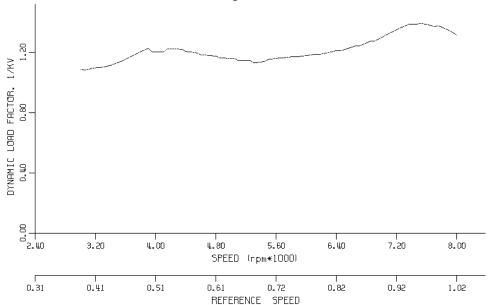
Test Case 3, digitized modification

Figure 6--Speed survey of dynamic load factor for the gears of test case III

PROGRAM VALIDATION AND LIMITATIONS

A study to validate an earlier version of DANST (ver. 2.00) compared analytical results with experimental values of tooth load and stress (Ref. 12). In general, the predicted stress is 10 to 15 percent less than the measured stress although the predicted forces were generally within five percent of measured values. The differences between analytical and experimental stress values were attributed to underestimating stress sensitivity.

Reference 13 reports a finite element investigation to examine differences between DANST stress predictions and strain gage values. The DANST stress values were about six percent less than the FEM values. This indicates that the DANST stress sensitivity estimate is reasonable. However, the measured (strain gage) stress values are considerably higher than the FEM predictions. The difference for the peak stress was eighteen percent.

A new validation study (Ref. 14) examined a greater range of operating speeds for six sets of test gears. This study found the analytical and measured values of the dynamic tooth forces generally agreed within 10 percent. (This study did not evaluate the tooth stress.)

At certain high speeds the DANST solution may underestimate dynamic loads. You can see some of this effect in Fig. 2 (test case I). It is much more prominent at a much higher speed such as 100 000 rpm (Fig 7). However, at the even higher speeds of 150 000 or 200 000 rpm this problem is less apparent. The dynamic load curve in Fig. 7 shows a small jump. This is an artifact of numerical error.

DANST can calculate the friction coefficient and frictional torque using either the Buckingham or Anderson and Lowenthal (also known as Benedict and Kelley) EHD lubrication models (see Ref. 3). Recent experimental efforts to measure dynamic gear tooth friction are described in Reference 16. We have not yet attempted to validate the friction predictions of the code.

DYNAMIC AND STATIC TOOTH LOAD
Test Case 1, Intermediate relief
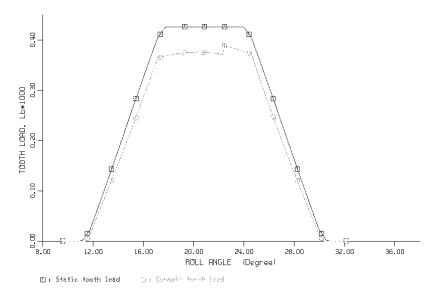Speed = 100000. rpm   Torque = 700.0 Lb-in

□: Static tooth load   ○: Dynamic tooth load

Figure 7--Example of underestimated dynamic load for Test Case I gears, 100 000 rpm, 700 in-lb

INSTALLING AND CUSTOMIZING

If you simply wish to use DANST-PC, the only files you will need are the executable (EXE) file and perhaps the "TEST-x.IN" files. We suggest you create a directory on your disk drive and copy the files to it. Use a text editor (such as EDIT, provided with DOS 5.0 or later) to prepare input data files. Unless you plan to use the source code files, you can ignore the rest of this section.

Those who wish to modify or customize the program will need the source code. DANST was written in ANSI FORTRAN 77 with a few extensions standard in FORTRAN 90. We produced the executable version using the Microsoft FORTRAN compiler, version 5 linked to Plott88 graphics subroutines. We split the source program into three files to avoid exceeding "stack" space. The file DAN-PREP.BAT was used to automate the compiling and linking process. DANST-PC has also been compiled successfully with Microsoft Power Station FORTRAN.

We expect DANST-PC will compile successfully with most standard FORTRAN 77 or FORTRAN 90 compilers. The graphical portions require commercially available Plot88 graphics library routines: Plotworks, Inc., 16440 Eagles Crest Road, Ramona, CA 92065, (619) 457-5090. Users without access to Plot88 who wish to use the analysis can delete the graphics portions of the program. DANST-PC can generate files for a separate plotting program.

The three ".FOR" files contain the FORTRAN source code (about 4500 lines) for DANST-PC. These include a main program and several subroutines. At the beginning of each subroutine is a short description. The source code must be copied to your computer system, compiled and linked. Names for input, output and temporary data files built into the program follow DOS naming conventions.


```
Files provided with DANST
README.TXT    -- Basic information, latest update info.
DANST-PC.PDF -- This user manual (PDF format)
DANST-PC.EXE -- Executable (program) file
TEST-1.IN    -- Input file for Test Case I
TEST-2.IN    -- Input file for Test Case II
```

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```
TEST-3.IN    -- Input file for Test Case III
TEST-3.MOD   -- Digitized profile data for Test Case III
DAN-PREP.BAT -- Used to compile and link
DANST-PC.FOR -- Source code No. 1
DANST-2 .FOR -- Source code No. 2
DANST-3 .FOR -- Source code No. 3
```

REFERENCES

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DANST is a FORTRAN computer program for static and dynamic analysis of spur gear systems. The program can be used for parametric studies to predict the static transmission error, dynamic load, tooth bending stress and other properties of spur gears as they are influenced by operating speed, torque, stiffness, damping, inertia, and tooth profile. DANST performs geometric modeling and dynamic analysis for low- or high-contact-ratio spur gears. DANST can simulate gear systems with contact ratios ranging from one to three. It was designed to be easy to use and it is extensively documented in several previous reports and by comments in the source code. This report describes installing and using a new PC version of DANST, covers input data requirements and presents examples.

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