Gear Navigation System

0. Abstract

In some cases, a dress gear with dimensions that differ from those of the work gear, or a dress gear modified with a complicated process such as bias correction, may be used in a honing operation.
However, in reality, the degree of machining accuracy can be judged only by checking the actual machined gears.
The Gear Navigation System solves these problems simply.

1. Introduction

Gear Navigation System software simulates gear cutting by hob, pinion cutter, shaving cutter, and honing, and analyzes it. Then, it is possible to simulate the gear meshing.
In addition, it is possible to search the tool database for a desired tool with the tool management function. In honing, modifications of the tooth profile and tooth trace and tooth form after tooth surface modifications will be calculated and displayed graphically.
A Gear Navigation System window is shown in Fig. 1.1.

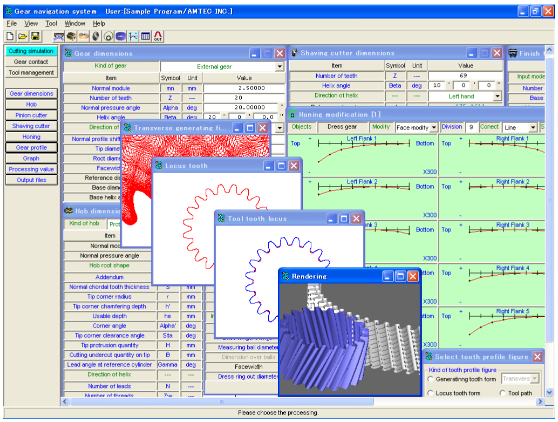


Fig. 1.1 Gear Navigation System

2. The Application Gear

- Spur and Helical Gears (Involute)
- External and Internal Gears

3. The Tool

3.1 Hob
(1) Standard hob
(2) Semi-topping hob (Bottom form is R or C)
(3) Protuberance hob
(4) Protuberance semi-topping hob
(5) Tooth profile shift hob
(6) Tooth modification hob
3.2 Pinion Cutter
(1) Standard pinion cutter
(2) Semi-topping pinion cutter (Bottom form is R or C)
(3) Protuberance pinion cutter
(4) Protuberance semi-topping pinion cutter
(5) The pinion cutter is applied to external gears and internal gears.
3.3 Shaving cutter
3.4 Honing

For dress gear, profile modification, tooth trace modification and tooth surface modification can be analyzed. And, it is possible to set the dress gear dimensions different from that of the work gear.

4. Gear dimensions setting

The gear dimension input window is shown in Fig. 4.1.

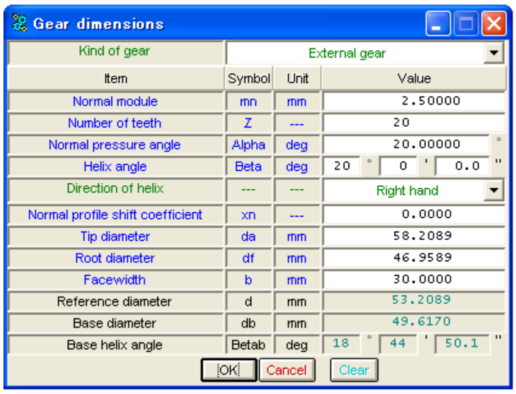


Fig. 4.1 Gear dimensions setting

5. Tool dimension setting

5.1 Hob dimension
The hob setting is shown in Figs 5.1-5.4. It is possible to set the hob dimension for up to 3 processes.

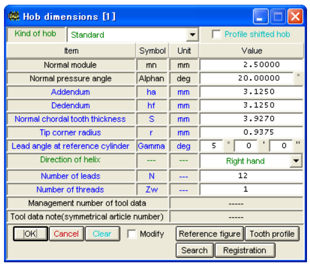


Fig. 5.1 Standard hob

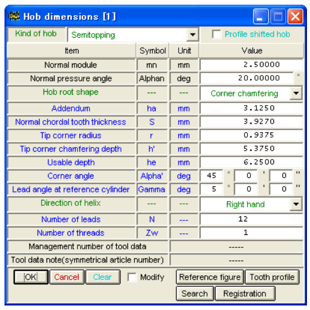


Fig. 5.2 Semi-topping hob

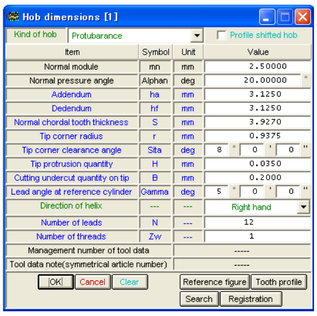


Fig. 5.3 Protuberance Hob

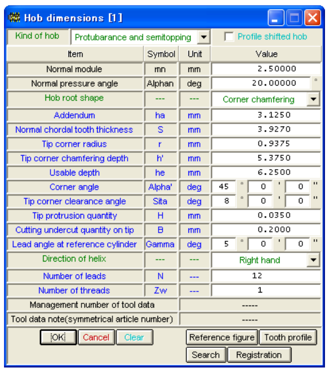


Fig. 5.4 Protuberance semi-topping Hob

5.2 Pinion cutter dimensions
The pinion cutter setting are shown in Fig.5.5-5.8.
The pinion cutter dimension can be set for up to 3 processes.

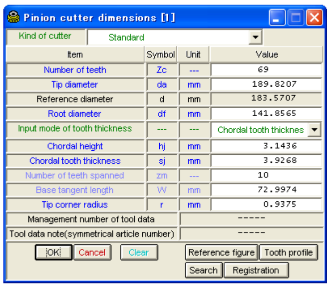


Fig. 5.5 Standard pinion cutter

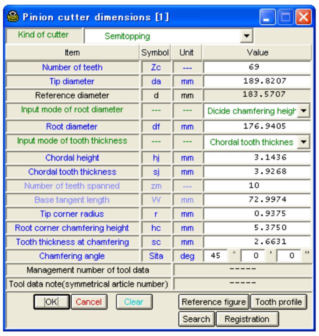


Fig. 5.6 Semi-topping pinion cutter

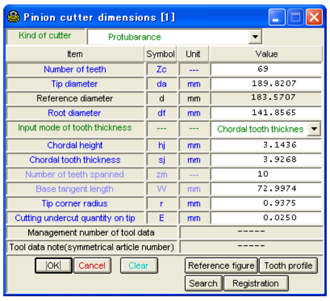


Fig. 5.7 Protuberance pinion cutter

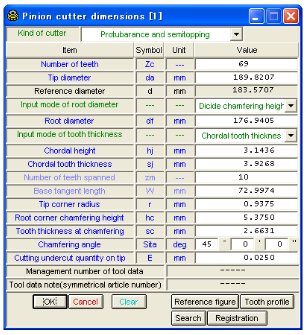


Fig. 5.8 Protuberance semi-topping pinion cutter

5.3 Shaving cutter

The settings for the shaving cutter are shown in Fig. 5.9.

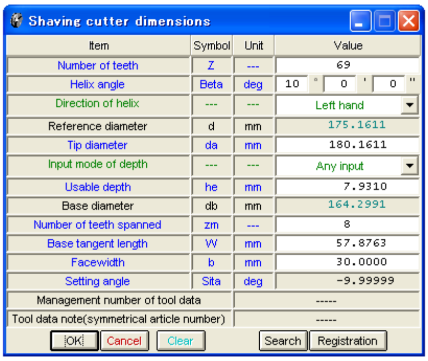


Fig. 5.9 Shaving cutter

5.4 Honing

The honing dimension setting sets dress gear dimension and honing grinding stone dimension. The honing dress gear and grinding stone dimensions can be set for up to 2 processes.

The following are shown in Figs 5.10 to 5.13: Dressing gear dimension, dressing gear modification setting, dressing gear modification topography, and honing grinding stone dimension.

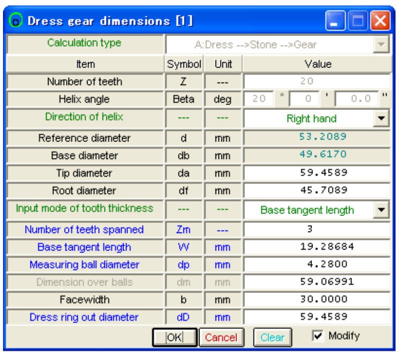


Fig. 5.10 Dressing gear dimension

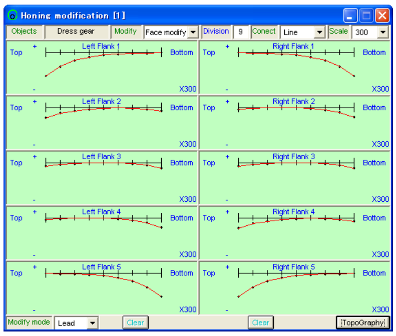


Fig. 5.11 Dressing gear modification on flank

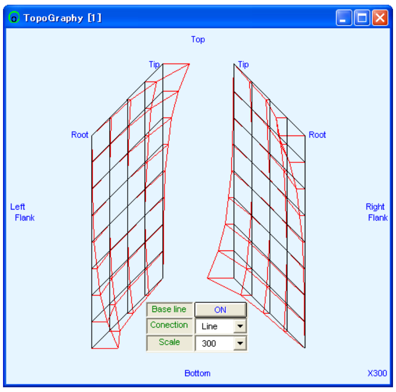


Fig. 5.12 Topography of modified dressing gear

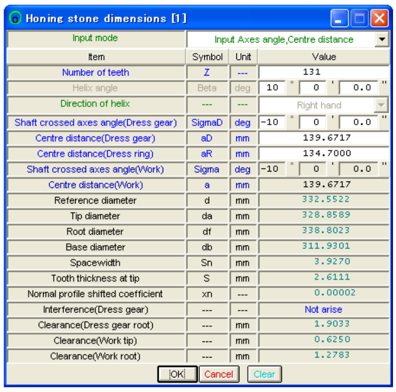


Fig. 5.13 Honing dimension

6. Setting of finishing gear tooth thickness

For measurement of thickness of tooth finished by hobbing, shaving, or honing, you can select either of the following methods: base tangent length, dimension over balls, circular thickness. Fig. 6.1 shows the window for the finished gear tooth thickness setting. In this example, hobbing, shaving, and honing are carried out once.

The rough cutting of the gear by hob with target base tangentlength of W1=19.350 mm and the honing procedure for finishing target base
tangent length of W3=19.287 mm are shown.

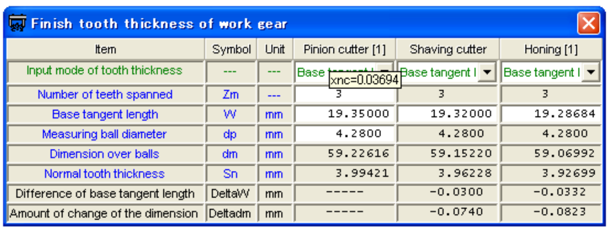


Fig. 6.1 Setting window for finishing tooth thickness of work gear

7. Gear tooth profile by processing

The gear shape, when dimension and machining condition are set, is displayed. It is possible that it superimpose tooth form shape processed by each tool and easily confirm diameters and depth measurement and machined gear tooth profile. The tooth form selection window is shown in Fig. 7.1 and the gear tooth form after analysis is shown in Figs 7.2 to 7.9.

Fig. 7.1 Tooth form selection window

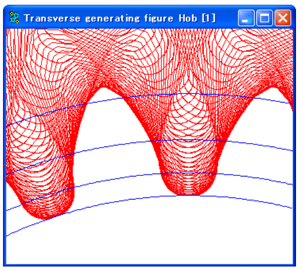


Fig. 7.2 Tooth generation

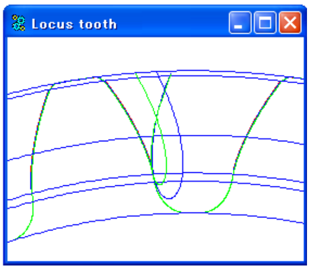


Fig. 7.3 Tooth profile

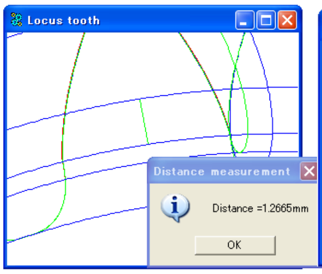


Fig. 7.4 Measurement

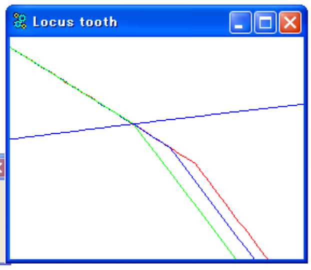


Fig. 7.5 Partial extension

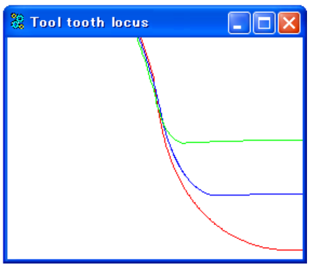


Fig. 7.6 Tool path line

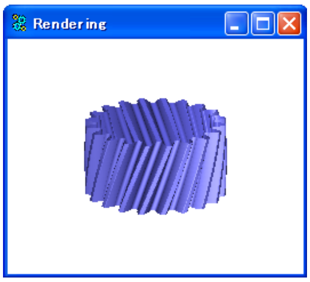


Fig. 7.7 Rendering

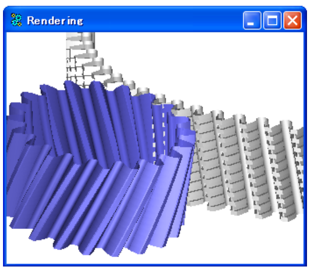


Fig. 7.8 Contact between shaving cutter and work gear

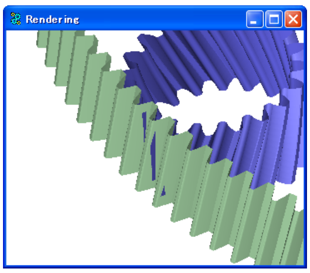
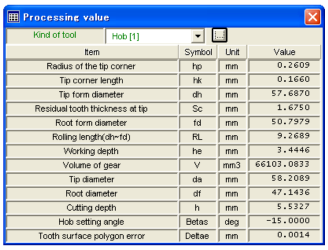


Fig. 7.9 Contact between grinding stone and work gear in honing

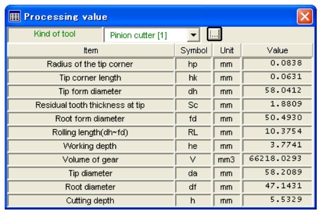
8. Processing value

The processing value of each tool is shown in Figs 8.1 to 8.4. It is possible to confirm detailed values such as chamfering length, face diameter, and gear volume with these tables.


Processing value — Kind of tool: Hob [1]

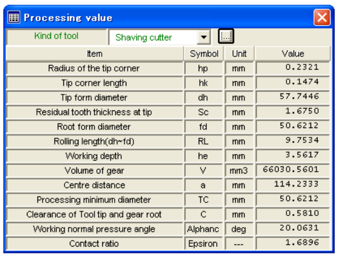
Item	Symbol	Unit	Value
Radius of the tip corner	hp	mm	0.2609
Tip corner length	hk	mm	0.1660
Tip form diameter	dh	mm	57.6870
Residual tooth thickness at tip	Sc	mm	1.6750
Root form diameter	fd	mm	50.7979
Rolling length(dh~fd)	RL	mm	9.2689
Working depth	he	mm	3.4446
Volume of gear	V	mm3	66103.0833
Tip diameter	da	mm	58.2089
Root diameter	df	mm	47.1436
Cutting depth	h	mm	5.5327
Hob setting angle	Betas	deg	-15.0000
Tooth surface polygon error	Deltae	mm	0.0014

Fig. 8.1 Hobbing processing value


Processing value — Kind of tool: Pinion cutter [1]

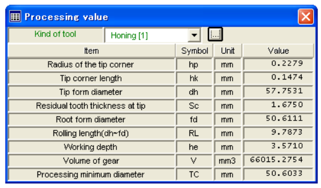
Item	Symbol	Unit	Value
Radius of the tip corner	hp	mm	0.0838
Tip corner length	hk	mm	0.0631
Tip form diameter	dh	mm	58.0412
Residual tooth thickness at tip	Sc	mm	1.8809
Root form diameter	fd	mm	50.4930
Rolling length(dh~fd)	RL	mm	10.3754
Working depth	he	mm	3.7741
Volume of gear	V	mm3	66218.0293
Tip diameter	da	mm	58.2089
Root diameter	df	mm	47.1431
Cutting depth	h	mm	5.5329

Fig. 8.2 Shaping processing value


Processing value — Kind of tool: Shaving cutter

Item	Symbol	Unit	Value
Radius of the tip corner	hp	mm	0.2321
Tip corner length	hk	mm	0.1474
Tip form diameter	dh	mm	57.7446
Residual tooth thickness at tip	Sc	mm	1.6750
Root form diameter	fd	mm	50.6212
Rolling length(dh~fd)	RL	mm	9.7534
Working depth	he	mm	3.5617
Volume of gear	V	mm3	66030.5601
Centre distance	a	mm	114.2333
Processing minimum diameter	TC	mm	50.6212
Clearance of Tool tip and gear root	C	mm	0.5810
Working normal pressure angle	Alphanc	deg	20.0631
Contact ratio	Epsiron	---	1.6896

Fig. 8.3 Shaving processing value


Processing value — Kind of tool: Honing [1]

Item	Symbol	Unit	Value
Radius of the tip corner	hp	mm	0.2279
Tip corner length	hk	mm	0.1474
Tip form diameter	dh	mm	57.7531
Residual tooth thickness at tip	Sc	mm	1.6750
Root form diameter	fd	mm	50.6111
Rolling length(dh~fd)	RL	mm	9.7873
Working depth	he	mm	3.5710
Volume of gear	V	mm3	66015.2754
Processing minimum diameter	TC	mm	50.6033

Fig. 8.4 Honing processing value

9. Deviation graph

Fig. 9.1 shows the profile deviation graph after the processing. This system has rich functions. The topography shows the tendency in the whole tooth form, modifying value at each diameter and graph scaling, etc.

These functions facilitate verifying whether the proper tooth form is obtained by machining when using a dress gear with dimensions different from those of the work gear or a dress gear modified with a complicated process such as bias correction. Figure 9.2 shows honed gear helix deviation graph. Figure 9.3 shows the topography of tooth profile and tooth trace shape.

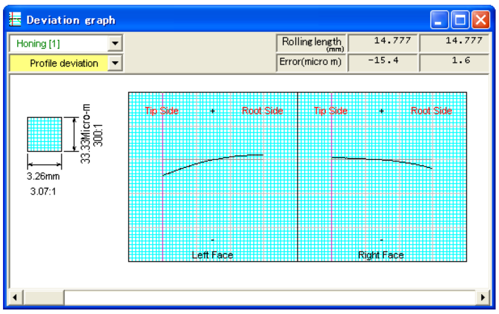


Fig. 9.1 An example of honed gear profile deviation graph

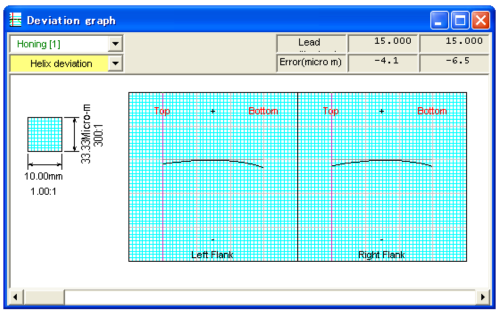


Fig. 9.2 Honed gear helix deviation graph

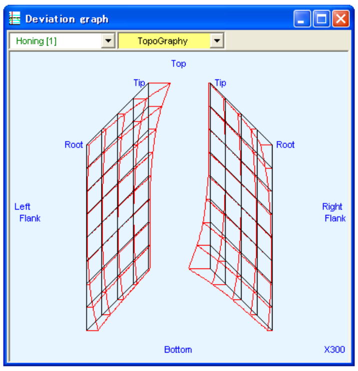


Fig. 9.3 Topography

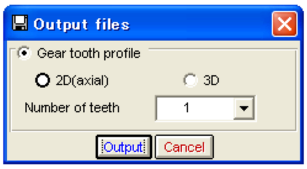


Fig. 10.1 Output tooth form coordinates file

10. Outputting tooth form coodinate file

It is possible to output tooth form coordinate value after the processing as a CAD data file and the file types DXF and IGES are supported. A tooth form coordinates file output window is shown in Fig. 10.1.

11. Gear contacting

Using stored cutting simulation data, it is possible to do a meshing simulation.

The meshing simulation window is shown in Fig. 11.1.

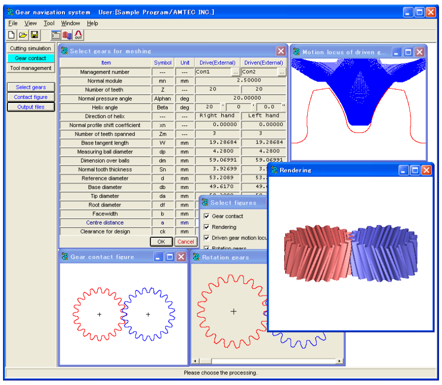
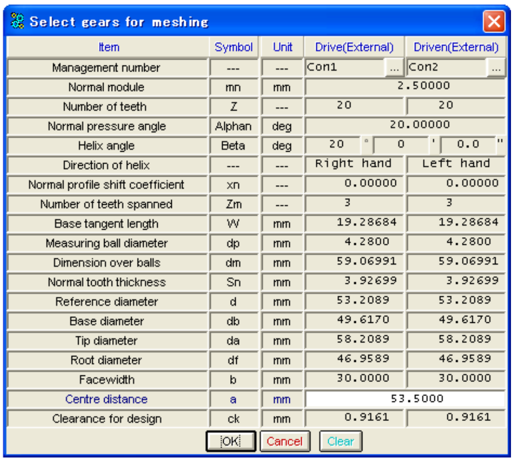


Fig. 11.1 Gear contact simulation

12. Selecting gear data for contact simulation

Select the data of gear to be contacted from the registered gear data and configure the setting. The data setting window is shown in Fig. 12.1.



Select gears for meshing

Item	Symbol	Unit	Drive(External)	Driven(External)
Management number	---	---	Con1	Con2
Normal module	mn	mm	2.50000	
Number of teeth	Z	---	20	20
Normal pressure angle	Alphan	deg	20.00000	
Helix angle	Beta	deg	20 ° 0 ' 0.0 "	
Direction of helix	---	---	Right hand	Left hand
Normal profile shift coefficient	xn	---	0.00000	0.00000
Number of teeth spanned	Zm	---	3	3
Base tangent length	W	mm	19.28684	19.28684
Measuring ball diameter	dp	mm	4.2800	4.2800
Dimension over balls	dm	mm	59.06991	59.06991
Normal tooth thickness	Sn	mm	3.92699	3.92699
Reference diameter	d	mm	53.2089	53.2089
Base diameter	db	mm	49.6170	49.6170
Tip diameter	da	mm	58.2089	58.2089
Root diameter	df	mm	46.9589	46.9589
Facewidth	b	mm	30.0000	30.0000
Centre distance	a	mm	53.5000	
Clearance for design	ck	mm	0.9161	0.9161

OK Cancel Clear

Fig. 12.1 Gear setting window for meshing simulation.

13. Gear contact

Fig. 13.1 shows the tooth form selection window. You can display the gear selected at (12) in 2D gear meshing, 3D meshing model, rotary motion locus of the driven gear, and/or continuous rotation. The 2D gear meshing figure supports partial extension, distance measuring function and drawing function of the circle, and it is possible to confirm the meshing conditions in detail. Gear contacting windows and motion locus windows are shown in Figs 13.2 to 13.8.

Fig. 13.1 Tooth form selection window

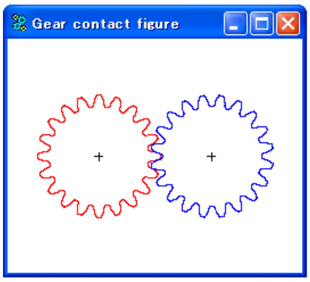


Fig. 13.2 Gear contacting

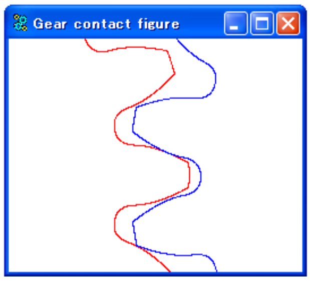


Fig. 13.3 Extension

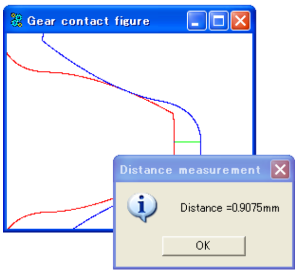


Fig. 13.4 Measurement (Top clearance measurement)

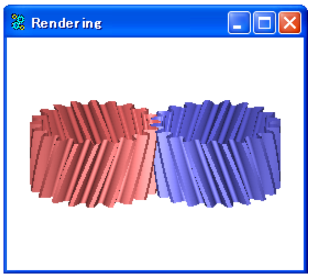


Fig. 13.5 Rendering

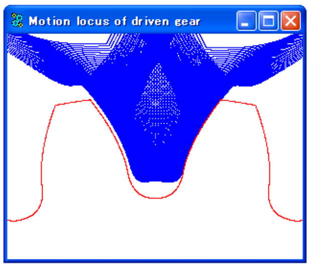


Fig. 13.6 Rotary motion locus of the driven gear

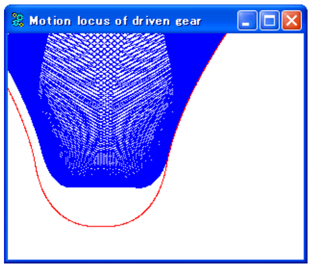


Fig. 13.7 Part extension

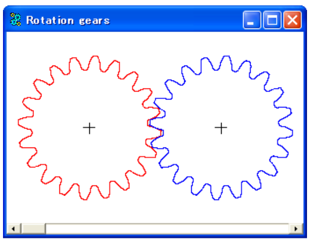


Fig. 13.8 Continuous rotation

Fig. 14.1 Output files in contacting

14. Output files in contacting gear data

It is possible to output the tooth data of contacting gear into DXF and IGES file format as a CAD data. The Output files window is shown in Fig. 14.1.

15. Tool management

By registering the retention tool dimension in the database, Gear Navigation System can search for the tool suitable for common use calculation and conditions such as chamfering length after the processing and effective tooth surface length in the processing simulation. The setting items for tool management are shown in Figs 15.1 to 15.5.

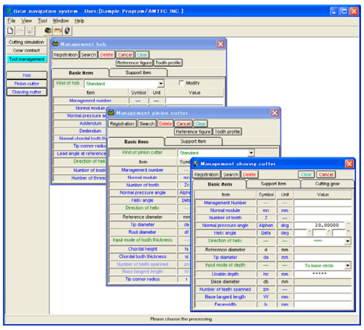


Fig. 15.1 Tool management window

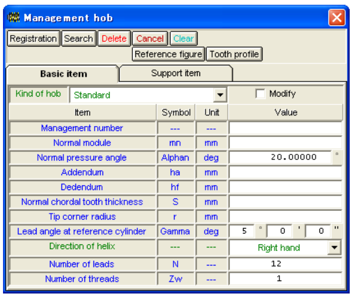


Fig. 15.2 Hob dimension

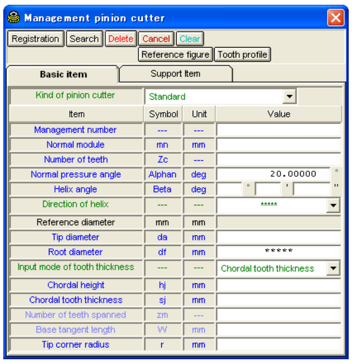


Fig. 15.3 Pinion shape cutter dimension

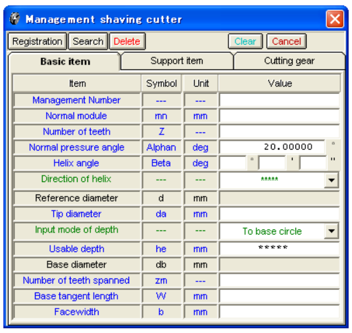


Fig. 15.4 Shaving cutter dimension

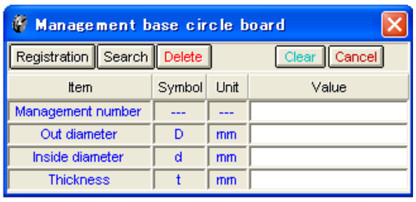


Fig. 15.5 Base disk dimension

16. Other functions

Hob setting angle calculation

Setting angle of the profile shifted hob is calculated.

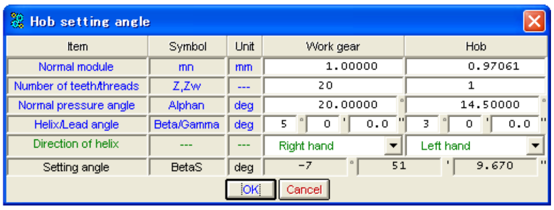


Fig. 16.1 Hob setting angle calculation

17. System requirements

① Operating system

Windows 2000, Windows XP

② Hardware

Personal computer with Pentium processor 800 MHz or above running Windows

③ CD-ROM drive

④ Display resolution 1024×768 or higher

⑤ At least 1 GB physical RAM

⑥ Hard disk area 2 GB up

⑦ Mouse or other pointing device

⑧ Printer