[14] GearProⅲ(involute gear profile design system)

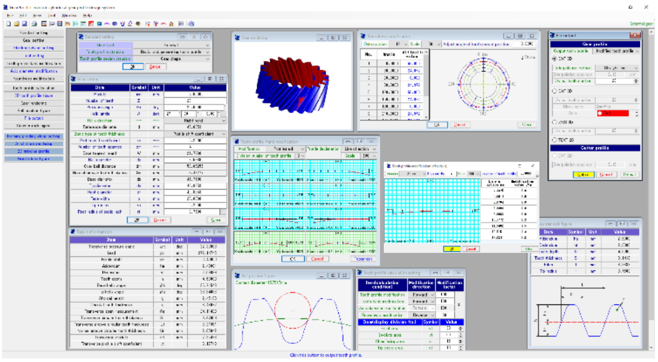


Fig. 14.1 GearProⅲ

14.1 Abstract

This software is software to generate involute tooth form. The injection molded plastic gear does not become a perfect circle at the gate position, but this software can generate a tooth shape considering deformation. In addition, tooth profile and lead modification, and axial diameter modification are also possible. It can also be used to simulate metallic gear machining as it can generate tooth profiles that also correspond to tool (HOB, pinion cutter) machining. Some of the functions that have been handled as options until now are included in the basic software, as well as various new functions are added, and the HELP function is also provided. Figure 14.1 shows the whole screen of GearPro iii.

14.2 Software structure

The structure of GearProiii is shown in Table 14.1. The basic software is ○ in Table 14.1 and ◎ is optional.

Table 14.1 software structure

No.	Item	Clause	Structure
1	Basic rack	14.4	○
	BS standard	14.4	◎
	DIN58400	14.4	◎
2	Gear specification	14.5	○
3	Tool specification	14.6	◎
4	Tooth profile modification	14.7	◎
5	Axial diameter modification	14.8	◎
6	Correct circularity	14.9	◎
7	Tooth profile	14. 10	○
8	Tooth profile (2D)	14.10	○
9	Measurement ball position	14.10	○
10	Tooth profile rendering	14.11	○
11	Tooth profile output	14.12	○
12	Counter rack tooth profile	14.13	◎
13	Forming tooth profile	-----	ASK
14	Design data	14.14	○

14.3 Gear to apply

(1) Type of gear: cylindrical gear (external gear, internal gear)

(2) Tooth profile: involute

(3) Basic rack：JIS, BS, DIN58400

(4) Tool

(4.1) Hob, dislocation hob: standard, semi-topping, proto balance, proto balance semi topping

(4.2) Pinion cutter: standard, semi-topping, proto balance, proto balance semi topping

(4.3) Machining by tool:

External gear：Hob or pinion cutter

Internal gear：pinion cutter

(5) Generated tooth profile : Gear tooth profile, electrode tooth profile

(6) Tooth profile modification: Correct circularity, Axial diameter modification

(7) Generation of abrasive tooth form for forming grinding stone

14.4 Property (Basic rack)

The basic rack is shown in Figure 14.2. In addition to JIS, the standard rack can be set according to the BS and DIN 4158400. Figure 14.3 shows the basic rack of BS standard and DIN 58400 standard.

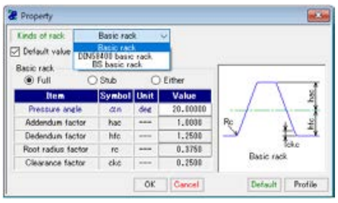
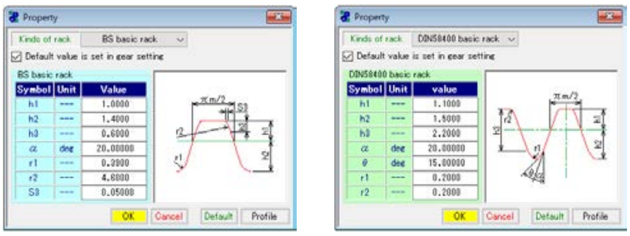


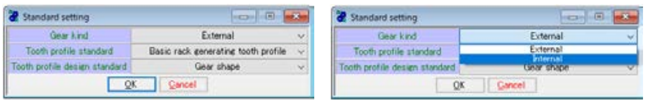
Fig. 14.2 Basic rack-1



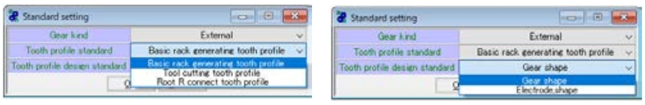
(a) BS (b) DIN 58400

Fig. 14.3 Basic rack-2

In addition to JIS standards, you can also set the basic rack according to BS standard (option) and DIN 4158400 standard (option). Then you can set tooth profile design standard (gear tooth profile, electrode). The tooth root R connection can be selected based on the tooth profile, but this is taken into consideration to accommodate the old drawings.



(a) Basic rack (b) Gear type



(c) Profile (d) Gear or Electrode

Fig. 14.4 Setting

The malfunction of making the tooth root a single R will cause tooth crest interference of the mating gear if the number of teeth is small. Also, in calculating the strength, the tooth root shape is calculated with the trochoid shape, but when making a gear with a single R, it does not make sense for the strength calculation. And, the single root R shape of the tooth root has greater stress concentration than the trochoid shape. This is also described in JIS B 1759 (2013) "Bending Strength Evaluation Method for Plastic Cylindrical Gears" and "Design Guidelines for Plastic Gears" issued by Molding Plastic Gear Research Subcommittee.

14.5 Gear specification

Set the gear specifications as shown in Fig. 14.5. In the tooth thickness input method, select one of (1) dislocation coefficient, (2) base tangent length, (3) over ball dimension, and (4) arc tooth thickness. Figure 14.6 shows the dimensional results.

Gear setting

Item	Symbol	Unit	Value
Module	mn	mm	2.00000
Number of teeth	Z	---	20
Pressure angle	αn	deg	20.00000
Helix angle	β	deg	27° 30' 0.00"
Helix direction	---	---	Right hand
Reference diameter	d	mm	45.0953
Input type of tooth thickness	---	---	Profile shift coefficient
Profile shift coefficient	xn	---	0.20000
Number of teeth spanned	zm	---	4
Base tangent length	W	mm	21.72603
Ball diameter	dp	mm	3.53600
Over ball distance	dm	mm	50.85255
Normal circular tooth thickness	Sn	mm	3.43277
Base diameter	db	mm	41.7196
Tip diameter	da	mm	49.8953
Root diameter	df	mm	40.8953
Face width	b	mm	20.0000
Tip radius	ra	mm	0.2000
Root radius of basic rack	rf	mm	0.7500

OK Cancel Clear

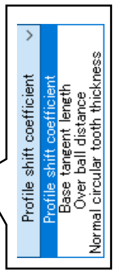


Fig. 14.5 Gear specification (input)

Result of dimension

Item	Symbol	Unit	Value
Transverse pressure angle	αt	deg	22.30998
Lead	pz	mm	272.14745
Profile shift	xm	mm	0.40000
Addendum	ha	mm	2.40001
Dedendum	hf	mm	2.09999
Tooth depth	h	mm	4.50000
Base helix angle	βb	deg	25.71543
Tip helix angle	βa	deg	29.94096
Chordal height	hj	mm	2.45139
Chordal tooth thickness	sj	mm	3.43072
Transverse span measurement	Wa	mm	24.11430
Transverse circular tooth thickness	St	mm	3.87004
Transverse groove circular tooth thickness	Ut	mm	3.21351
Normal groove circular tooth thickness	Un	mm	2.85042
Transverse module	mt	mm	2.25476
Transverse profile shift coefficient	xt	---	0.17740

Fig. 14.6 Gear dimension

Now, when setting the shrinkage factor as "electrode" in Fig. 14.4 (d) as shown in Figure 14.7, the gear size and electrode dimensions are determined as shown in Figure 14.8.

Erectrode,shape correction setting

Item	Symbol	Unit	Value	
Module shrinkage factor	Sp	---	20.00	
Correction factor of pressure angle	Sα	---	0.00	/1000
Correction factor of helix angle	Sβ	---	3.00	
Discharge gap	δ	μm	20.00	
face width	b'	mm	20.0000	

OK Cancel Clear

Fig. 14.7 Electrode (setting)

Result of dimension

Item	Symbol	Unit	Value(Gear)	Value(Electrode,type)
Transverse pressure angle	αt	deg	21.50238	21.50238
Lead	pz	mm	328.37509	336.02972
Profile shift	xm	mm	0.60000	0.61224
Addendum	ha	mm	2.60001	2.63307
Dedendum	hf	mm	1.89999	1.95877
Tooth depth	h	mm	4.50000	4.59184
Base helix angle	βb	deg	21.07593	21.07593
Tip helix angle	βa	deg	24.88953	24.87185
Chordal height	hj	mm	2.66309	2.69744
Chordal tooth thickness	sj	mm	3.57539	3.60596
Transverse span measurement	Wa	mm	23.33838	23.77138
Transverse circular tooth thickness	St	mm	3.87319	3.90616
Transverse groove circular tooth thickness	Ut	mm	2.92769	3.03351
Normal groove circular tooth thickness	Un	mm	2.70483	2.80260
Transverse module	mt	mm	2.16478	2.20896
Transverse profile shift coefficient	xt	---	0.27716	0.27716

Fig. 14.8 Gear and electrode-gear dimension

14.6 Tool specifications (option)

The gear cutting tool can select a HOB or pinion cutter. The tool size input screen is shown in 14.9, the reference diagram is shown in Figure 14.10, and the actual blade shape of the tool is shown in Figure 14.11. Figure 14.12 and Figure 14.13 show the creation tooth profile of the set tool. As shown in the application of 14.2, the tool type corresponds to various tools.

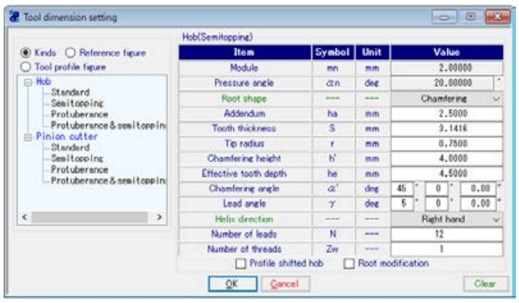


Fig. 14.9 Tool dimension (HOB)

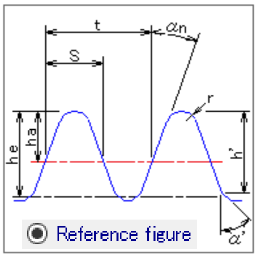


Fig. 14.10 Tool (model)

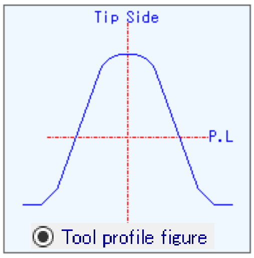


Fig. 14.11 Tool shape

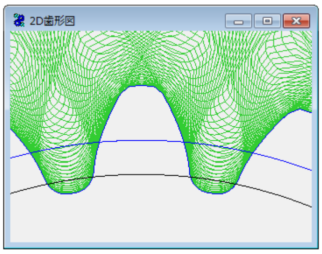


Fig. 14.12 Tooth profile

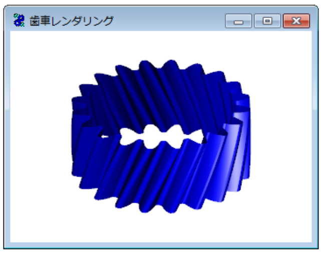


Fig. 14.13 Rendering

The input screen of the protuberance semi-topping pinion cutter is shown in Figure 14.14, and the creation tooth shape by the set tool is shown in Figure 14.12 and Figure 14.13.

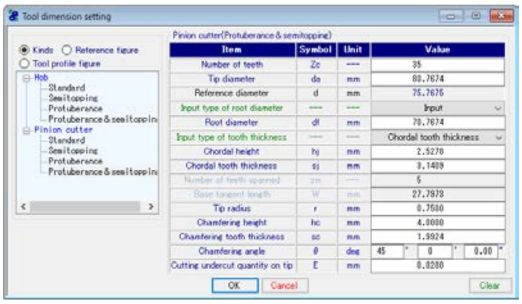


Fig. 14.14 Tool dimension (pinion cutter)

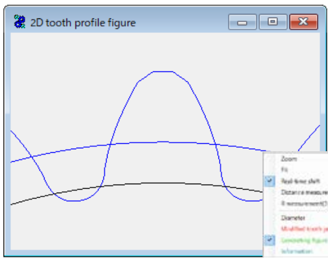


Fig. 14.15 Tooth profile

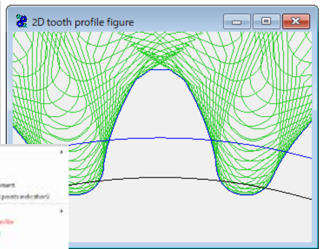


Fig. 14.16 Generated by HOB

14.7 Tooth profile modification (option)

When giving tooth surface modification, set it in Figure 14.17. Three types of modification can be selected: tooth profile modification, tooth lead modification, tooth profile / tooth lead modification. Here is an example of tooth profile / tooth lead modification. Fig. 14.18 shows the tooth profile modification, and Fig. 14.19 shows the result of giving the tooth lead modification. Figure 14.20 shows the result. In Figure 14.18, you can enter the numerical value directly or input it from the pattern shape as to how to modify it. The maximum number of divisions can be set to 50 points.

Figure 14.26 shows an example in which one tooth profile modification and one tooth trace modification were applied. In the case of bias modification, it can be set with three tooth shapes (five are possible) and one tooth trace as shown in Fig. 14.21.

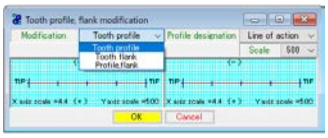


Fig. 14.17 Tooth and surface modification (setting)

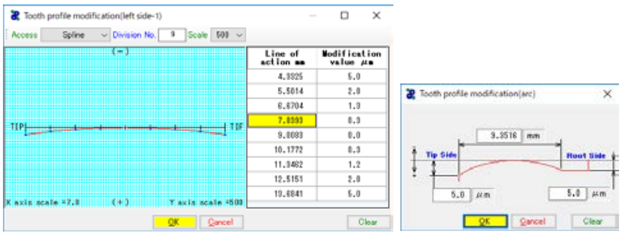


Fig. 14.18 Tooth modification (setting)

Fig. 14.19 Lead modification (setting)

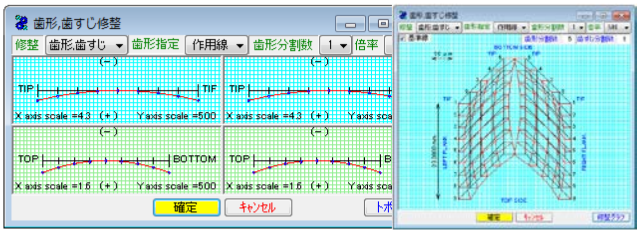


Fig.14.20 Tooth and surface modification, Topo graph

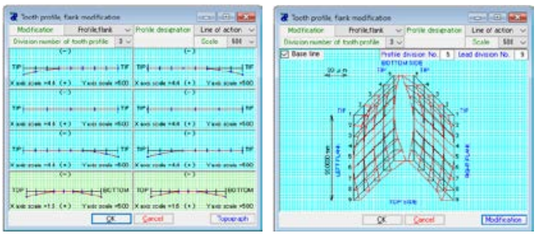


Fig. 14.21 Bias modification and topo graph

14.8 Axial diameter modification (option)

This is a function for correcting the diameter change in the tooth width direction due to the shrinkage during molding when resin-molding a two-stage gear. As an example, the gear in the case of a diameter change as shown in Figure 14.22 can be displayed as shown in Figure 14.23.

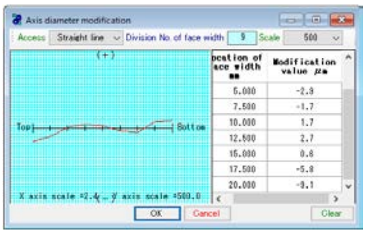


Fig. 14.22 Axial diameter modification

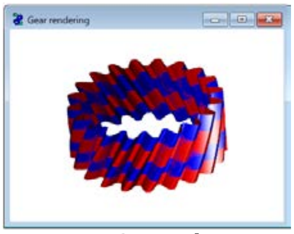


Fig. 14.23 Rendering

14.9 Correct circularity (option)

Injection molded plastic gears do not have a perfect circular shape as a result of the position of the gate. As a countermeasure, if you solve it by increasing the number of gates in some cases, extra man-hours are required. Therefore, in this example, assuming a molded gear with three gates of completed gears, consider an elliptical gear in Fig. 14.24. And when outputting the inverse shape of the tooth profile, a perfect circular gear will be formed at the completion of molding. In Fig. 14.24, the tooth modification amount is set to 50μm and the number of ovals (number of gates) is set to 3 (change is optional, maximum 20). Figure 14.25 shows a graph of roundness modification.

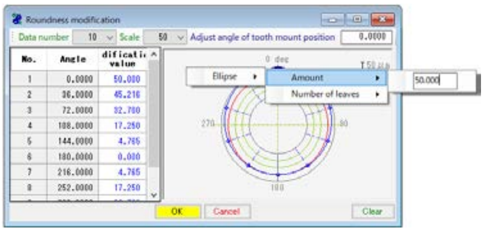


Fig. 14.24 Correct circularity-1

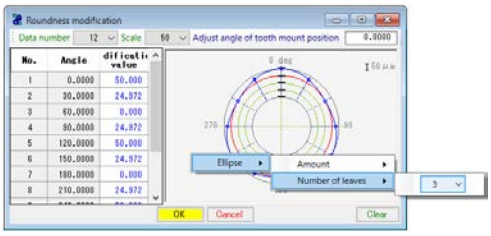


Fig. 14.25 Correct circularity-2

Fig. 14.26 Tooth profile generation 1 has tooth profile modification, tooth lead modification, circularity modification as [positive]. However, this means that the tooth shape set in Fig. 14.25 is output as it is. In contrast, Figure 14.27 Tooth Profile Output 2 has a modification direction [reverse]. This means to output the inverse shape of the modification amount given. That is, if we manufacture the mold with this [reverse] it aims at becoming a true circle at completion. However, as [reverse] will not be as expected as 100% prediction, you can set the degree of contraction ratio. In the example, only circularity is set to 80%, others are set to 100%.

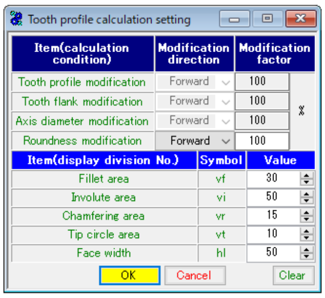


Fig. 14.26 Computation 1

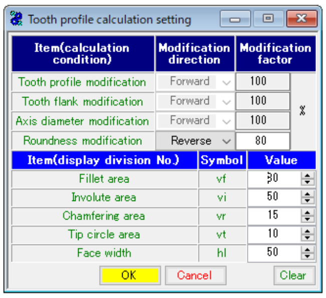


Fig. 14.27 Computation 2

14.10 Tooth profile

Fig. 14.28 shows the tooth profile generated by setting the circularity modification in Fig. 14.25 and generating it in [Reverse] in Fig. 14.27. An enlarged view of the tooth tip is shown in Figure 14.29, but the deviation of these tooth tip shows a difference due to tooth tip modification and eccentricity. However, the deviation of the tooth tip of A in Figure 14.29 is large, but B and C are not greatly shifted. The reason for this is also apparent from the circularity modification amount in Figure 14.25. If you measure the distance of part A in Figure 14.28 as shown in Figure 14.30, you can see that there is a difference of 0.041 mm. Also, the R measurement function shown in the auxiliary form in Figure 14.28 is very convenient when measuring the size of the corner of the tooth root shape.

Figure 14.31 shows the measurement ball position diagram, but this may be the case when the ball and the root of the tooth contact with each other when measuring low teeth or the like. Since it can be confirmed in advance in such a case, it can be effectively utilized even in the manufacturing department.

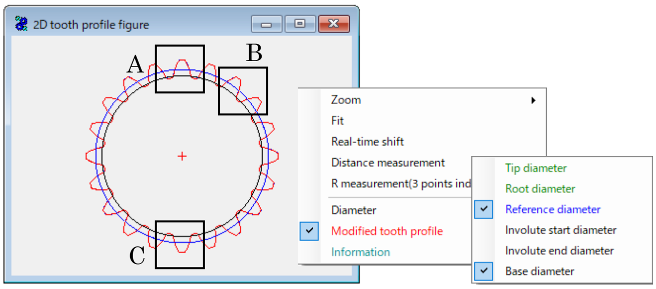


Fig. 14.28 Tooth profile

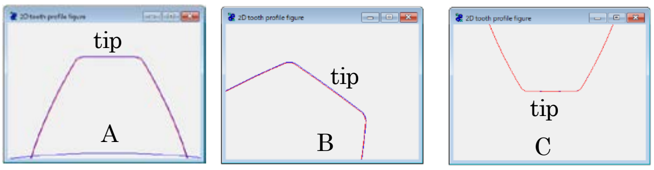


Fig. 14.29 Tooth profile (zoom)

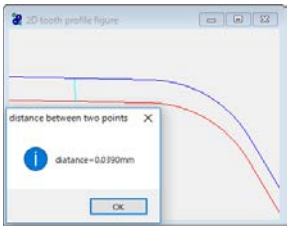


Fig. 14.30 distance measurement

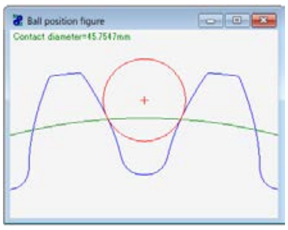
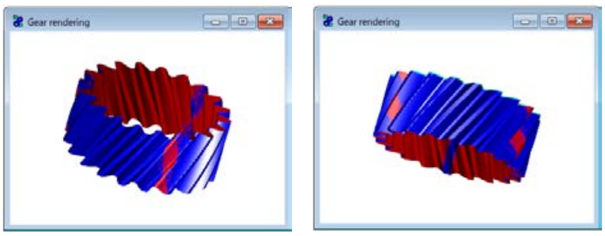


Fig. 14.31 Ball position

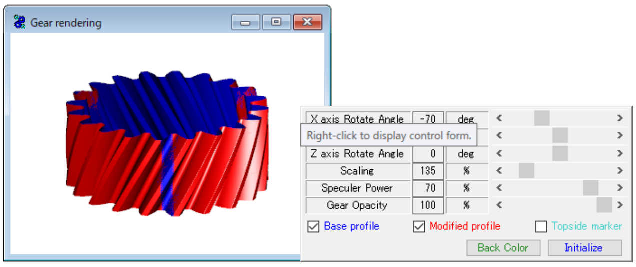
14.11 Tooth profile rendering

Fig. 14.32 shows the tooth profile plotted in Fig. 14.25 with roundness modification set in Fig. 14.27 and [reverse] in Fig. 14.27. Also, since the tooth shape rendering shown in Fig. 14.33 is drawn with [Positive] in Fig. 14.26, the color tone is reversed as shown in Fig. 14.32.



(a) direction angle: 0 ° (b) direction angle: 90°

Fig. 14.32 Rendering, circularity modification [reverse]

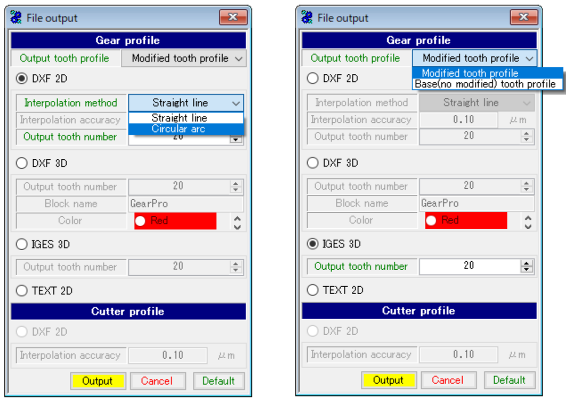


circularity modification [positive]

Fig. 14.33 Rendering and auxiliary form

14.12 Tooth profile file output

The tooth profile file can generate DXF-2D, DXF-3D, IGES-3D, TEXT 2D as shown in Figure 14.37. In addition, it can output a tool blade shape. Figures 14.38 and 14.39 show examples of CAD plotting.



(a) DXF (b) 3D-IGES

Fig. 14.34 Tooth profile file output

Fig. 14.35 Sample, DXF-2D

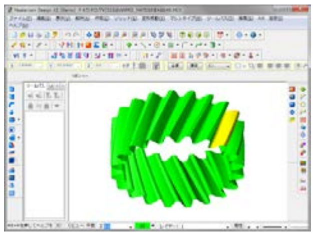


Fig. 14.36 Sample, IGES-3D

14.13 Counter rack tooth profile

Figure 14.38 shows the hob size when machining the gear in Figure 14.37.

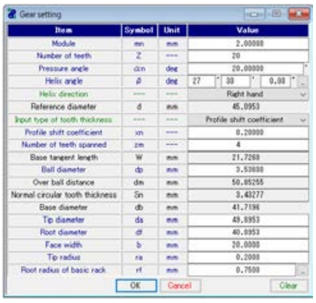


Fig. 14.37 Gear specification

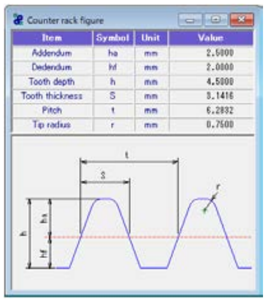


Fig. 14.38 HOB size

◆ It is also possible to generate a forming grinding stone tooth profile. For details, please contact us separately.