[4] involute ASM (high-intensity gear design system)

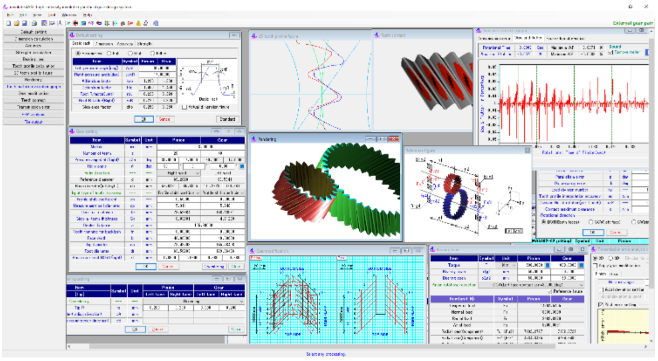


Fig. 4.1 involute ASM (high-intensity gear/asymmetry gear)

4.1 Abstract

This software is design support software for asymmetric pressure angle involute gear (hereinafter referred to as asymmetric gear). The whole screen is shown in Figure 4.1. Asymmetrical gears can increase tooth load capacity without changing gear size or material. Compared with standard pressure angle, high pressure square teeth have lower Hertz stress, smaller friction coefficient, smaller slip ratio, and lower flash temperature.

4.2 Software structure

The configuration of involute ASM is shown in Table 4.1. "○" in the table is included in the basic software, "◎" is optional.

Type of gear: involute gear, external and internal gear

Table 4.1 software structure

Item	Structure
〈1〉 Basic rack	○
〈2〉 Gear dimension	○
〈3〉 Inference	○
〈4〉 Tooth creation drawing	○
〈5〉 Meshing drawing	○
〈6〉 Meshing rotation function	○
〈7〉Tooth profile (DXF file)	○
〈8〉 Tooth profile rendering	○
〈9〉 Gear accuracy	○
〈10〉 Design data management	○
〈11〉JGMA6101,6102, JGMA401,402	○
〈12〉 Metal × plastic gear strength (JIS B 1759)	○
〈13〉 Bearing load	○
〈14〉 Tooth profile (3D-IGES file)	○
〈15〉 Rotational transmission error (Fourier analysis, Wow・flutter, CSV output)	◎
〈16〉 Tooth modification (involute, lead, bias)	◎
〈17〉 Contact pattern	◎
〈18〉 FEM Tooth Profile Analysis	◎

4.3 Property（Basic rack, accuracy, strength）

Setup screen is shown in Fig.4.2〜4.5.

・gear combination : external × external, external × internal
・Basic rack : normal, low, special
・tooth tip circle decision : normal, equal clearance
・There are two types of strength calculation standards for steel gears as shown in Figure 4.5.
・JGMA 401-02:1974, 402-02:1975
・JGMA 6101-02:2007, 6102-02:2009

In addition, the strength calculation standard of plastic gears corresponds to JIS B 1759 (2013).

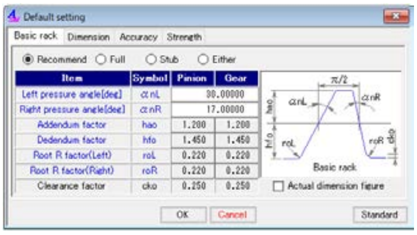


Fig. 4.2 Basic rack (asymmetry)

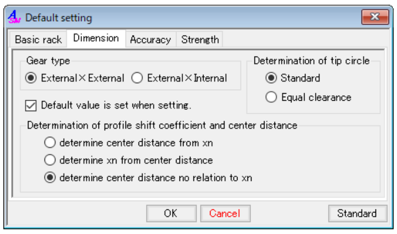


Fig. 4.3 Dimension

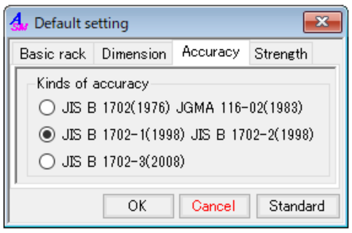


Fig. 4.4 Accuracy

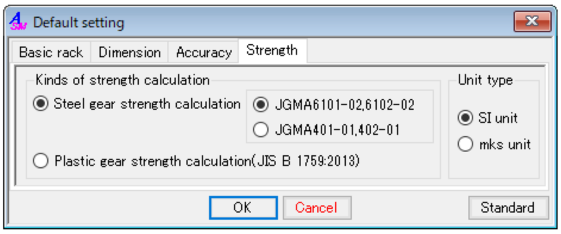


Fig. 4.5 Strength

4.4 Gear dimension

The gear dimensions calculate the dimensions, contact ratio, sliding ratio, tooth thickness, etc.. The contact ratio of the undercut-generated gear is calculated based on the True Involute form (TIF) diameter. Also, if the tip is rounded, the contact ratio is calculated taking into account the tip R.

(1) The relationship between center distance and dislocation coefficient is the following three types.

(1.1) The profile shift factor is given to the pinion and gear to determine the center distance.

(1.2) A profile shift factor is given to each gear based on the center distance.

(1.3) The center distance is arbitrarily determined ignoring the profile shift factor.

(2) There are 4 types of setting method of profile shift factor as follows.

(2.1) Input the profile shift factor directly to each gear.

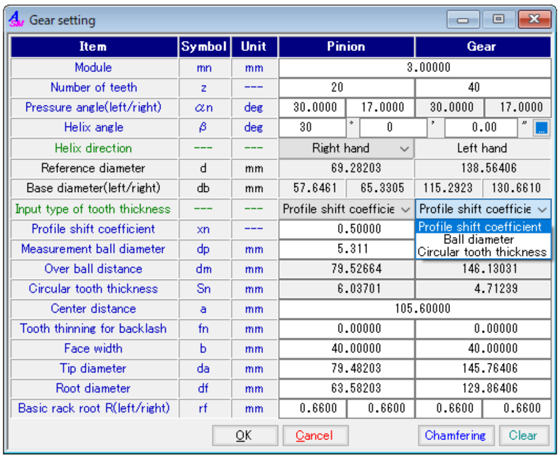
(2.2) Input the over pin size and determine the profile shift factor.

However, in the case of asymmetric gear, it is not possible to the span measurement.

(2.3) The arc tooth thickness is input to determine the profile shift factor.

Fig. 4.6 shows the gear specification setting screen.

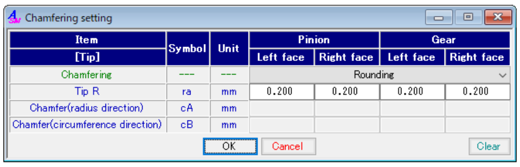
Fig. 4.8 shows the dimension result screen when the tooth tip R is set to 0.2 (C surface is also possible) with the chamfering setting shown in Fig. 4.7.



Item	Symbol	Unit	Pinion		Gear	
Module	mn	mm	3.00000			
Number of teeth	z	---	20		40	
Pressure angle(left/right)	αn	deg	30.0000	17.0000	30.0000	17.0000
Helix angle	β	deg	30 °	0 '	0.00 "	
Helix direction	---	---	Right hand		Left hand	
Reference diameter	d	mm	69.28203		138.56406	
Base diameter(left/right)	db	mm	57.6461	65.3305	115.2923	130.6610
Input type of tooth thickness	---	---	Profile shift coefficie		Profile shift coefficie	
Profile shift coefficient	xn	---	0.50000		Profile shift coefficient / Ball diameter / Circular tooth thickness	
Measurement ball diameter	dp	mm	5.311			
Over ball distance	dm	mm	79.52664		146.13031	
Circular tooth thickness	Sn	mm	6.03701		4.71239	
Center distance	a	mm	105.60000			
Tooth thinning for backlash	fn	mm	0.00000		0.00000	
Face width	b	mm	40.00000		40.00000	
Tip diameter	da	mm	79.48203		145.76406	
Root diameter	df	mm	63.58203		129.86406	
Basic rack root R(left/right)	rf	mm	0.6600	0.6600	0.6600	0.6600

OK　Cancel　Chamfering　Clear

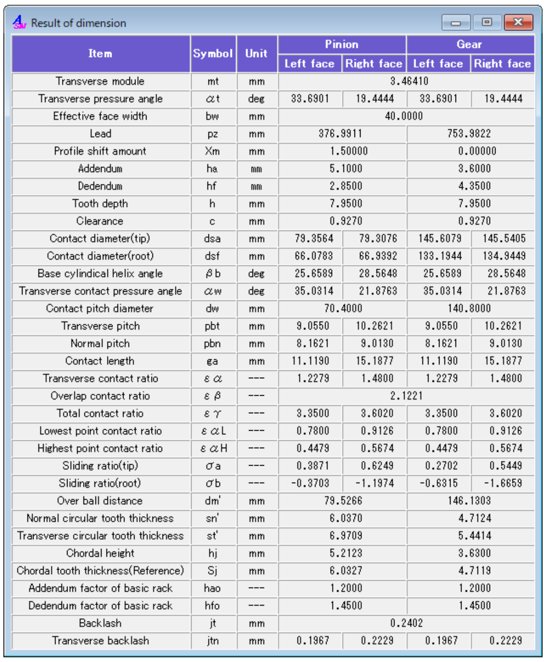
Fig. 4.6　Gear dimensions



Item [Tip]	Symbol	Unit	Pinion Left face	Pinion Right face	Gear Left face	Gear Right face
Chamfering	---	---	Rounding			
Tip R	ra	mm	0.200	0.200	0.200	0.200
Chamfer(radius direction)	cA	mm				
Chamfer(circumference direction)	cB	mm				

OK　Cancel　Clear

Fig. 4.7　Chamfering setting

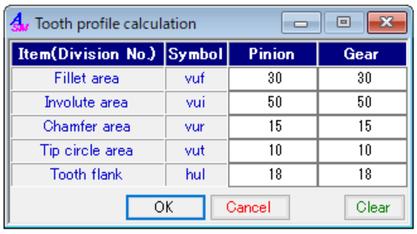


Item	Symbol	Unit	Pinion Left face	Pinion Right face	Gear Left face	Gear Right face
Transverse module	mt	mm	3.46410			
Transverse pressure angle	αt	deg	33.6901	19.4444	33.6901	19.4444
Effective face width	bw	mm	40.0000			
Lead	pz	mm	376.9911		753.9822	
Profile shift amount	Xm	mm	1.50000		0.00000	
Addendum	ha	mm	5.1000		3.6000	
Dedendum	hf	mm	2.8500		4.3500	
Tooth depth	h	mm	7.9500		7.9500	
Clearance	c	mm	0.9270		0.9270	
Contact diameter(tip)	dsa	mm	79.3564	79.3076	145.6079	145.5405
Contact diameter(root)	dsf	mm	66.0783	66.9392	133.1944	134.9449
Base cylindical helix angle	βb	deg	25.6589	28.5648	25.6589	28.5648
Transverse contact pressure angle	αw	deg	35.0314	21.8763	35.0314	21.8763
Contact pitch diameter	dw	mm	70.4000		140.8000	
Transverse pitch	pbt	mm	9.0550	10.2621	9.0550	10.2621
Normal pitch	pbn	mm	8.1621	9.0130	8.1621	9.0130
Contact length	ga	mm	11.1190	15.1877	11.1190	15.1877
Transverse contact ratio	εα	---	1.2279	1.4800	1.2279	1.4800
Overlap contact ratio	εβ	---	2.1221			
Total contact ratio	εγ	---	3.3500	3.6020	3.3500	3.6020
Lowest point contact ratio	εαL	---	0.7800	0.9126	0.7800	0.9126
Highest point contact ratio	εαH	---	0.4479	0.5674	0.4479	0.5674
Sliding ratio(tip)	σa	---	0.3871	0.6249	0.2702	0.5449
Sliding ratio(root)	σb	---	-0.3703	-1.1974	-0.6315	-1.6659
Over ball distance	dm'	mm	79.5266		146.1303	
Normal circular tooth thickness	sn'	mm	6.0370		4.7124	
Transverse circular tooth thickness	st'	mm	6.9709		5.4414	
Chordal height	hj	mm	5.2123		3.6300	
Chordal tooth thickness(Reference)	Sj	mm	6.0327		4.7119	
Addendum factor of basic rack	hao	---	1.2000		1.2000	
Dedendum factor of basic rack	hfo	---	1.4500		1.4500	
Backlash	jt	mm	0.2402			
Transverse backlash	jtn	mm	0.1967	0.2229	0.1967	0.2229

Fig. 4.8　Gear dimension result

4.6　Tooth profile

Tooth profile calculation can give division numbers to each tooth profile as shown in Figure 4.9. Then calculate the left and right tooth profile with "**Tooth profile calculation**" and show the tooth profile as shown in Fig. 4.10. The functions related to tooth shape are tooth profile information (Fig. 4.11), tooth shape creation (Fig. 4.12), zoom and distance measurement (Fig. 4.13), and R measurement (Fig. 4.14) as shown in the supplementary form. In addition, there are functions to display and rotate diameter, modification tooth profile, action line, tip width, odd tooth Y measurement.



Item(Division No.)	Symbol	Pinion	Gear
Fillet area	vuf	30	30
Involute area	vui	50	50
Chamfer area	vur	15	15
Tip circle area	vut	10	10
Tooth flank	hul	18	18

OK　Cancel　Clear

Fig. 4.9　Tooth profile computation specification

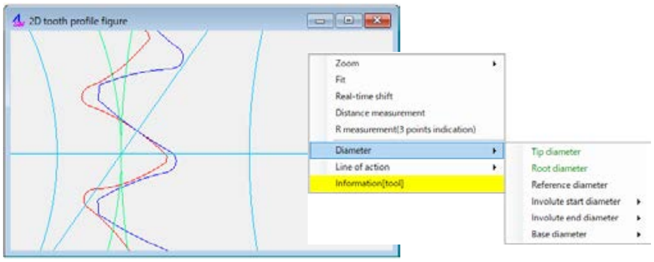


Fig. 4.10　Meshing drawing & support form

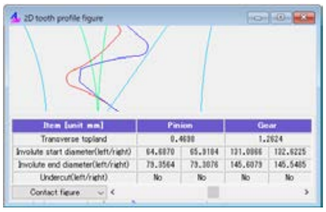


Fig. 4.11 Tooth profile information

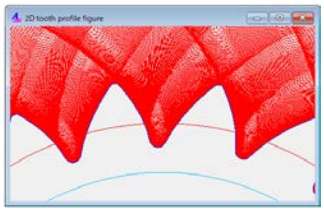


Fig. 4.12　Generation profile

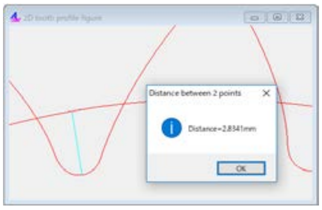


Fig. 4.13　Distance measurement

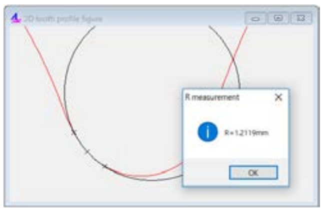


Fig. 4.14　R- measurement

4.7　Teeth profile rendering

The mesh of the 3D tooth profile can be drawn as shown in Figure 4.15, and the contact line can be observed at the mesh. In addition, the direction of the tooth profile can be freely changed by the auxiliary foam, and enlargement, reduction and rotation display of the gear can be displayed.

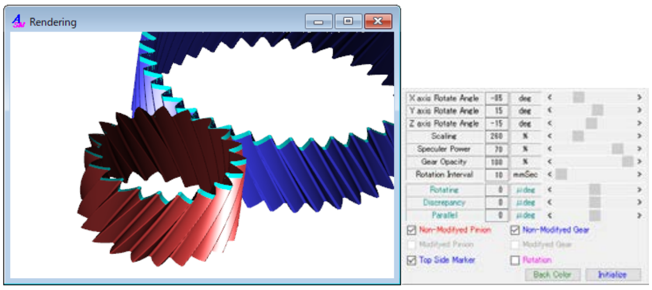


Fig. 4.15　Tooth profile rendering & support form

4.8 Gear accuracy

Figures 4.16 and 4.17 show tolerances for errors according to the new JIS gear accuracy standards JIS B 1702-1: 1998 and JIS B 1702-2: 1998. In addition, it is possible to switch between the new JIS and the old JIS by the settings shown in Figure 4.4. There are the following five types of gear accuracy standards.

・JIS B 1702-1:1998, JIS B 1702-2:1998, JIS B 1702-3:2008
・JIS B 1702:1976
・JGMA 116-02:1983

Fig. 4.16　JIS B 1702-1-2 setting

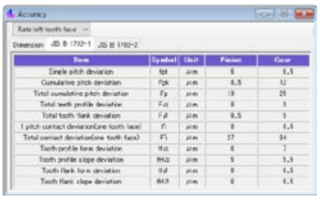


Fig. 4.17　Accuracy tolerance

4.9　Gear strength calculation (steel)

The gear strength calculation has " **JGMA6101-02:2007**" and " **JGMA 6102-02:2009**" based on " **ISO6336:2006**" as shown in Fig. 4.5. In addition, there are two types of "JGMA401-01: 1974" and "402-01: 1975". Fig. 4.18 shows the setting screen of strength calculation. In this example, the high-pressure angle side is used as the acting tooth surface, but it is also possible to calculate the strength with the low-pressure angle side as the acting tooth surface. The selection of materials displays a selection form of the materials adapted to "material" and "heat treatment" as shown in Figure 4.19. Fig. 4.20 shows the setting screen for the coefficient related to bending, Fig. 4.21 shows the screen for setting the coefficient related to surface pressure, and Fig. 4.22 shows the strength calculation results.

Note that " ... " in the screen is an auxiliary function that allows you to perform numerical conversion, various coefficients, and coefficient selection.

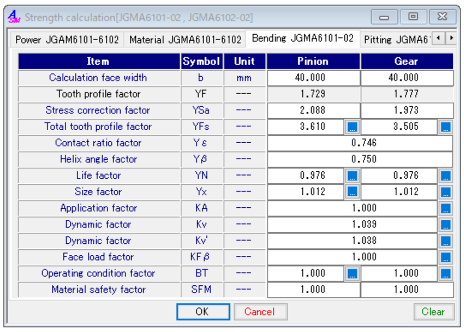


Fig. 4.18　Strength calculation (Power setup)

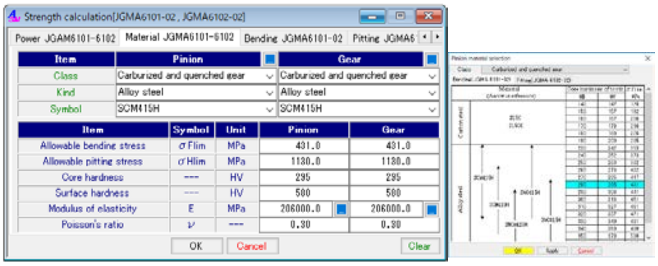


Fig. 4.19　Strength calculation（material）

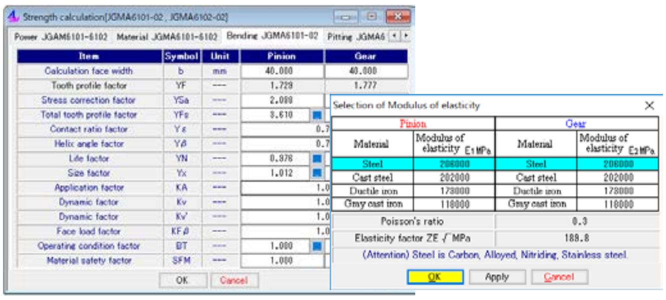


Fig. 4.20　Strength calculation（for bending factor）

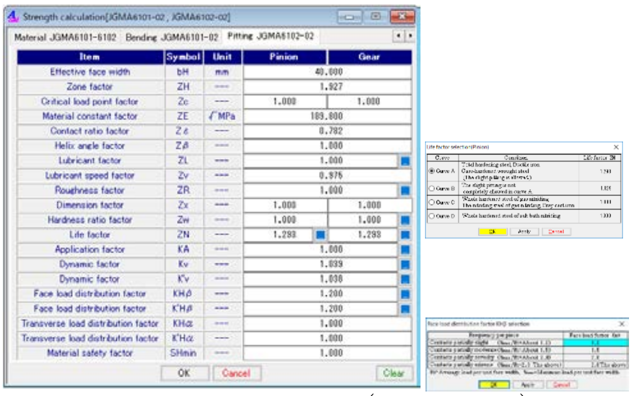


Fig. 4.21　Strength calculation（for pitting factor）

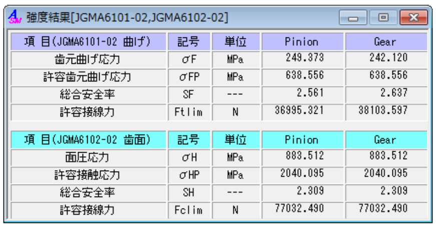
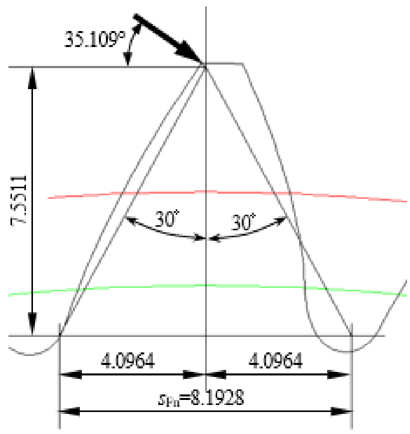


Fig. 4.22　Strength calculation result

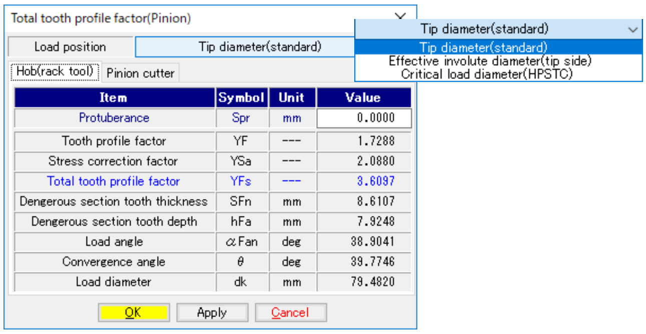
4.9a　Tooth profile factor

The method of calculating the dangerous section tooth thickness when determining the tooth profile factor of a symmetrical tooth gear is defined in each standard, but the dangerous section tooth thickness of the asymmetric tooth gear is not defined. In this software, as shown in Fig. 4.23 and Fig. 4.24, the dangerous section distance on the high-pressure angle side is doubled to be the dangerous section tooth thickness. The load position can be selected from the tip and "HPSTC".



(m_n=3, z=40, α=30°, β=0°, x=0)

Fig. 4.23　Tooth thickness at critical section (Ex. at Tip load)

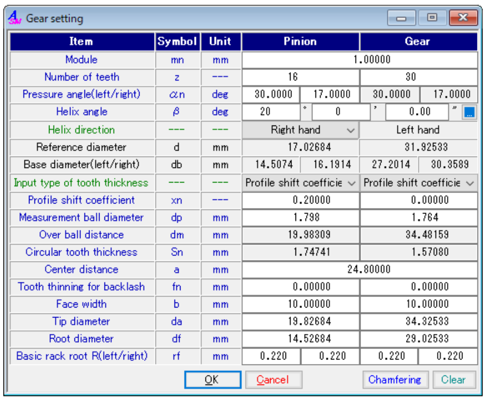


The load position can choose at tip or HPSTC.

Fig. 4.24　Tooth form factor

4.10 Gear strength calculation (plastic gear)

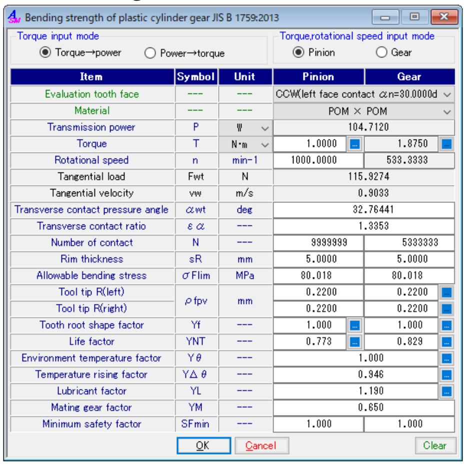
The strength of plastic gears can be calculated by selecting JIS B 1759 (2013) in Fig. 4.5. Although JIS B 1759 "Method for evaluating bending strength of plastic cylindrical gears" is not applied to asymmetrical tooth gears, the tooth form factor is calculated as shown in Figure 4.23. The allowable bending stress of plastic material is based on the gear operation test, and the allowable bending stress of POM is determined to be 80.0 [MPa] from the experimental results of various places. Then, the bending stress at the tooth is compared with the allowable bending stress at the tooth taking into consideration various factors (such as shape factor of the base, life factor, temperature coefficient of the atmosphere, etc.). Please see the standard for details. An example of strength calculation of plastic gears is shown in Figure 4.25 to 4.29.


Gear setting

Item	Symbol	Unit	Pinion		Gear	
Module	mn	mm	1.00000			
Number of teeth	z	---	16		30	
Pressure angle(left/right)	αn	deg	30.0000	17.0000	30.0000	17.0000
Helix angle	β	deg	20 °	0 '	0.00 "	
Helix direction	---	---	Right hand		Left hand	
Reference diameter	d	mm	17.02684		31.92533	
Base diameter(left/right)	db	mm	14.5074	16.1914	27.2014	30.3589
Input type of tooth thickness	---	---	Profile shift coefficient		Profile shift coefficient	
Profile shift coefficient	xn	---	0.20000		0.00000	
Measurement ball diameter	dp	mm	1.798		1.764	
Over ball distance	dm	mm	19.98309		34.48159	
Circular tooth thickness	Sn	mm	1.74741		1.57080	
Center distance	a	mm	24.80000			
Tooth thinning for backlash	fn	mm	0.00000		0.00000	
Face width	b	mm	10.00000		10.00000	
Tip diameter	da	mm	19.82684		34.32533	
Root diameter	df	mm	14.52684		29.02533	
Basic rack root R(left/right)	rf	mm	0.220	0.220	0.220	0.220

OK Cancel Chamfering Clear

Fig. 4.25 Gear dimensions

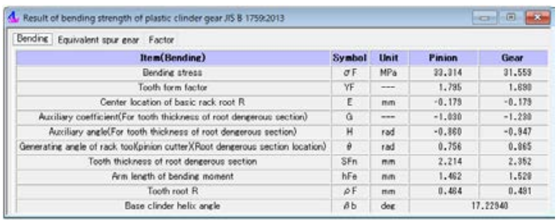

Bending strength of plastic cylinder gear JIS B 1759:2013

Torque input mode: Torque→power / Power→torque
Torque,rotational speed input mode: Pinion / Gear

Item	Symbol	Unit	Pinion	Gear
Evaluation tooth face	---	---	CCW(left face contact αn=30.0000d	
Material	---	---	POM × POM	
Transmission power	P	W	104.7120	
Torque	T	N·m	1.0000	1.8750
Rotational speed	n	min-1	1000.0000	533.3333
Tangential load	Fwt	N	115.9274	
Tangential velocity	vw	m/s	0.9033	
Transverse contact pressure angle	αwt	deg	32.76441	
Transverse contact ratio	εα	---	1.3353	
Number of contact	N	---	9999999	5333333
Rim thickness	sR	mm	5.0000	5.0000
Allowable bending stress	σFlim	MPa	80.018	80.018
Tool tip R(left)	ρfpv	mm	0.2200	0.2200
Tool tip R(right)			0.2200	0.2200
Tooth root shape factor	Yf	---	1.000	1.000
Life factor	YNT	---	0.773	0.829
Environment temperature factor	Yθ	---	1.000	
Temperature rising factor	YΔθ	---	0.946	
Lubricant factor	YL	---	1.190	
Mating gear factor	YM	---	0.650	
Minimum safety factor	SFmin	---	1.000	1.000

OK Cancel Clear

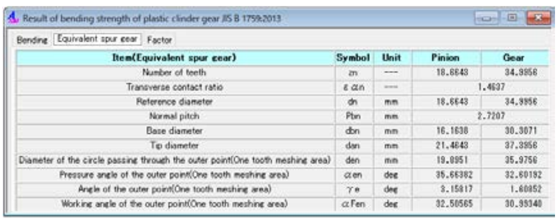
Fig. 4.26 Strength calculation (Power setup)


Result of bending strength of plastic clinder gear JIS B 1759:2013

Bending | Equivalent spur gear | Factor

Item(Bending)	Symbol	Unit	Pinion	Gear
Bending stress	σF	MPa	33.314	31.553
Tooth form factor	YF	---	1.795	1.690
Center location of basic rack root R	E	mm	-0.179	-0.179
Auxiliary coefficient(For tooth thickness of root dengerous section)	G	---	-1.030	-1.230
Auxiliary angle(For tooth thickness of root dengerous section)	H	rad	-0.860	-0.947
Generating angle of rack tool(pinion cutter)(Root dengerous section location)	θ	rad	0.756	0.865
Tooth thickness of root dengerous section	SFn	mm	2.214	2.352
Arm length of bending moment	hFe	mm	1.462	1.520
Tooth root R	ρF	mm	0.484	0.491
Base clinder helix angle	βb	deg	17.22940	

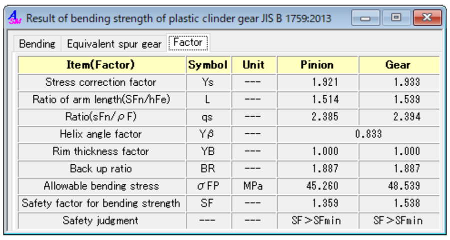
Fig.4.27 Strength calculation result


Result of bending strength of plastic clinder gear JIS B 1759:2013

Bending | Equivalent spur gear | Factor

Item(Equivalent spur gear)	Symbol	Unit	Pinion	Gear
Number of teeth	zn	---	18.6643	34.9956
Transverse contact ratio	εαn	---	1.4637	
Reference diameter	dn	mm	18.6643	34.9956
Normal pitch	Pbn	mm	2.7207	
Base diameter	dbn	mm	16.1638	30.3071
Tip diameter	dan	mm	21.4643	37.3956
Diameter of the circle passing through the outer point(One tooth meshing area)	den	mm	19.8951	35.9756
Pressure angle of the outer point(One tooth meshing area)	αen	deg	35.66382	32.60192
Angle of the outer point(One tooth meshing area)	γe	deg	3.15817	1.60852
Working angle of the outer point(One tooth meshing area)	αFen	deg	32.50565	30.99340

Fig. 4.28 Virtual spur gear


Result of bending strength of plastic clinder gear JIS B 1759:2013

Bending | Equivalent spur gear | Factor

Item(Factor)	Symbol	Unit	Pinion	Gear
Stress correction factor	Ys	---	1.921	1.933
Ratio of arm length(SFn/hFe)	L	---	1.514	1.539
Ratio(sFn/ρF)	qs	---	2.385	2.394
Helix angle factor	Yβ	---	0.833	
Rim thickness factor	YB	---	1.000	1.000
Back up ratio	BR	---	1.887	1.887
Allowable bending stress	σFP	MPa	45.260	48.539
Safety factor for bending strength	SF	---	1.359	1.538
Safety judgment	---	---	SF>SFmin	SF>SFmin

Fig. 4.29 Factors

4.11 Bearing load

Calculate the load acting on the gear and the load acting on the bearing. The load type calculates 20 types of load acting on each bearing, such as tangential force and normal force. The calculation result is shown in Figure 4.30.

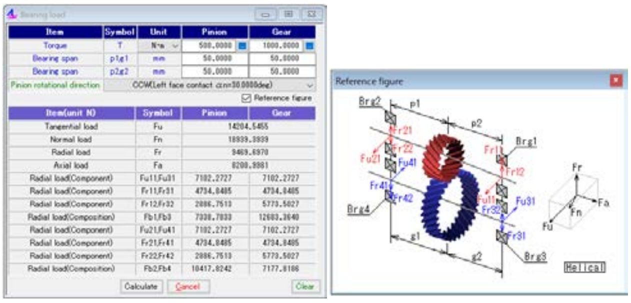


Fig. 4.30 Bearing load

4.12 Tooth surface modification (tooth profile, lead, bias)

An example of tooth surface modification is shown in Figure 4.31. In order to obtain this tooth profile, tooth shape correction can also be given by numerical input as shown in Fig. 4.32. However, it is also possible to input numerical values to the patterned tooth profile as shown on the right. Similarly, lead modification can also be set as shown in Figure 4.33. This tooth profile modification and lead modification can be expressed as shown in Figure 4.34. And if it copies to the opposite tooth side, it will become the same tooth profile of the right and left tooth surface, and if it is combined, it can be displayed as Figure 4.31.

In the combo box at the top of the screen in Fig. 4.34, you can select "Tooth profile", "Lead" and "Tooth profile and Lead". Also, the direction of the tooth profile can be specified by the action line or gear diameter. And, the magnification of tooth profile modification can be set up to maximum 1000 times.

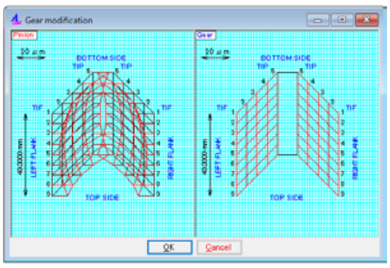


Fig. 4.31 Tooth surface modification (topo graph)

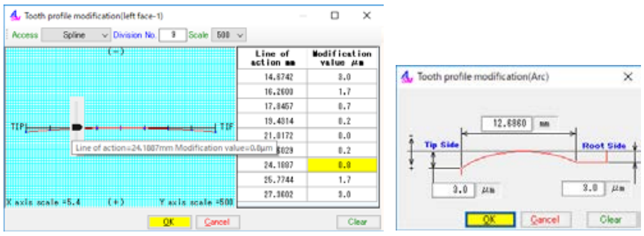


Fig. 4.32 Tooth profile modification

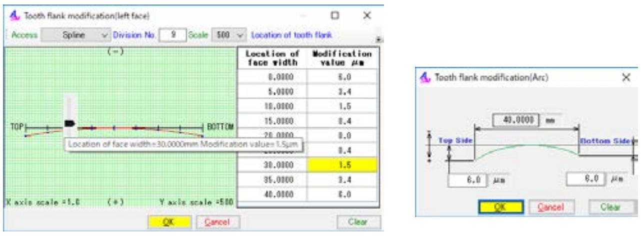


Fig. 4.33 Lead modification

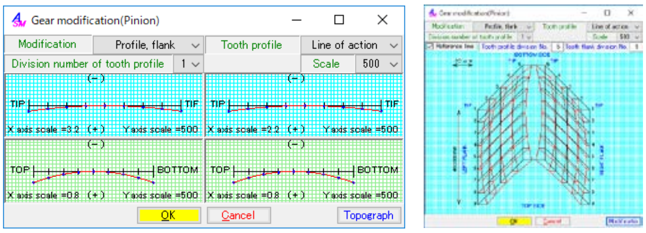
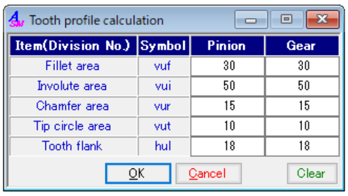


Fig. 4.34 Tooth profile & lead modification, topo graph

The tooth profile which has been given tooth surface modification can be set by the tooth profile calculation specifications in Fig. 4.35. The tooth profile calculation conditions set here are valid for the tooth shape shown in Figures 4.10 to 4.14. And this tooth profile can be displayed as shown in Figure 4.36 because it can be superimposed in the rendering in Figure 4.14. Here, the tooth surface is adjusted on the pinion, so the yellow tooth surface appears in the red tooth surface in the figure (the gear is uncorrected).



Item(Division No.)	Symbol	Pinion	Gear
Fillet area	vuf	30	30
Involute area	vui	50	50
Chamfer area	vur	15	15
Tip circle area	vut	10	10
Tooth flank	hul	18	18

Fig. 4.35 Tooth profile calculation

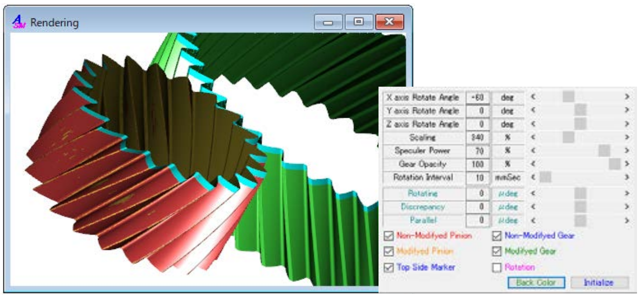
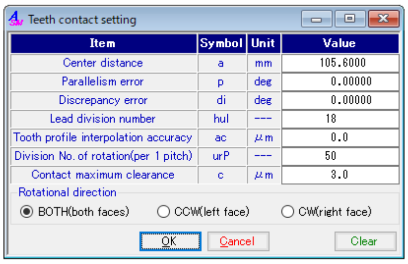


Fig.4.36 Tooth rendering (tooth modification)

4.13 Tooth surface contact

Tooth contact condition can be set in Fig. 4.37 and tooth contact can be confirmed. Here, the tooth contact is shown in Figure 4.38 and Figure 4.39 when the contact clearance is 2.0 μm with the parallelism error and the misalignment error as 0.



Item	Symbol	Unit	Value
Center distance	a	mm	105.6000
Parallelism error	p	deg	0.00000
Discrepancy error	di	deg	0.00000
Lead division number	hul	---	18
Tooth profile interpolation accuracy	ac	μm	0.0
Division No. of rotation(per 1 pitch)	urP	---	50
Contact maximum clearance	c	μm	3.0

Fig.4.37 Contact analysis setting

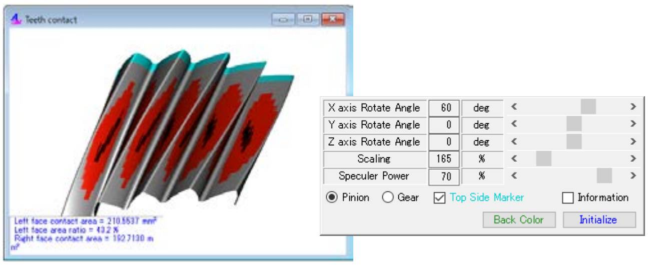


Fig.4.38 Contact pattern (pinion)

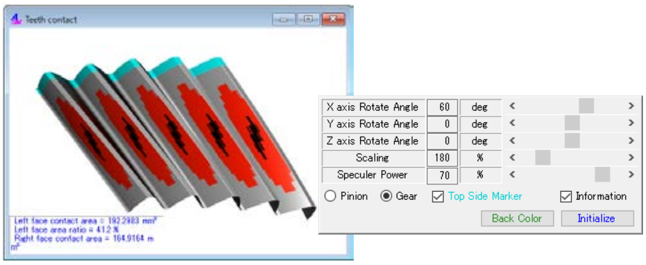


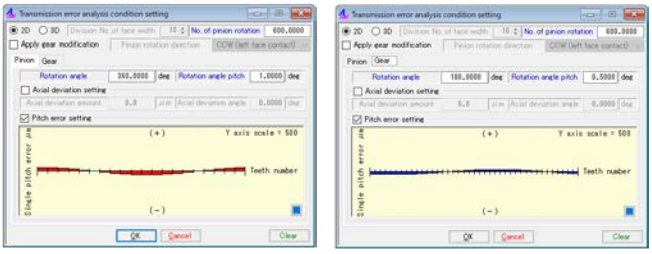
Fig.4.39 Contact pattern (gear)

4.14 Transmission error

In transmission error analysis, it is possible to perform no-load transmission error analysis with the tooth profile given in Fig. 4.31. Axis deflection and rotational speed can be set with the transmission error setting in Figure 4.40, and 2D analysis or 3D analysis can be performed. Also, the pitch error can be set to the maximum value or the pitch error of all teeth as shown in Figure 4.41.

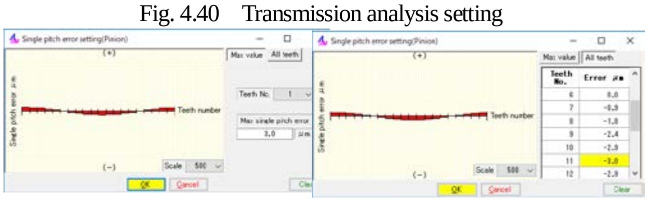
Transmission error analysis results, CSV File (rotation unevenness) and Fourier analysis results are shown in Figures 4.42 to 4.44. You can also hear [Noise] at Sound うねり除去 in Figure 4.42. Transmission error analysis, wow flutter, and Fourier analysis results can be output to a CSV file as shown in Figure 4.45 using in the lower left of Figure 4.42.

This software is a no-load transmission error analysis. Please use [22] CT-FEM ASM for stress analysis, transmission error analysis and flash temperature analysis corresponding to load and axial angle error.



(a) pinion (b) gear

Fig. 4.40 Transmission analysis setting



(a) Maxi. value setting (b) all teeth setting

Fig. 4.41 Pitch error setting

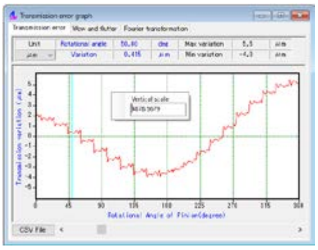


Fig. 4.42　TE result

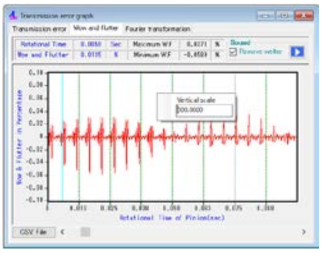


Fig. 4.43　Wow flutter

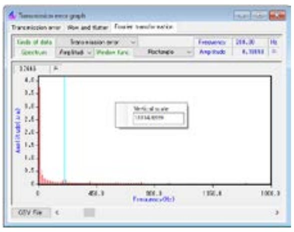
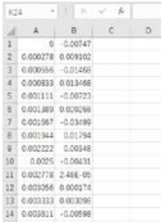


Fig.4.44　Fourier analysis



	A	B	C	D
1	0	-0.00747		
2	0.000278	0.009102		
3	0.000556	-0.01468		
4	0.000833	0.013468		
5	0.001111	-0.00723		
6	0.001389	0.020266		
7	0.001667	-0.03499		
8	0.001944	0.01794		
9	0.002222	0.00348		
10	0.0025	-0.00431		
11	0.002778	2.48E-05		
12	0.003056	0.000174		
13	0.003333	0.003098		
14	0.003611	-0.00598		

Fig.4.45　csv file example

4.15　Tooth profile output

The generated tooth profile can be output in the tooth profile file format shown in Figure 4.46. In the case of 3D-IGES, output is as shown in Figure 4.47.

In the coordinate correction setting shown in Fig. 4.48, it is possible to output the tooth profile in consideration of use for the mold. As an example, Fig. 4.49 shows a tooth profile (2D) considering a module contraction rate of 20/1000. In addition, tooth profile coordinate values can be output as a text file by "**TXT 2D**" at the bottom of Fig. 4.46.

Fig. 4.46　Tooth file format

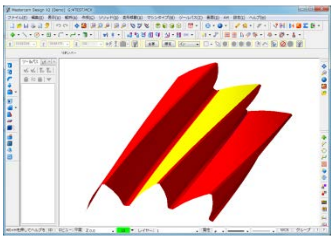


Fig.4.47　CAD sample

Fig.4.48　Coordinate correction setup

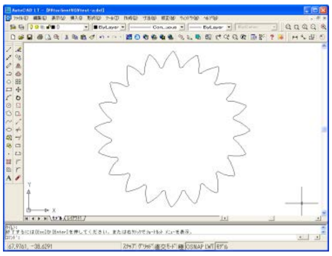
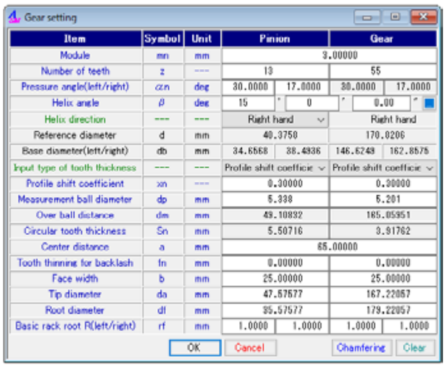


Fig.4.49　CAD sample

4.16　Calculation example of internal gear

The internal gear can be calculated by selecting "External gear × internal gear" in the settings in Figure 4.3. Examples of gear specifications, dimensions, meshing diagrams, tooth profile rendering, and tooth contact are shown in Figures 4.50 to 4.53. The pinion shown in Fig. 4.52 has the same gear face modification as in Fig. 4.31. In addition, strength calculation, transmission error analysis, tooth profile output, etc. are the same as "external gear × external gear".



Item	Symbol	Unit	Pinion		Gear	
Module	mn	mm	3.00000			
Number of teeth	z	---	13		55	
Pressure angle(left/right)	αn	deg	30.0000	17.0000	30.0000	17.0000
Helix angle	β	deg	15 °	0 ′	0.00 ″	
Helix direction	---	---	Right hand		Right hand	
Reference diameter	d	mm	40.3750		170.0206	
Base diameter(left/right)	db	mm	34.6568	38.4936	146.6248	162.8575
Input type of tooth thickness	---	---	Profile shift coefficie		Profile shift coefficie	
Profile shift coefficient	xn	---	0.30000		0.30000	
Measurement ball diameter	dp	mm	5.338		5.201	
Over ball distance	dm	mm	49.10832		165.05951	
Circular tooth thickness	Sn	mm	5.50716		3.91762	
Center distance	a	mm	65.00000			
Tooth thinning for backlash	fn	mm	0.00000		0.00000	
Face width	b	mm	25.00000		25.00000	
Tip diameter	da	mm	47.57577		167.22057	
Root diameter	df	mm	35.57577		179.22057	
Basic rack root R(left/right)	rf	mm	1.0000	1.0000	1.0000	1.0000

Fig. 4.50　Gear dimensions (internal gear)

Fig. 4.51　Meshing drawing

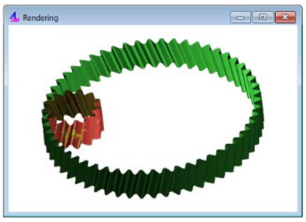
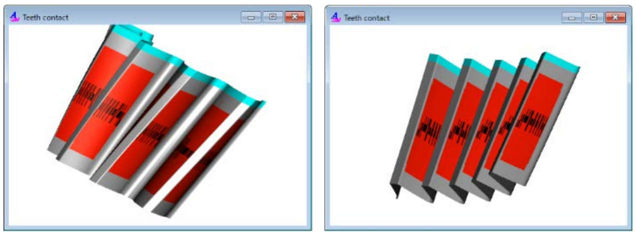


Fig.4.52　Tooth profile rendering



(a) pinion　(b) gear

Fig.4.53　Contact pattern

4.17　FEM tooth profile stress analysis (option)

Examples of FEM analysis are shown in Figure 4.54 and Figure 4.55. The setting method is the same as **[1]involuteΣiii(spur and helical gear design system)**.

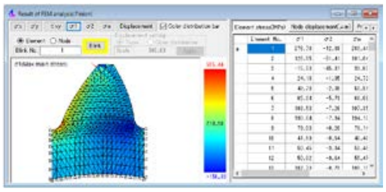


Fig.4.54　FEM (2D), σ_1

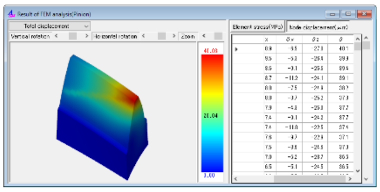


Fig.4.55　FEM (3D), δ_m

4.18　Other

The printing function, [HELP] function, and saving / reading of design data are the same as **[1]involuteΣiii(spur and helical gear design system)**.

Please use **[22] CT-FEM ASM** for the analysis of 3D stress, tooth surface stress, flash temperature etc. of asymmetric gear.