

[31]AGMA925-A03 (Scoring)

Effect of Lubrication on Gear Surface Distress

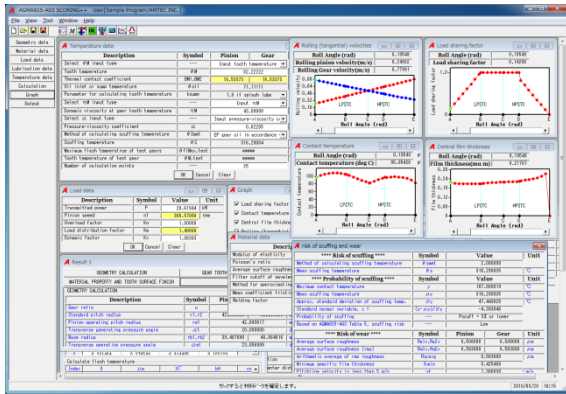


図 31.1 AGMA925-A03

31.1 概要

AGMA925-A03:2003:2003 の規格に基づいて歯車歯面損傷に対する潤滑効果を評価します。

(1)適用規格

AGMA925-A03 Effect of Lubrication on Gear Surface Distress

(2)歯車の種類

インボリュート平, はすば歯車 (外歯車, 内歯車)

31.2 歯車諸元入力

図 31.2 に歯車諸元入力の画面を示します。

歯車諸元入力は, AGMA925-A03 の [Annex A Flow chart for evaluating scuffing risk and oil film thickness] に基づいています。

Description	Symbol	Pinion	Gear	Unit
Input unit	---	SI		
Output unit	---	SI		
Gear type	---	External		
Driving member	---	Gear		
Normal module	m _n	4.00000		mm
Number of teeth	z ₁ , z ₂	21	26	
Normal generating pressure angle	α _n	20.00000		deg
Helix angle	β	0.00000		deg
Helix direction	---	*****		
Operating center distance	a _w	96.00000		mm
Standard outside radius	ra ₁ , ra ₂	46.57090	57.27700	mm
Face width	b	66.04000		mm
Profile modification	---	hi load		

図 31.2 歯車諸元入力

31.3 材料データ設定

図 31.3 に材料データ設定画面を示します。

使用する材料, ヤング率, ポアソン比, 歯面粗さなどを設定します。

Description	Symbol	Pinion	Gear	Unit
Modulus of elasticity	E1, E2	206942.71880	206942.71880	N/mm ²
Poisson's ratio	ν ₁ , ν ₂	0.30000	0.30000	
Average surface roughness at Lx	Ra _{1x} , Ra _{2x}	0.50800	0.50800	μm
Filter cutoff of wavelength λ	Lx	0.80000		mm
Method for approximating mean coef. friction	μ _{met}	AGMA217.01[7] and Kelley[2]		
Mean coefficient friction, constant	μ _m const	0.10900		
Welding factor	X _w	1.00000		

図 31.3 材料データ設定

31.4 荷重データ設定

図 31.4 に荷重データ設定画面を示します。

かみあいにおける伝達動力, 回転数及び係数を設定します。

Description	Symbol	Value	Unit
Transmitted power	P	20.61944	kW
Pinion speed	n ₁	308.67000	rpm
Overload factor	K _o	1.00000	
Load distribution factor	K _m	1.40000	
Dynamic factor	K _v	1.06389	

図 31.4 荷重データ設定

31.5 潤滑条件設定

図 31.5 に潤滑条件設定画面を示します。

歯車の潤滑条件として潤滑油の種類, ISO グレード番号を選択し設定します。

Description	Symbol	Value	Unit
Lubricant type	---	Mineral oil	
ISO viscosity grade number	---	460	
Kinematic viscosity at 40 deg C	ν ₄₀	407.00000	mm ² /s
Temperature at which ν ₁ was determined	θ ₁	40.00000	°C
Temperature at which ν ₂ was determined	θ ₂	100.00000	°C
Dynamic viscosity at temperature θ ₁	η ₁	27.17018	mm ² /s
Dynamic viscosity at temperature θ ₂	η ₂	4.29418	mm ² /s
Parameter for calculating α	k	0.016471	
Parameter for calculating α	s	0.134800	

図 31.5 潤滑条件設定

31.6 温度条件設定

図 31.6 に温度条件設定画面を示します。

歯車の歯の温度, オイルの温度などの諸条件及び計算方式を設定します。

Description	Symbol	Pinion	Gear	Unit
Select #M input type	---	Input tooth temperature		
Tooth temperature	θ _M	82.22222		°C
Thermal contact coefficient	BH1, BH2	16.53973	16.53973	N/(mm s ^{0.5} K)
Oil inlet or case temperature	θ _{oil}	71.11111		°C
Parameter for calculating tooth temperature	k _{temp}	1.0 if splash lube		
Select #M input type	---	Input ω _M		
Dynamic viscosity at gear tooth temperature	η _M	43.00000		mPa·s
Select α input type	---	Input pressure-viscosity α		
Pressure-viscosity coefficient	α	0.02285		mm ² /N
Method of calculating scuffing temperature	θ _{Met}	EP gear oil in accordance		
Scuffing temperature	θ _{scuff}	316.28884		°C
Minimum flash temperature of test gears	θ _{fl, test}	88888		°C
Tooth temperature of test gear	θ _{M, test}	88888		°C
Number of calculation points	---	25		

図 31.6 温度条件設定

31.7 計算結果 1(Geometry)

図 31.7 に Geometry 計算結果を示します。

Description	Symbol	Pinion	Gear	Unit
Gear ratio	u		1.238935	
Standard pitch radius	r ₁ , r ₂	42.000000	62.000000	mm
Pinion operating pitch radius	r _{w1}	42.893617		mm
Transverse generating pressure angle	α _t	20.000000		deg
Base radius	r _{b1} , r _{b2}	99.467698	49.584018	mm
Transverse operating pressure angle	α _{rb1}	9.358393		deg
Transverse base pitch	p _{bt}	11.389526		mm
Normal base pitch	p _{bn}	11.809526		mm
Axial pitch	p _x	12.566371		mm
Base helix angle	β _b	0.000000		deg
Operating helix angle	β _w	0.000000		deg
Normal operating pressure angle	α _{wn}	23.985393		deg
Distance along line of action - Point A	OA	9.735600		mm
Distance along line of action - Point B	OB	12.313584		mm
Distance along line of action - Point C	OC	16.789142		mm
Distance along line of action - Point D	OD	18.524126		mm
Distance along line of action - Point E	OE	24.722469		mm
Distance along line of action - Point F	OF	37.588060		mm
Active length of line of action	Z	17.068810		mm
Transverse contact ratio	ε _α	1.448214		
Fractional part of ε _α	ε _α	0.448214		
Axial contact ratio	ε _β	0.000000		
Fractional part of ε _β	ε _β	0.000000		
Minimum contact length	L _{min}	88.040000		mm

図 31.7 Geometry の計算結果

31.8 計算結果 1(Gear tooth velocity and loads)

図 31.8 に Gear tooth velocity and load 計算結果を示します。

Description	Symbol	Pinion	Gear	Unit
Angular velocity	ω_1, ω_2	32.313375	26.059264	rad/s
Operating pitch line velocity	v_t		1.386038	m/s
Nominal tangential load	F_{tnom}		14876.538066	N
Combined derating factor	K_D		1.489362	
Actual tangential load	F_t		22156.550486	N
Normal operating load	F_{mn}		24980.176837	N
Normal unit load	w		354.530288	N/mm

図 31.8 Gear tooth velocity and load 計算結果

31.9 計算結果 1(Material property and tooth surface finish)

図 31.9 に Material property and tooth surface finish 計算結果を示します。

Description	Symbol	Value	Unit
Reduced modulus of elasticity	E_r	227293.630939	N/mm ²
Average of pinion and gear average roughness	R_{avg}	0.509000	μm
Surface roughness constant	C_{Ravg}	1.816720	
Composite surface roughness at filter cutoff	σ_x	0.718420	μm

図 31.9 Material property and tooth surface finish

31.10 計算結果 2

図 31.10 に計算結果 2 を示します。

各かみ合い点における Load sharing ratio, Flash temperature および Film thickness の数値を表で出力します。

Index	ϕ (rad)	X_f	ρ_n (mm)	bH
A	0.195495	0.142857	8.132262	0.059822
B	0.327206	1.000000	8.478328	0.186102
C	0.425648	1.000000	8.239143	0.194840
D	0.494634	1.000000	8.385537	0.195806
E	0.626406	0.000000	8.466326	0.000000
1	0.195495	0.142857	8.132262	0.059822
2	0.213449	0.253701	8.536689	0.083275
3	0.921404	0.926444	8.914405	0.102194

Index	K	μm	X_f	bH	vs
A	0.800000	0.103003	0.142857	0.059822	0.1
B	0.800000	0.103003	1.000000	0.186102	0.1

Index	U	W	Hc	hc (μm)
A	1.507561e-11	0.000037	3.539779e-05	0.217080
B	1.184300e-11	0.000189	2.458782e-05	0.208464

図 31.10 計算結果 2

31.11 グラフ(Load sharing factor)

図 31.11 にグラフ(Load sharing factor)を示します。

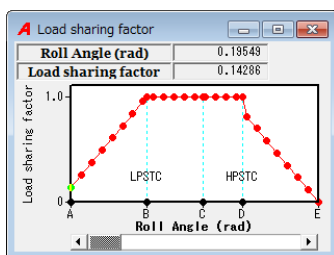


図 31.11 Load sharing factor

31.12 グラフ(Contact temperature)

図 31.12 にグラフ(Contact temperature)を示します。

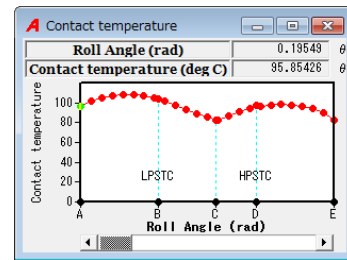


図 31.12 Contact temperature

31.13 グラフ(Central film thickness)

図 31.13 にグラフ(Central film thickness)を示します。

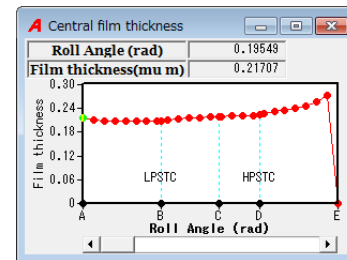


図 31.13 Central film thickness

31.14 グラフ(Rolling velocities)

図 31.14 にグラフ(Rolling velocities)を示します。

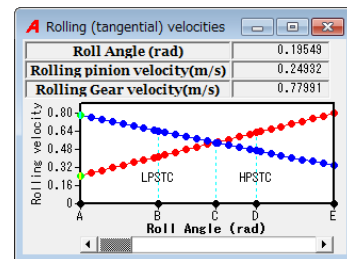


図 31.14 Rolling velocities

31.15 計算結果(Scuffing と摩耗の確率)

図 31.15 に Scuffing と摩耗の確率を示します。

Symbol	Value	Unit
θ_{smet}	2.000000	
Mean scuffing temperature	316.230835	$^{\circ}\text{C}$
Maximum contact temperature	107.858819	$^{\circ}\text{C}$
Mean scuffing temperature	316.230835	$^{\circ}\text{C}$
Approx. standard deviation of scuffing temp.	47.448625	$^{\circ}\text{C}$
Standard normal variable, x =	-4.393048	
Probability of scuffing	---	$P_{scuff} = 5\%$ or lower
Based on AGMA325-A03 Table 6, scuffing risk	---	Low
Average surface roughness	0.509000	μm
Average surface roughness (rms)	0.563880	μm
Arithmetic average of rms roughness	0.563880	
Minimum specific film thickness	0.425408	
Pitchline velocity is less than 5 m/s	1.386038	m/s
Mean min. specific film thk. (eq. 110)	0.215958	
Std. dev. of min. spec. film thk. (eq. 111)	0.112623	
Minimum specific film thickness	0.425408	
Mean minimum specific film thickness	0.215958	
Standard deviation of the min. specific film	0.112623	
Standard normal variable, x =	1.859753	
Probability of wear	---	$P_{wear} = 5\%$ or lower

図 31.15 Scuffing と摩耗の確率

※表示桁数は、規格に準じています。