

μ



Κρεωνά Αναστασία

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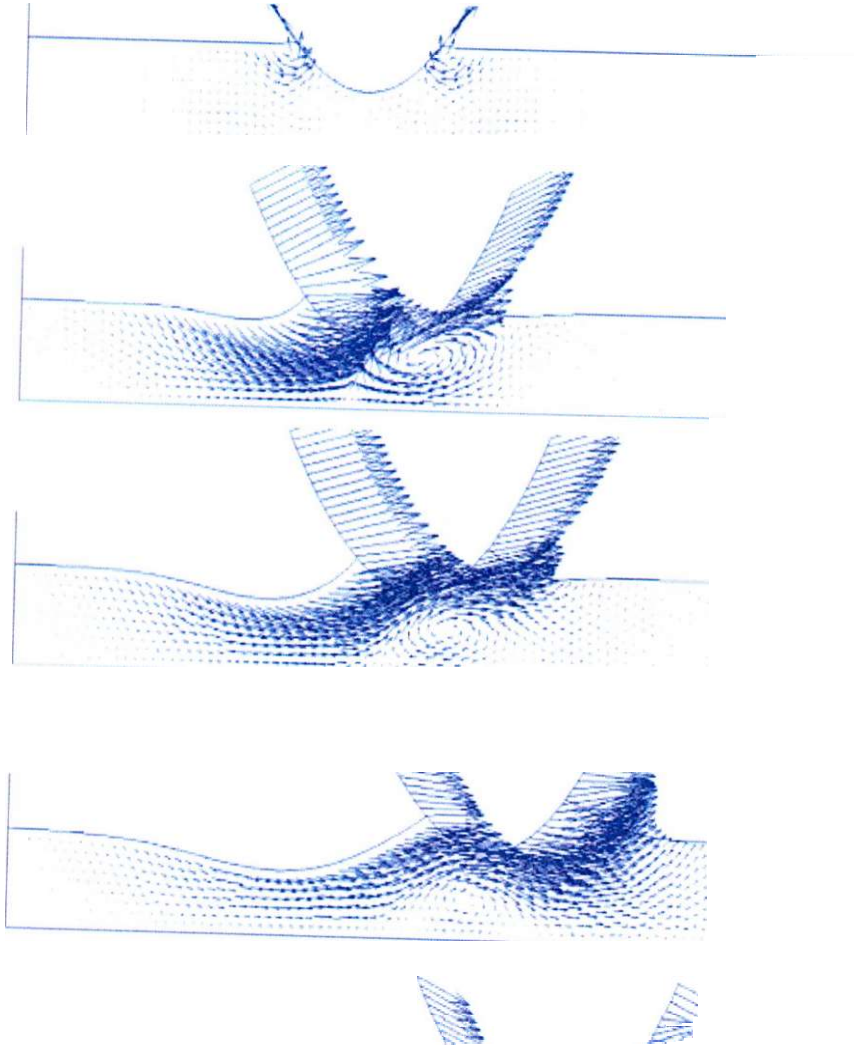
2010

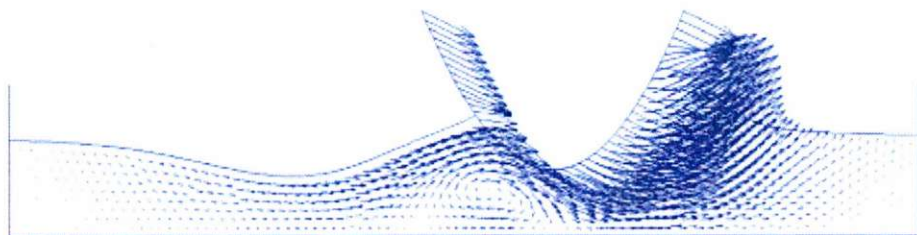
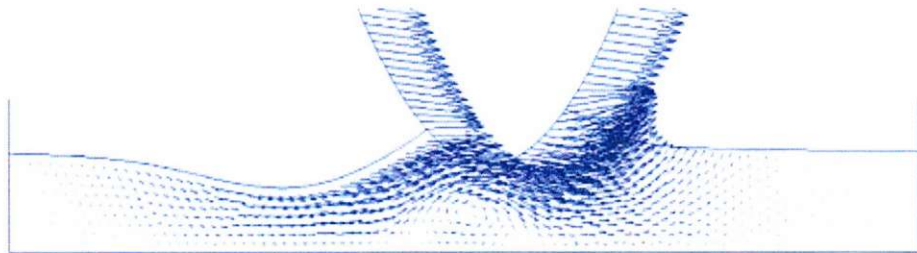
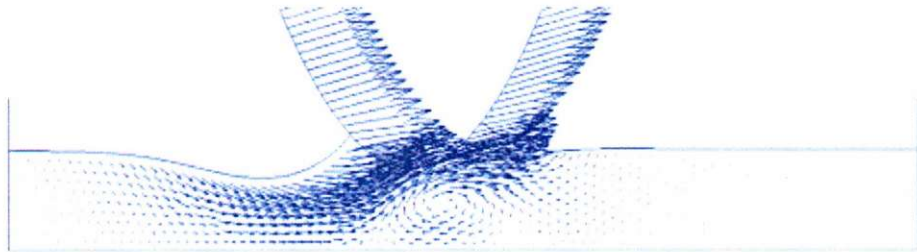
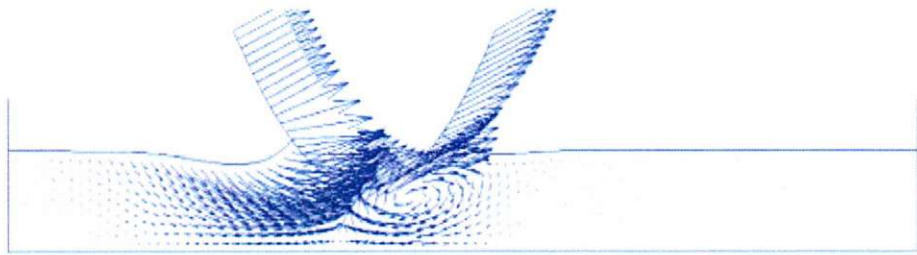
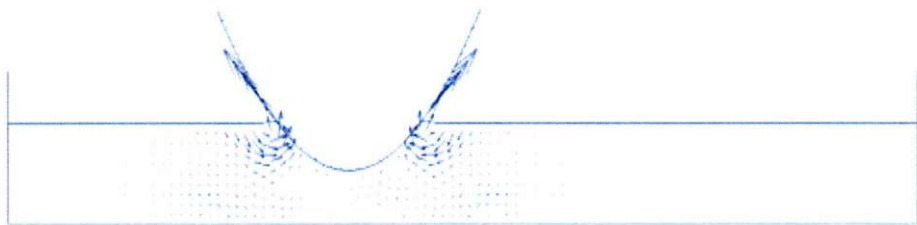
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μ . . : 11-10-2010
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: _____
2010





	1:		
1.1		μ(.11)
1.2	μ		μ(.37)
1.3		-	- μ(.47)
1.3.1	μ	(.47)
1.3.2		(.49)

2: -

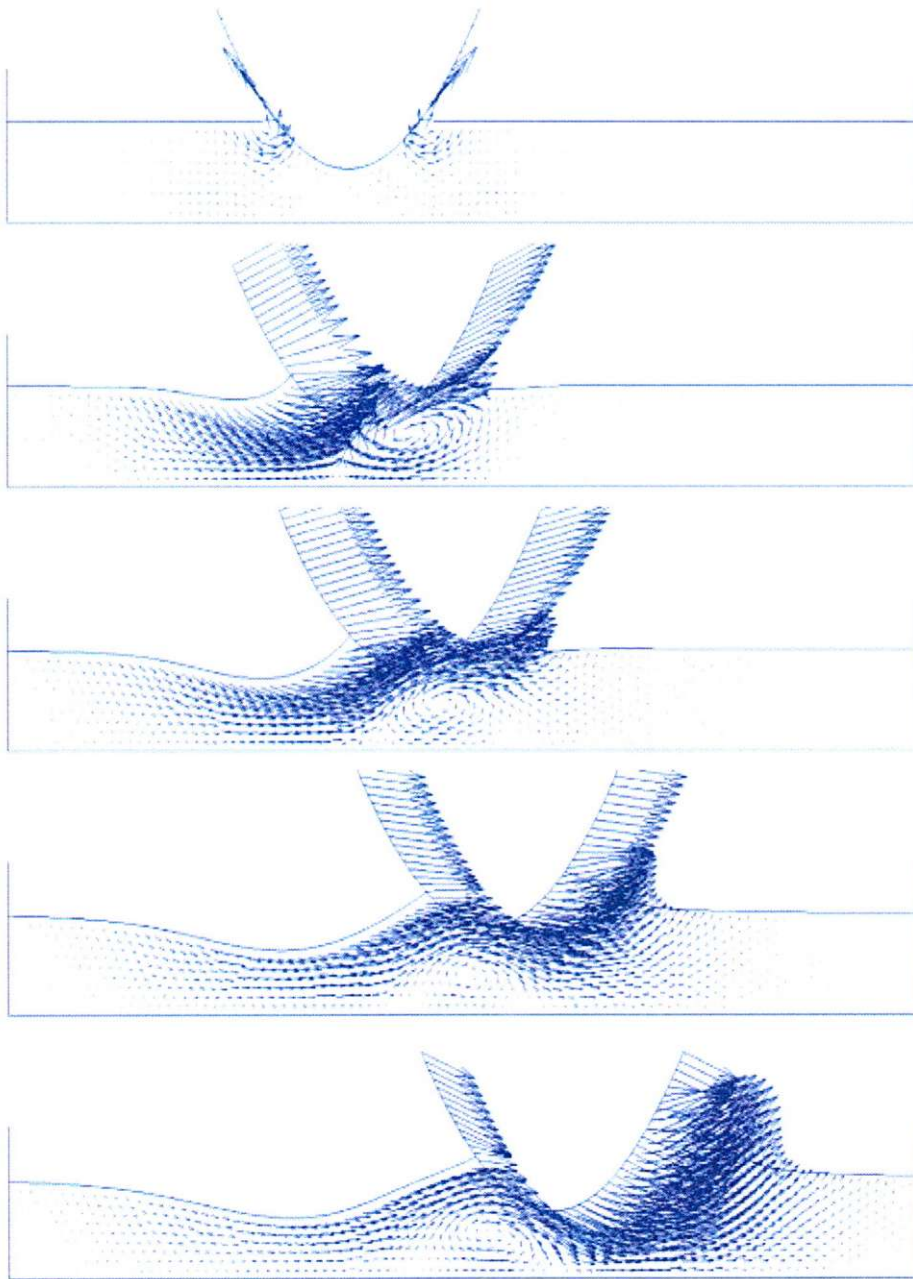
FISHER-PEARSON

2.1		-	μ	μ	μ	
	μ		μ			Fisher-Pearson.....(.59)
2.2	μ		μ	μ		Fisher- Pearson.....(.67)

3:

3.1	μ		μ(.72)
3.2	μ		μ(.74)

4:		-(.162)
		(.175)
		(.206)



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μ μ

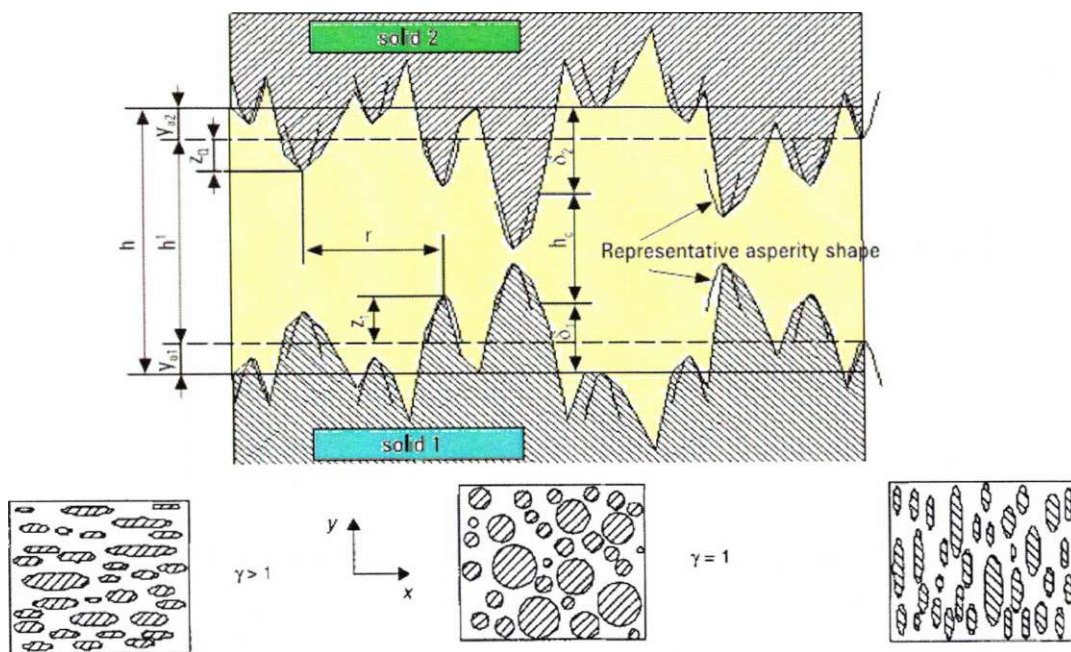
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1.1

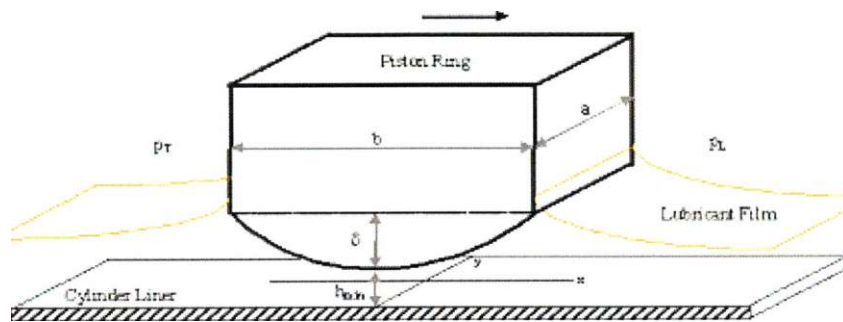
1980 μ μ μ
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Reynolds
Patir Cheng,
Greenwood Tripp .



μ 1.1 μ

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1.2

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P_{mf} μ μ μ $p_{mf} \text{ (kPa)}$ 4-

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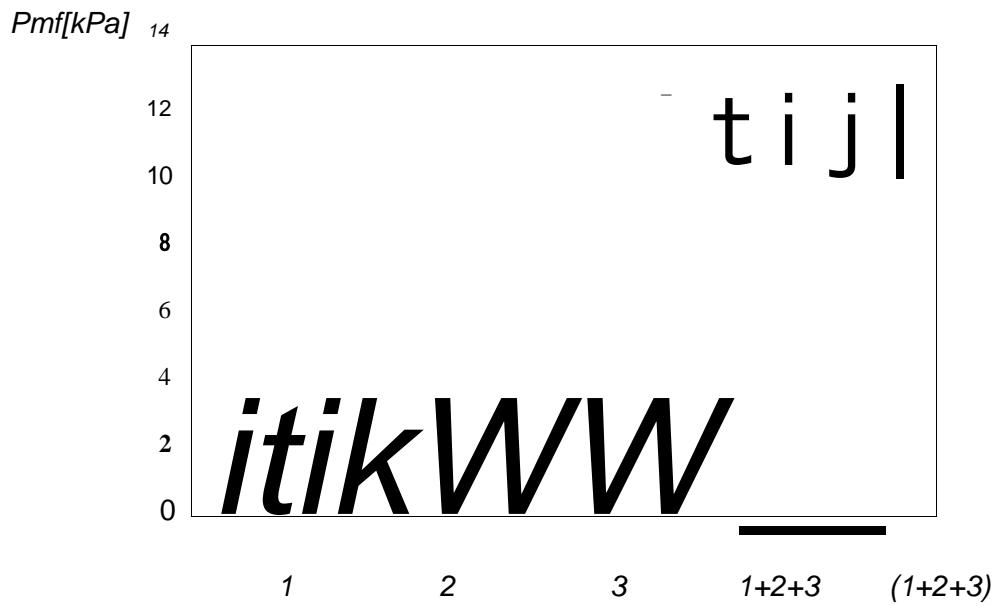
$$P_{mf} \sim \sqrt{F(P)U(P)db/V}$$

$$: F: \mu ,$$

$$U: \mu\mu \mu \mu ,$$

:

$$V: .$$



μ 1.3 $p_{mf} \text{ [kPa]}$ μ

μ $\cdot(\mu)$ μ μ μ

1. ()

2: ()

3. ()

1+2+3 : , μ μ μ

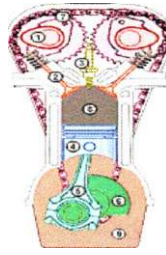
(1+2+3): , μ μ

μ

* : /
 500 rpm/70 mPa.s, 500 rpm/11 mPa.s, 955 rpm/70 mPa.s, 955 rpm/11 mPa.s
 μ , μ Renault 851-
 541 ^{3/}

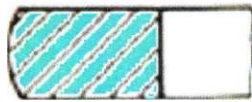
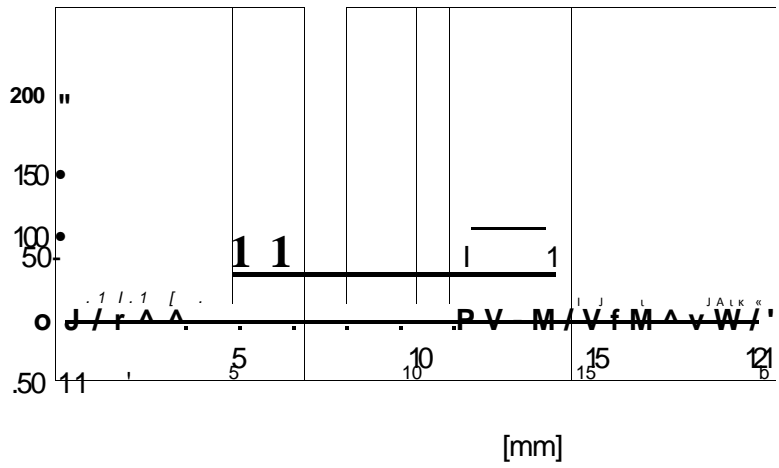
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 μ μ () () μ
 μ **ρ_{mf}**
 , μ μ **ρ_{mf}**
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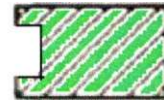
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(Y)

μ 1.4:)

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μ μ μ , μ

3. (μ)

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(° 1) μ « » ,

(° 2), μ , « »

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μ μ

blow by).

^{3/} 277-541 mm (1.75 mm), μ μ , μ

μ (profil) , μ (20-50 mm).

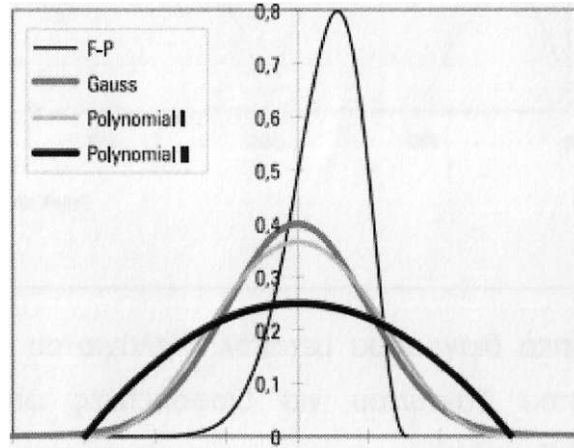
μ 0.50 2.0 10⁵ Pa. μ μ 1500-6000 rpm

7.4 mPa.s (15W40-130⁰ C), μ μ μ μ 4-9 μ

Diesel, μ 4
 , 3-6 μ , μ μ μ
 , μ μ μ
 μ 0.25 - 0.80 μ μ
 μ μ 120 - 630 h .
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 μ μ , 2 mm, μ
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 μ μ 2.0 10^5 Pa.
 μ μ 1500 -
 4500 rpm 7.4 mPas (15W40-130⁰ C), μ
 μ μ μ
 8-13 μ . 2 μ .
 μ Diesel, μ 4
 , 6.5 μ
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$\mu\mu$
 μ 0.80 μ μ μ μ 120 - 630 h
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 μ 0.2-
 0.4mm, μ 4.5mm 7.8×10^5 Pa.
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 1500 - 6000 rpm 7.4 mPas (15W40-130⁰ C),
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 blow by) μ ,
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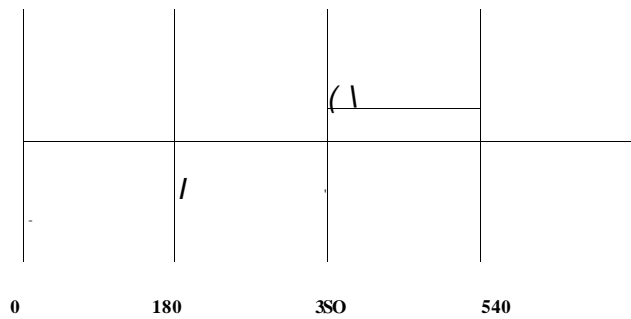
Comparison between standardized probability density functions proposed for surface asperities heights or peaks heights distribution and a representative worn liner Fisher-Pearson peaks heights distribution curve



μ 1.5.3 μ μ μ

Measured and calculated via real wmliner roughness integral functions piston ring-liner friction force L=175 mm, R. = 18.00mm (unloaded mnditions) $\lambda = 0.2 \mu\text{m}$, $\sigma = 0.40 \mu\text{m}$, $\beta = 0.60$, $\omega = 510 \text{rpm}$, $\eta = 0.020 \text{Pa}\cdot\text{s}$

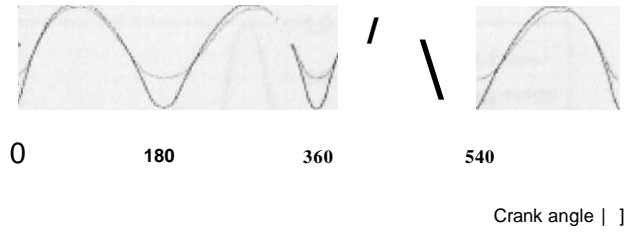
Friction force (N)



μ 1.6 μ μ μ μ

Calculated piston ring-liner minimum film thickness $L = 175\text{mm}$,
 $R = 18.00\text{mm}$ (unloaded conditions) $N = 510\text{rpm}$, $\mu = 0.020\text{ Pa}\cdot\text{s}$

Oil film thickness h [μm]



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, Poisson,),

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μ μ - μ ,

μ μ .

μ Patir-Cheng & Greenwood -Tripp

, μ μ μ μ μ .

μ μ

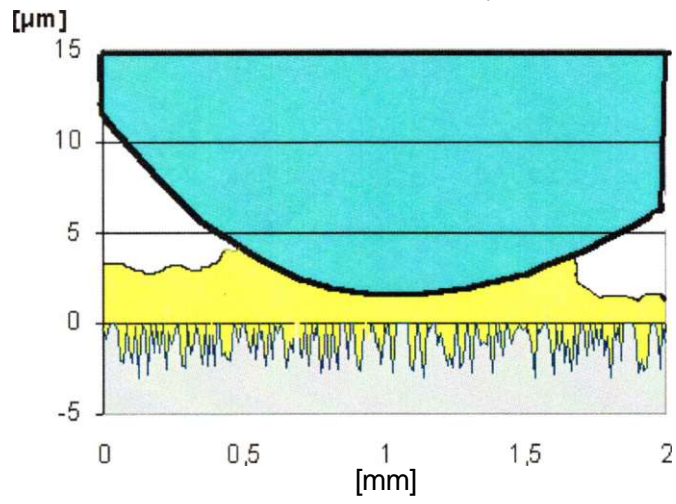
μ μ

μ μ - μ (μ)

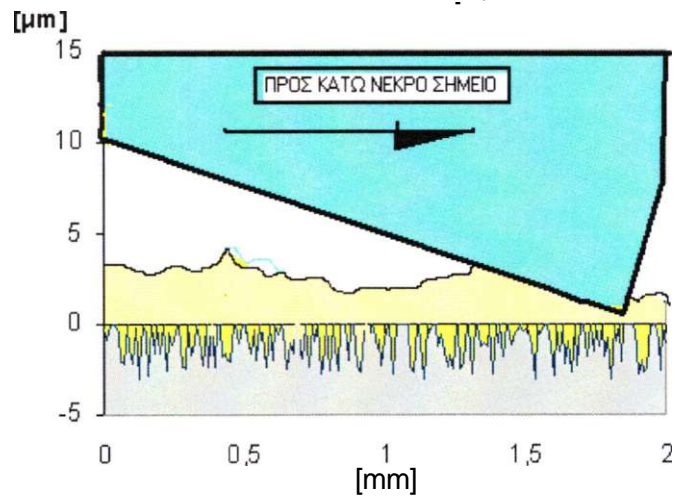
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μ μ μ μ μ μ μ μ μ μ

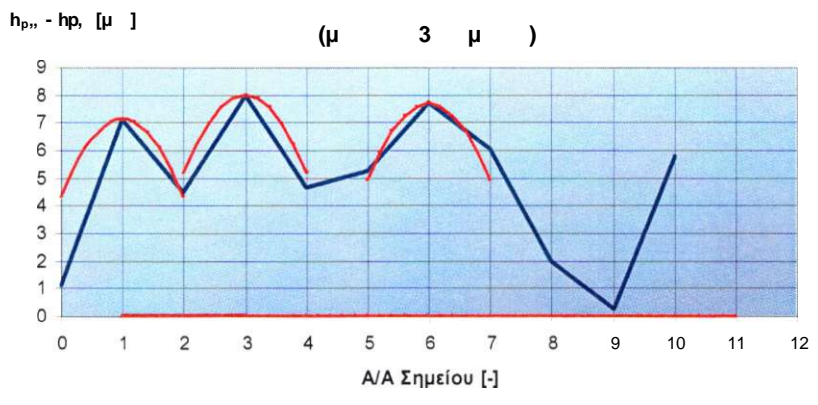


μ 1.8 μ μ (μ + μ) ,

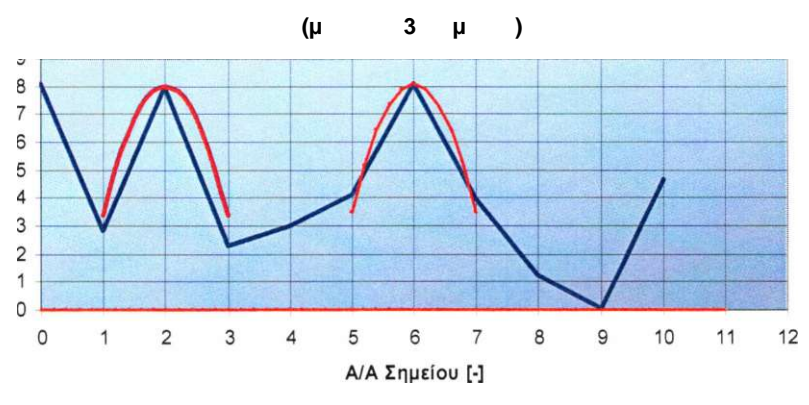


μ 1.9 μ μ 2 μ

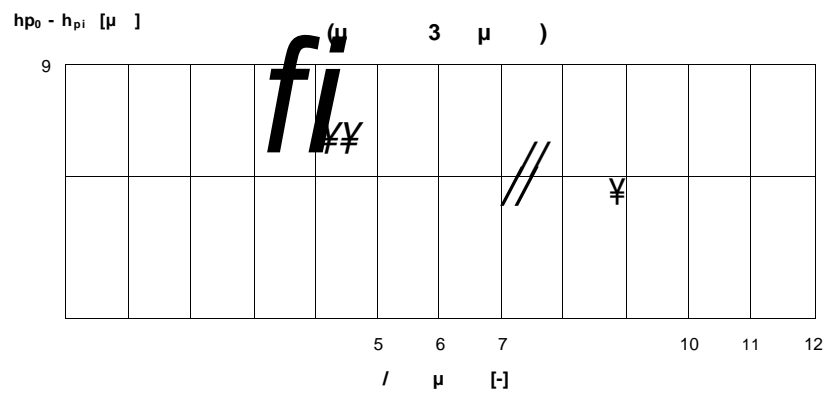
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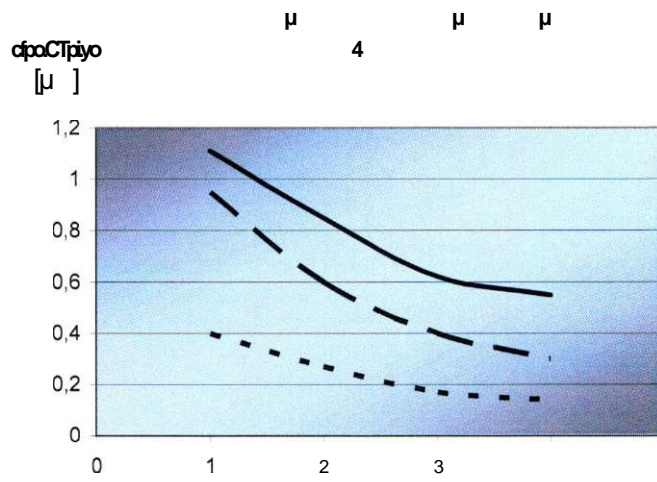
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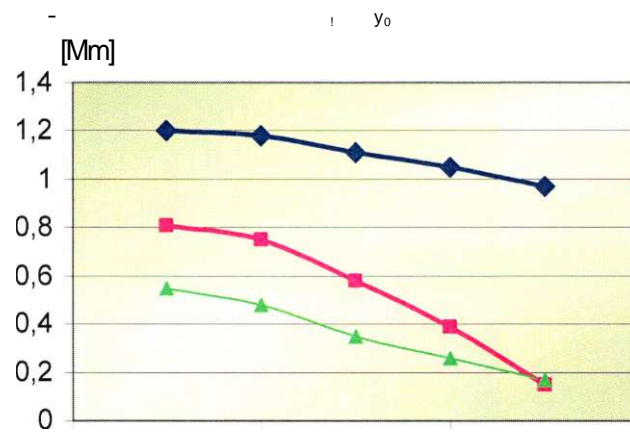
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(B)

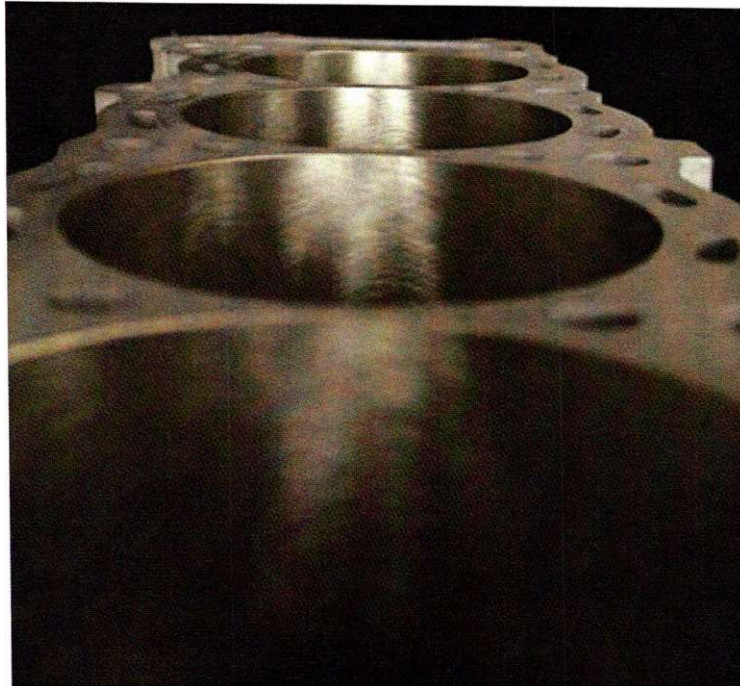
μ 1.11 $\mu\mu$ μ μ y_0
 () μ Renault,
 μ μ μ

$y_0:$ μ μ μ μ μ

μ 1.12:

μ

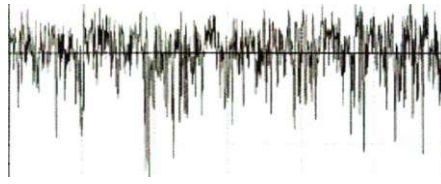
μ .



μ 1.13

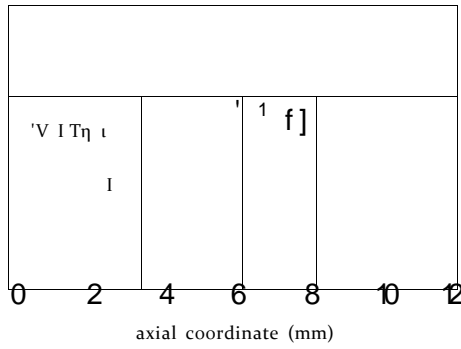
,

I awards combustion chamber



$K_i > 2 \quad 4 \quad 6 \quad \gg \quad 10$
axial coordinate (mm)

(a) mid-stroke, thrust plane at 0 hours



(b) mid-stroke, thrust plane at 120 hours

Fig. 7. Cylinder wall topographs variation [21].

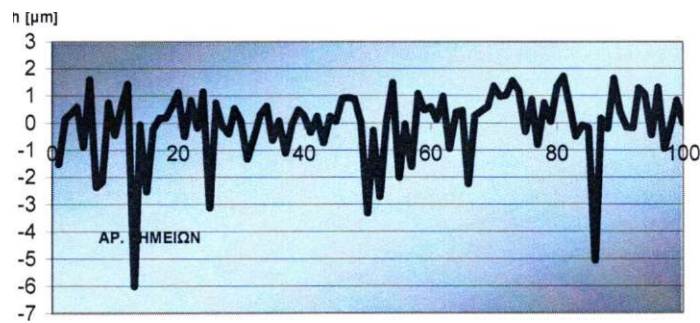
$\mu \quad 1.14$

$\mu \quad \mu \quad (\quad)$

(a) (0) μ (b) (

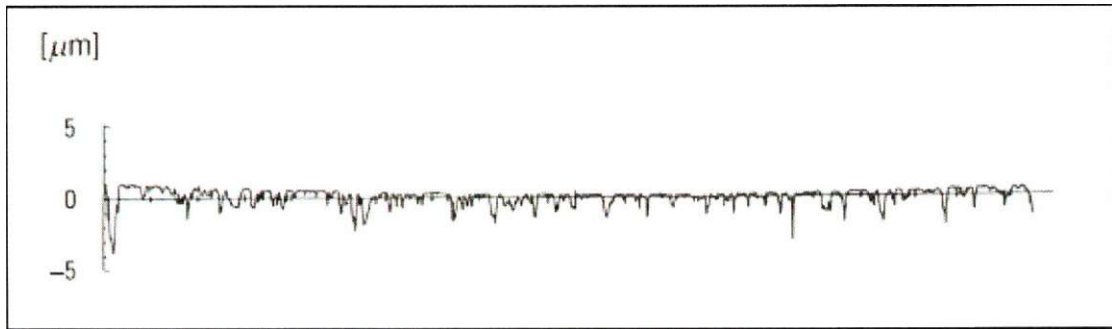
120

) $\mu \quad \mu \quad \mu \quad .$
- 2μ

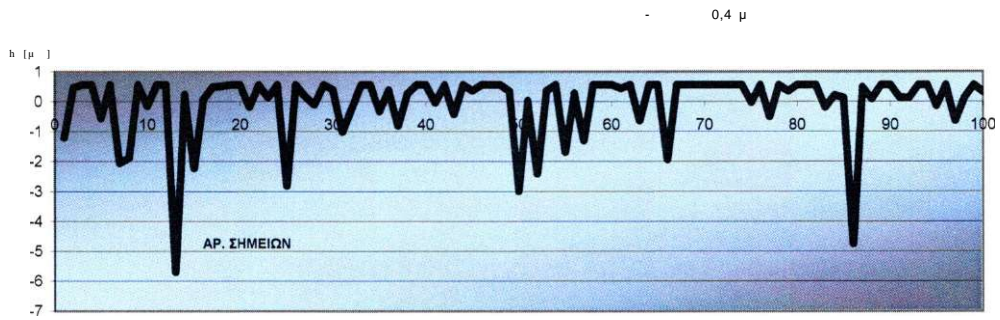


$\mu \quad 1.15$

(μ) μ



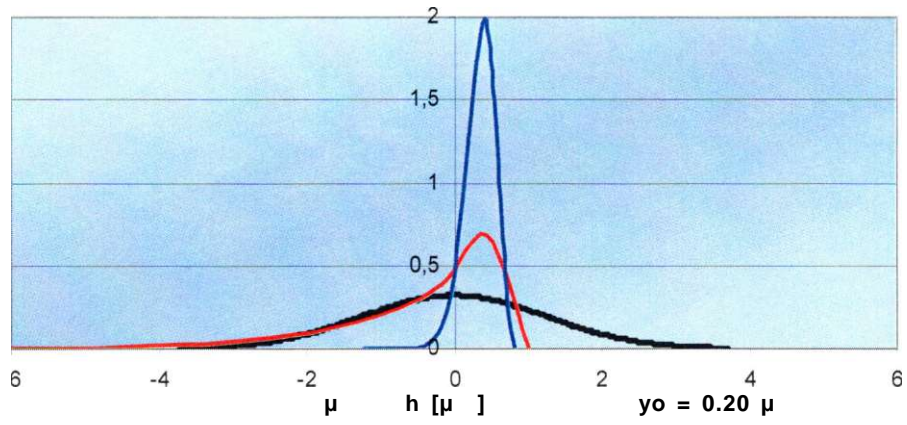
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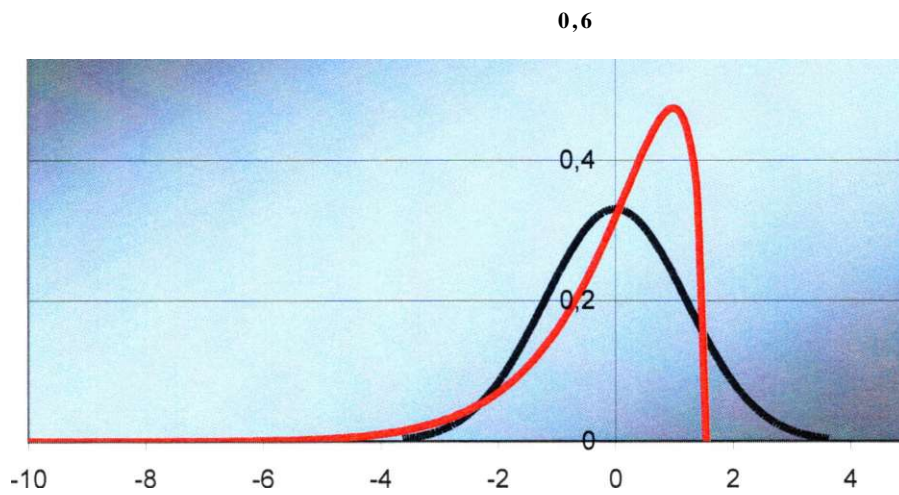
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μ 1.16 μ " μ " ()
 () μ .

μ Fisher-Pearson μ μ



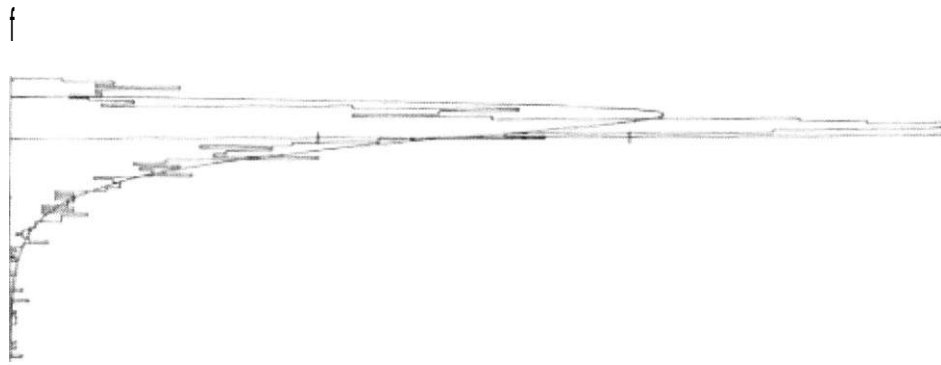
μ 1.17 μ μ μ ($\mu\mu$) μ
 $(\mu \mu\mu)$ μ μ Gauss
 μ
 μ
 μ 2- 3)



μ 1.18 $\mu\mu$ μ μ μ μ μ
 μ μ μ Fisher Pearson ($\mu\mu$)
 μ μ Gauss.

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μ 1.19 $\mu\mu$ $\mu\mu$ μ μ μ

μ μ μ μ Fisher Pearson ().

Vim)

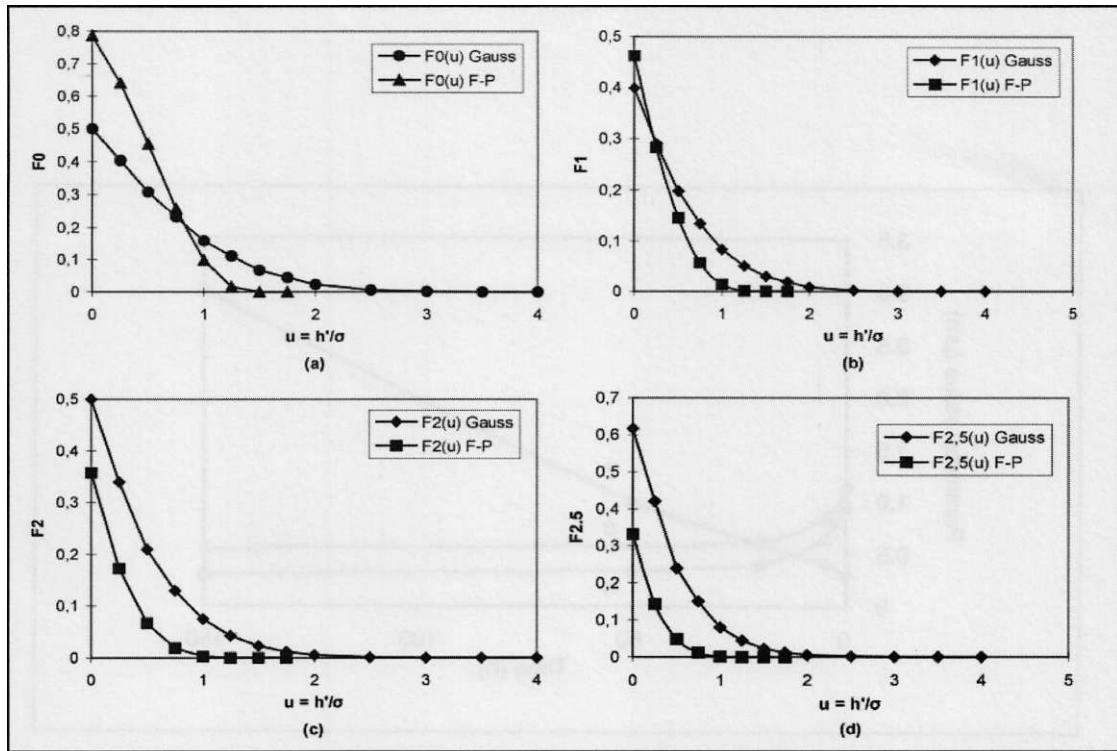
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-5

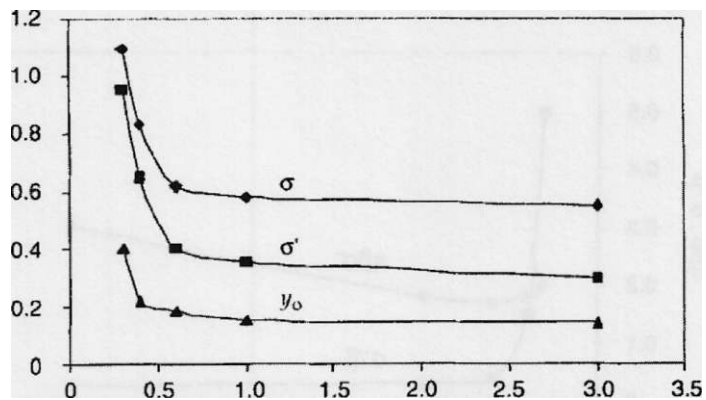
μ 1.20 $\mu\mu$ $\mu\mu$ μ μ

() Fisher Pearson



Σχήμα 1.21 Συναρτήσεις Fisher Pearson σε σύγκριση με προερχόμενες από

μ μ μ μ μ
 μ μ μ μ μ
 μ (Patir-Cheng).



μ 1.22 μ μ μ μ
 μ μ μ μ
 μ (\rightarrow , \rightarrow ')

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50 100 150

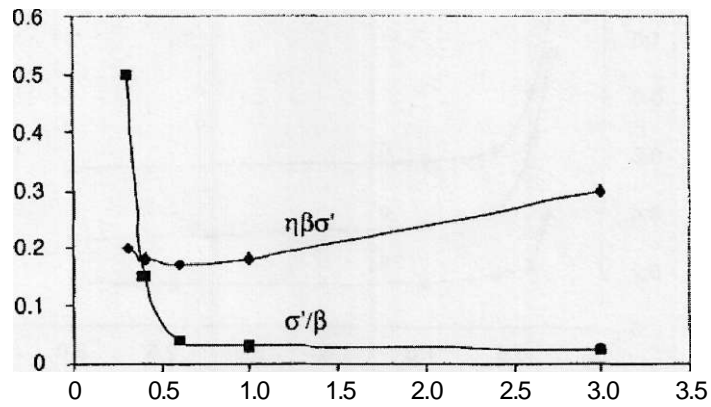
Time (h)

μ 1.23

μ μ μ

μ

. (\rightarrow , $a_{pi} \rightarrow$ ')



μ 1.24

μ μ μ

μ μ

. (\rightarrow , \rightarrow ')

1.2

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Reynolds μ

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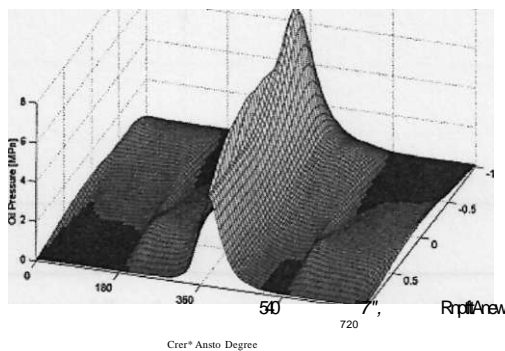
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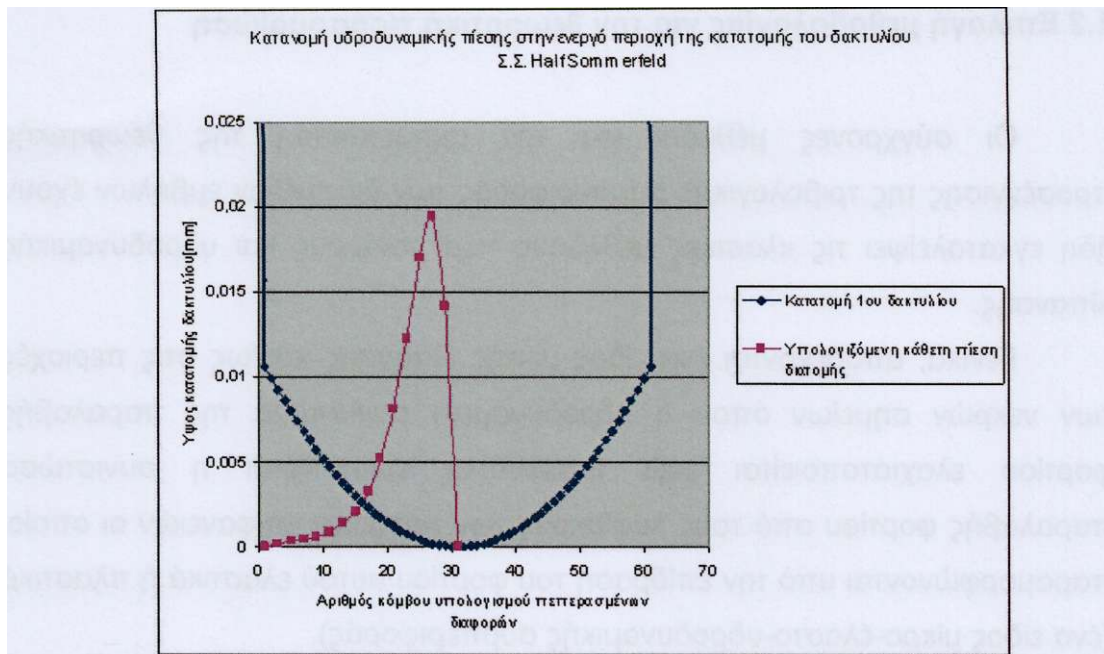
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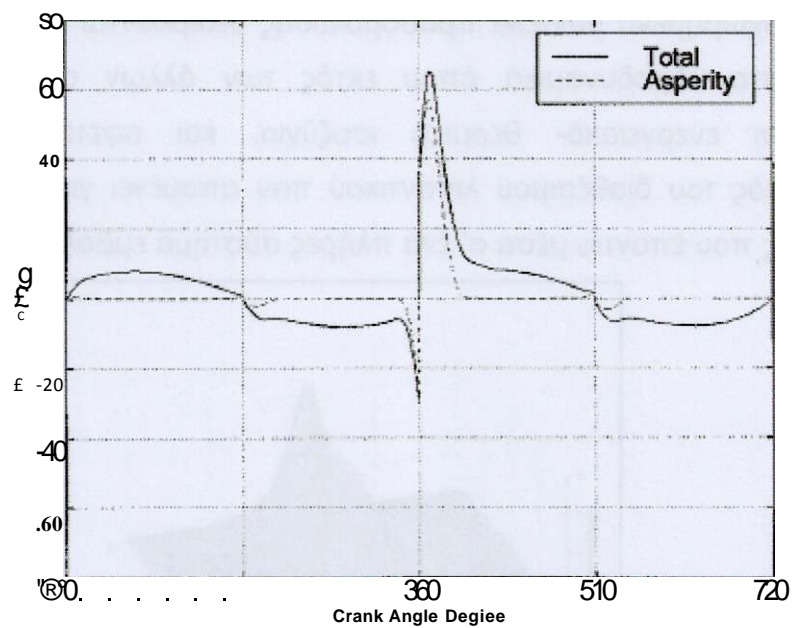
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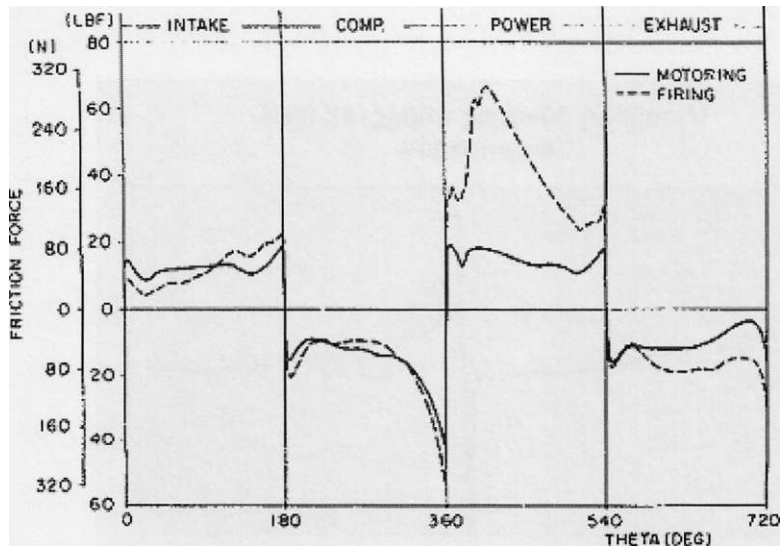


Σχήμα 1.2.2: Τυπική κατατομή 1^{ου} δακτυλίου με την κατανομή

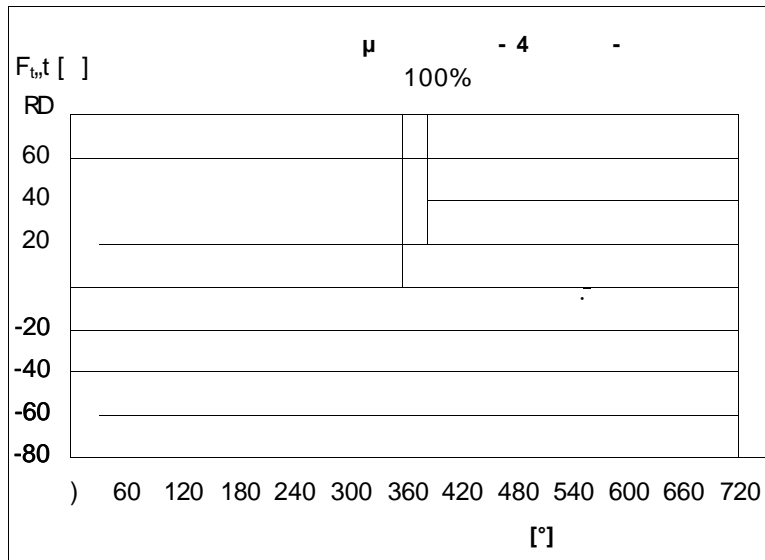
μ (μ μ μ).



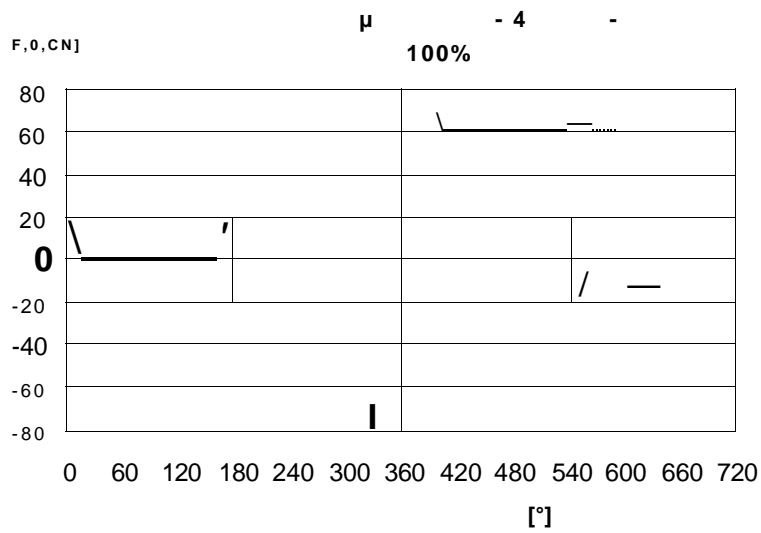
μ 1.2.3: μ μ μ 1 , (μ μ)



μ 1.2.4: $\mu\mu$ μ 1
 , (μ
 - μ μ)



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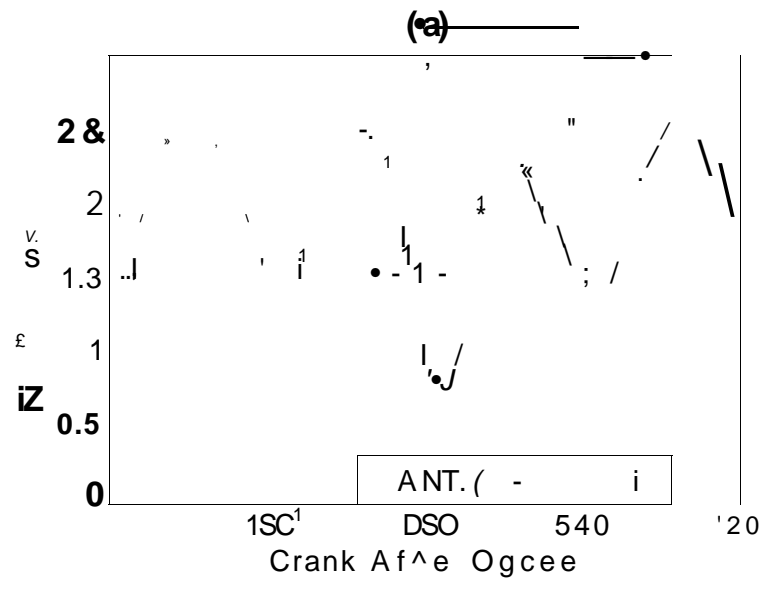
μ 1.2.5:

$\mu\mu$

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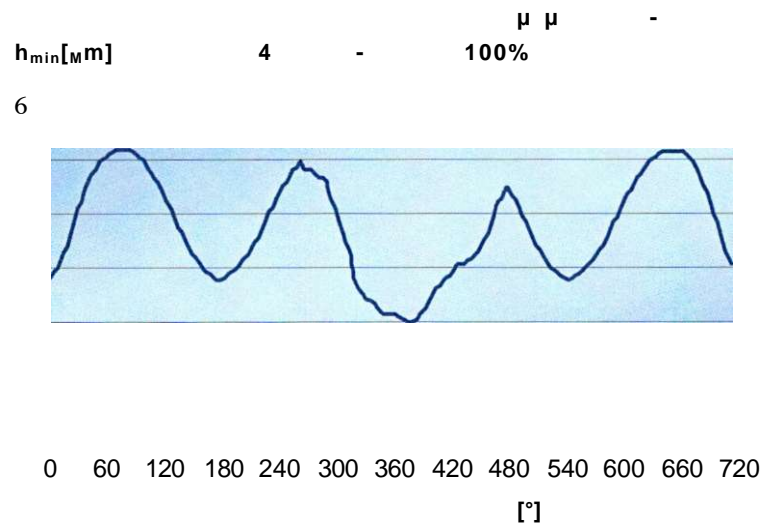
. (μ μ)



μ 1.2.6

μ 1

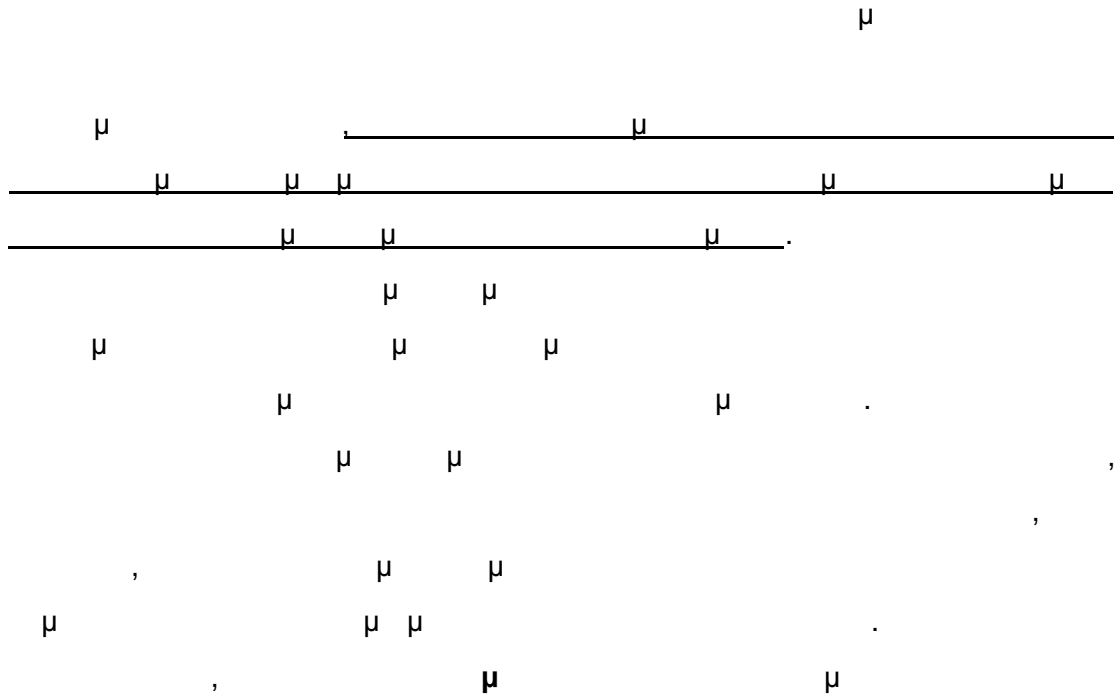
(μ)



μ 1.2.7

μ 1

(μ μ)



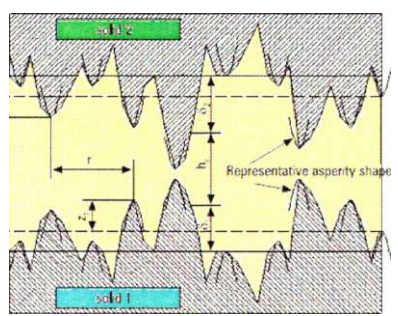
Greenwood (Greenwood-Williamson Greenwood-Trip),

(transversal $1/9 < < 1/3$)

(longitudinal $1 < < 9$)

(OILFILM) (. .)

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- μ μ

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μ **Greenwood-Tripp** μ

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$W_{tot} =$

$W_{tot\ a} = \mu$

$W_{toth} = \mu$

$$F_{tot} = F_{fob} + F_{toth}$$

F_{tor} = μ

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Greenwood

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(Gauss).

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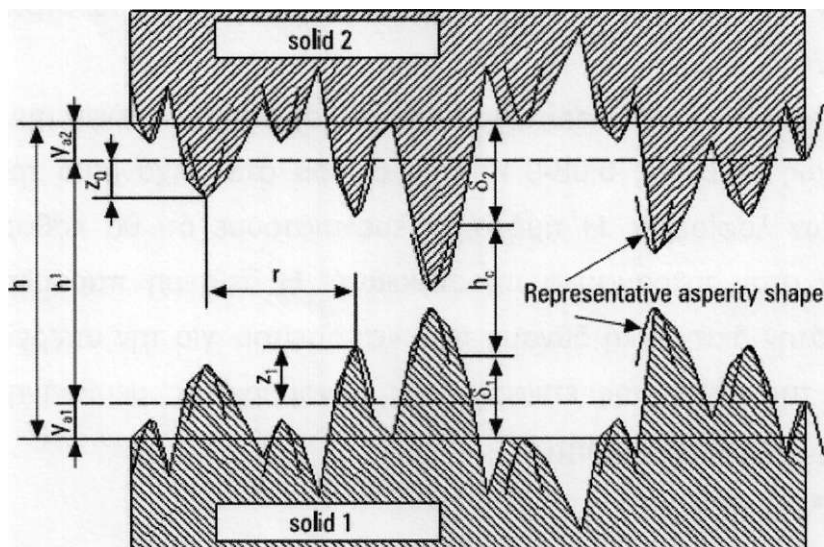
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μ 1.2.8

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$$f_x e'' \quad 1 \quad " \setminus H < 3,5$$

$$f_x^H (H'' - H)^{h''} \quad \sqrt{2} \quad , H'' > H > \quad 3,5$$

$$0, H > H$$

- . * = 4, $d_x = 1.705 \times 10^{-V_2} = 4.05419$, $d_3 = 1.37025$, $\wedge = 8.8123 \times 10^{n5}$
 $J/ = 2.1523$, $y; = 2.1339 \times 10^{n4}$, $/_2 = 3.804467$, $/_3 = 1.341516$, $\wedge = 1.1201 \times 10^{n4}$
 $= 1.9447$

$F_{5/2} \quad F_2 \quad \mu \quad \mu$

$\mu \quad :$

) $d/ \leq 3,5$

) $d/ \leq 4 \quad \geq 3,5$

) $d/ \geq 4$

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1.3.1

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Patir-Cheng

Reynolds

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Patir-Cheng (Gauss)

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10.0 μ μ

μ μ .

1.3.2

.

) -

μ

μ

:

1. $\mu \quad \mu \quad \mu$
 $\mu \quad .$

2. $\mu \quad \mu \quad \mu \quad \mu$
 $\mu \mu \quad .$

$\mu \mu$

$\mu \quad \mu$

$.$

μ

μ

μ

μ

μ

μ

$,$

μ

μ

$\mu\mu$

$,$

μ

$.$

μ

μ

$\mu \mu$

μ

μ

$.$

μ

μ

μ

μ

μ

μ

$.$

μ

μ

μ

μ

μ

$,$

$,$

$,$

μ

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μ

μ

μ

μ

μ

μ

$\mu \mu$

μ

$.$

)

μ

μ

$.$

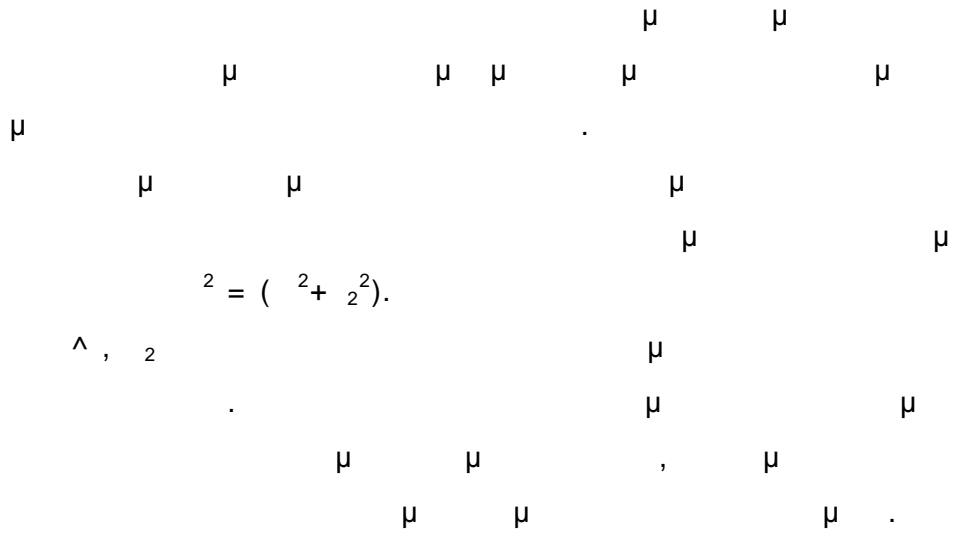
μ

μ

μ

μ

μ



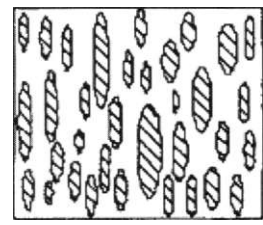
1:
 $= 1,1\mu$
 $= 0,20$
 $/ = 0,05$

2: 10
 $= 0,40\mu$
 $= 0,17$
 $/ = 0,004$

3: 100
 $= 0,30\mu$
 $= 0,30$
 $/ = 0,0028$

$\hat{c}^2 > < >$
cPTi 771 < 7>

->



$\gamma < 1$

$$\mu = \frac{1}{2} \left(\mu_1 + \mu_2 \right) + \frac{1}{2} \left(\mu_1 - \mu_2 \right) \cos \left(\frac{\pi}{2} \right) \quad (5)$$

$$\mu = \frac{1}{2} \left(\mu_1 + \mu_2 \right) + \frac{1}{2} \left(\mu_1 - \mu_2 \right) \cos \left(\frac{\pi}{2} \right)$$

$$\mu = \frac{1}{2} \left(\mu_1 + \mu_2 \right)$$

$$\mu : h_T = h + \dots$$

$$z_2^2 = C_{Jpol}^2 + z_2^2$$

$$h/3 > 1$$

$$y = f(x).$$

$$h + y_{0i} + y_{02} < z_2 - 2f(r/2)$$

$$w = z_2 - 2f(r/2) - (h + y_{0i} + y_{02})$$

1) $w = z_2 - 2f(r/2) - (h + y_{0i} + y_{02})$, [m]

2) \dots , [m]

3) \dots , [m²]

) μ

Reynolds μ

:

$$\frac{d}{dx} \left[\frac{1}{2} \rho U^2 \right] + \frac{d}{dy} \left(\frac{\rho h^3}{12 \mu} \frac{dh}{dy} \right) = \frac{dh}{dx} + 127 \frac{dh}{dt}$$

:

$$\frac{dx}{dy} = \frac{2}{h} \left[\frac{dh}{dx} + 127 \frac{dh}{dt} \right]$$

$$U_j \mu = 1, 2 \quad \dots \quad \mu$$

: μ

, :

μ

μ

$$\dots \quad \mu \quad \mu \quad \mu \quad \dots \quad [Pas]$$

μ

$\mu \quad h_T$

$\mu \quad \mu$

$\mu \quad \mu \quad h \quad \mu \quad \mu$

, :

$$\frac{dp}{dx} + \frac{dp}{dx_j} \frac{dy}{dy}$$

\wedge

:

$$\int_0^{h_j} \frac{1}{2} \rho U^2 dx = \frac{\rho h^3}{12 \mu} \frac{dp}{dx} \frac{dy}{dy} = \frac{Pb - Pa}{Lx}$$

$\mu \quad \mu$

Patir-Cheng

μ

$\mu \quad \mu$

μ

:

$$f(\lambda, r) = \begin{cases} -ce^{-\lambda r}, & r < 1 \\ +cw^r, & r > 1 \end{cases}$$

$$f(\lambda, r) = \dots, \frac{1}{7}$$

$$\dots = \dots ; = \dots, \dots$$

λ, \dots

$\mu \quad \mu \quad \sqrt{5} \quad \sqrt{5} y, \quad \mu$

$\mu \quad \mu \quad \mu \quad \mu \quad \mu$

μ .
 , y μ μ
 . :

: : μ μ μ μ .
 : μ μ μ μ $(R_{xx}(0)=a_x^2)$.
 h μ μ μ :

$$h_T = \int_{\Omega} j(h-S)/\rho_0(S) dS$$

Reynolds

Half Sommerfeld, μ
 μ

μ μ Reynolds .
 μ =1 =1
 $=0$ $h_T = h$ $(u_1-u_2)=u$.
 μ :

$$\frac{d}{dx} \overline{\tau_{xy}} = \overline{\frac{dp}{dx}} = \overline{\frac{dh}{dx}} \cdot \frac{dh}{dt}$$

μ μ μ μ
 μ μ μ
 :
 μ μ μ μ μ μ
 μ « » μ , μ
 μ μ μ , μ μ $f_a=$
 yU (μ : U :) .
 μ μ μ
 μ μ :

$$Fh = \int_s^T h ds$$

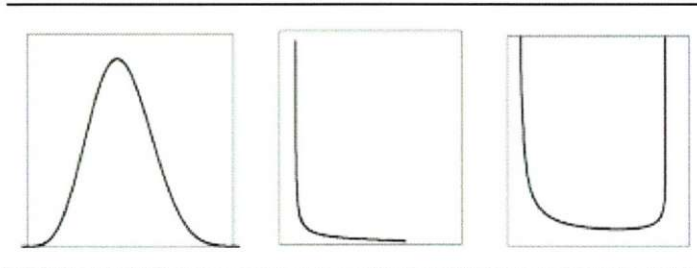
To μ μ :

$$F_{total} = F_a + F_H$$

ΣΤΑΤΙΣΤΙΚΗ ΑΝΑΛΥΣΗ ΤΡΑΧΥΤΗΤΑΣ

ΤΟ ΣΥΣΤΗΜΑ FISHER-PEARSON

Probability curve



»

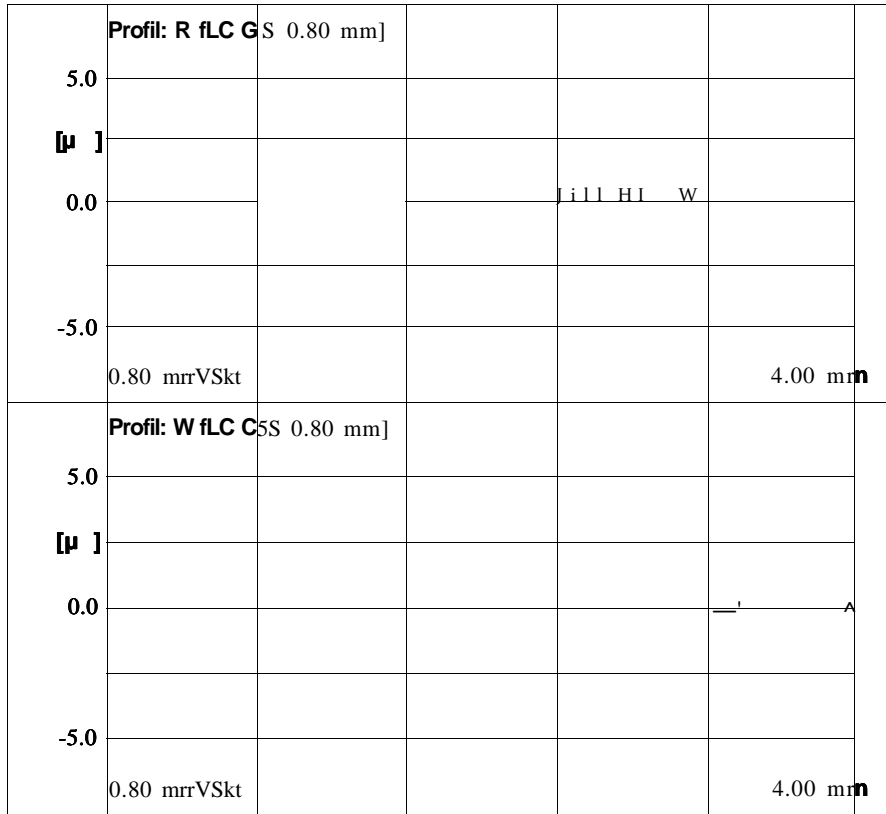
W

2.1.

μ

μ

Fisher-Pearson :



μ 2.1.1 .

μμ

μ

(-roughness)

μ

(-waviness).

μ

,

μ

μ

μ

μ

μ

μ

μ

μ

μ

μ

μ

μ

μ

(points-peaks-randii)T^

μ

Fisher-Pearson

μ

Pearson,

μ

μ

μ

μμ

μ

μ

μ

μ

μ (μ μ , μ μ).
 μ μ μ μ μ k
 μ μ
 :

$k < 0$	μ μ μ		
$0 < k < 1$	μ μ		$-\infty$ $+\infty$
$1 < k$	μ μ μ (μ)	$l >$ ∞	a $+\infty$ -

μ «skewness» ($\mu\mu$ - $\mu\mu$) μ μ Fisher. μ
 k

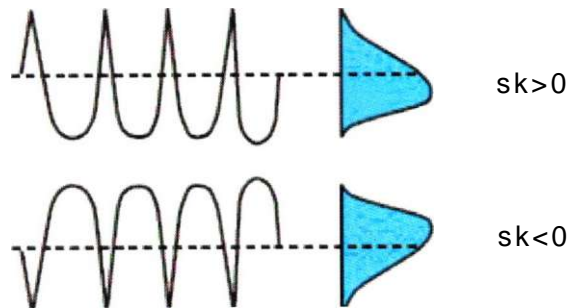
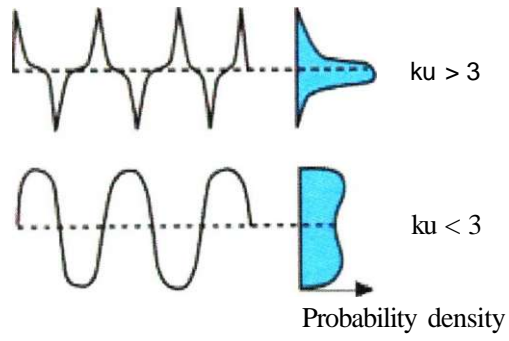
μ k :

$$\hat{\mu} = \frac{(\mu_2 + 3)^2}{4(4 - 2 - 3 - 1)(2 - 2 - 3 - 1 - 6)}$$

1. Pearson Fischer- μ

$P_j = Y_j^2$, $= \mu^2 + 3\sigma^2$ («kurtosis») μ μ

Fisher.



2. μ

μ μ , μ μ
 $, > 0$:

,, , q_1, q_2 :

$$.ndr - \wedge - P . - \gg$$

$$3, -2 \quad 2 + 6$$

() :

$$a_1 = \frac{w q_1}{Q_2} \quad a_2 = w - a_1 \quad \text{and } w = 2f[s^2(\lambda - k)(l + r)]$$

f_0

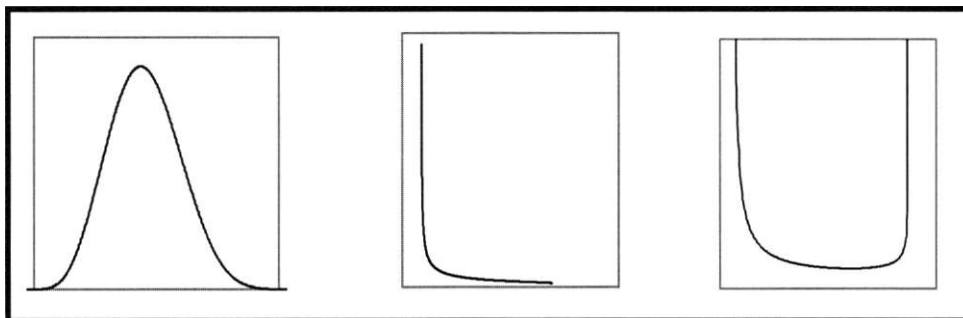
$$f_0 = \int_{a_1}^{a_2} J(x - a_1)^{(q_1 - 1)} (a_2 - x)^{(q_2 - 1)} dx$$

, < 0 = - and = -

$$f = M(x - a_1)^{\mu} (a_2 - x)^{\mu - 1}$$

μ μ

μ (« » « »), L/J U .



μ μ (> 1) μ 0 μ
 μ μ $(0 < \mu < 1)$
 $\mu\mu$ μ $2, 3, 4$

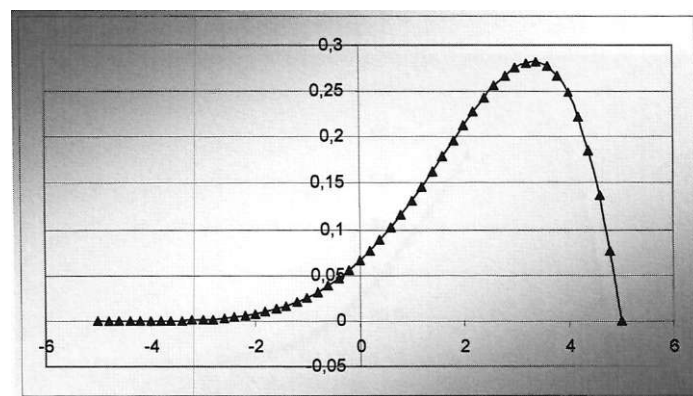
$$2 = (j - x_m)^{2/(n-1)} = (2 - ()^2) / ((- 1))$$

$$3 = (n / ((n-1)(-2)) (-)^2 = (2^3 - 3 \cdot 2^2 + 2()^3) / ((- 1)(- 2))$$

$$4 = (+ 1) (- 1) 4 - 3(- 1) [(-)^2]^2 / ((- 1)(- 2)(- 3)) =$$

$$= (2(+ 1) 4 - 4(+ 1) 3 - 3(- 1)(2)^2 + 12 2()^2 -$$

$$6()^4) / ((- 1)(n-2)(n-3))$$



$()$ $\mu\mu$ μ < 0 ,
 μ

() $\mu \mu \mu = 0$, μ
 μ μ
 .

		-		-	
-3	-4	-2		2	4

() $\mu \mu \mu > 0$.

μ 2.1.2 μ μ Fisher-Pearson μ .

μ μ μ μ 2
 μ :

$$g_1 = k_2 / \sqrt{k_2}^3 \quad g_2 = K_4 / K_2^2.$$

Pearson :

$$b_1 = g_1^2 \quad b_2 = g_2 + 3$$

$\mu\mu$ μ
 μ μ μ
 2 , μ μ
 $m - a \dots m + a$ μ μ
 μ (

μ μ μ :
 $a = \sqrt{(2b_2 \cdot s^2) / (3 - b_2)}$ ($s^2 = k_2$) μ :
 $f = f_0 [1 - (x - x_m)^2 / a^2]^q$ $q = (5b_2 - 9) / (2(3 - b_2))$.

μ μ μ
:
 $f = f_0 / [1 + (x - x_m)^2 / a^2]^q$
 $= \sqrt{(2b_2 \cdot s^2) / (b_2 - 3)}$ $q = (5b_2 - 9) / (2(b_2 - 3))$.

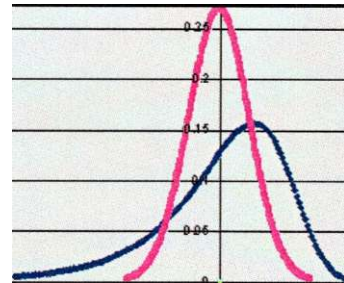
$\mu\mu$ μ μ μ (.
 μ) :

$$f = f_0 (\cos \theta)^2 q e^{\theta}$$

$\tan \theta = (X - c) / a$ $r = 6(b_2 - b_1 - 1) / (2b_2 - 3b_1 - 6)$
 $q = 1 + r / 2$, $p = r \sqrt{k} / (1 - k)$, $a = \sqrt{s^2 (r - 1) (1 - k)}$, $c = x_m - pa / r$.

μ μ μ ^

μ



0

2.1.3

μ : μ F-P

, μ

« »

, $0 < < 1$.

μ μ μ

:

$$f = f_0(x-a)^{q_1} / (x-a+c)^{q_2+1}$$

μ
 μ

μ

μ

< 0
 μ

μ

μ

μ

μ

.

2.2 Fisher- Pearson

_____ : $v=160\text{m/min}$, $s=0.08\text{mm/rev}$ ()

_____ μ : mean=0 std.dev=0.511 skewness=-0.0093

kurtosis=2.69 $b_1 = \text{skewness}^2 = 8.65 \times 10^{-5}$ $b_2 = \text{kurtosis} = 2.69$

$$k = \frac{b_1(b_2+3)^2}{4(4b_2 - 3b_1)(2b_2 - 3b_1 - 6)} = -0.000i = \frac{2 - \Delta}{3b_1 - 2b_2 + 6} = 16J4?$$

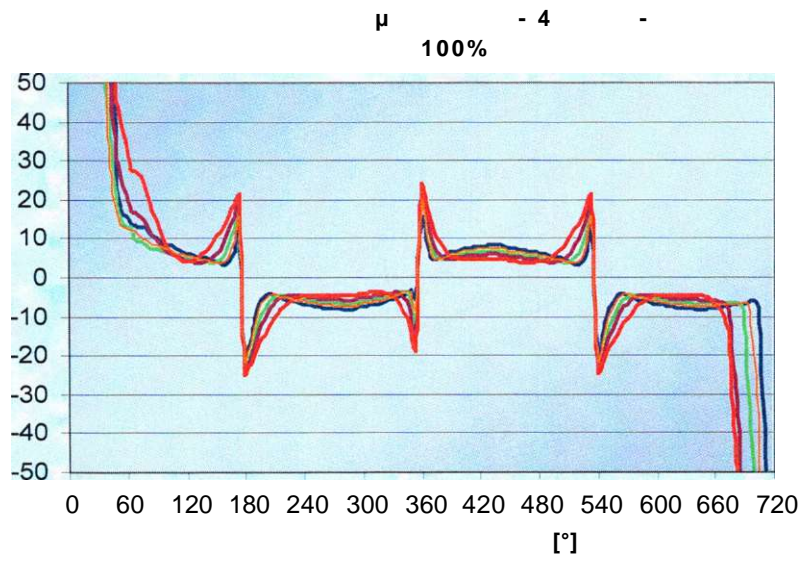
$$q_1 = \frac{1 - \sqrt{1 - (-k)}}{1 - k} = 8.089$$

Microsoft. rand() μμ excel μ
μ μ 0 1 μ μ
μ , μ μ
μ μ 2,5 μ 5 μ
μ μ excel

fortran.

μ μ μ honing
μ μμ PPR(points-pics-radii)
μ μ -(
) μ
" μ " μ - μ
μ μ μ μ .

ΑΠΟΤΕΛΕΣΜΑΤΑ



3.1

μ : μ μ μ μ μ μ μ μ μ μ
 1) , μ 2000-6000 rpm
 (2000,3000,4000,5000,5500,6000 rpm)

2) μ μ μ
 .
 1 : '=0,20 '/ =0,05 =1,1 μ '=0,95 μ
 σ_0 = 0,40 μ
 2 : '= 0,17 '/ = 0,004 =0,82 μ '= 0,40 μ
 σ_0 = 0,17 μ
 3 : '=0,30 '/ = 0,0028 = 0,55 μ '= 0,30 μ
 σ_0 = 0,14 μ

μ
 μ μ μ μ μ μ μ
 μ μ - :
 μ μ : 88mm
 (μ) : 1,75mm (1° 2°)
 2*0,25 (3°)
 : 200000 Pa (1° 2°)
 700000 Pa (3°)
 μ μ : 84mm

: 136mm

: 511cm³

μ : 2044 cm³ 2,00Lt

- 1 μ : μ : 15mm
- 2 μ : μ : 10 μ

μ : =7,39 mPas (ELF 15W40 120°C)

μ μ $\mu\mu$ μ μ

$\mu\mu$ μ

μ μ μ + μ μ

, - $\mu\mu$

4,

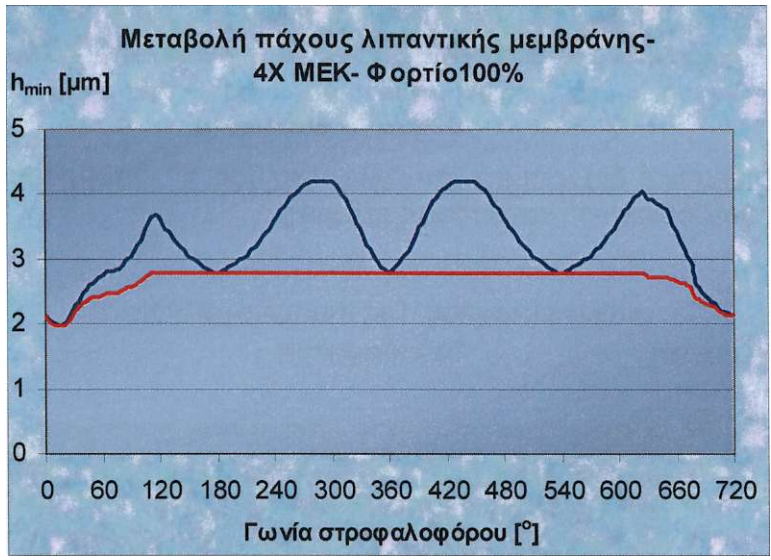
μ , μ μ μ μ ,

$\mu\mu$ μ μ μ μ ,

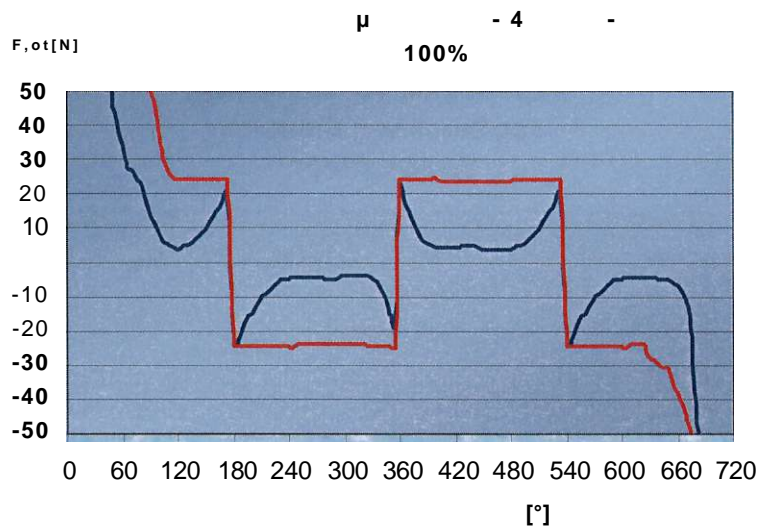
.

3.2

μ μ μ
 μ μ μ
 2000 -100% * μ μ
 μ μ

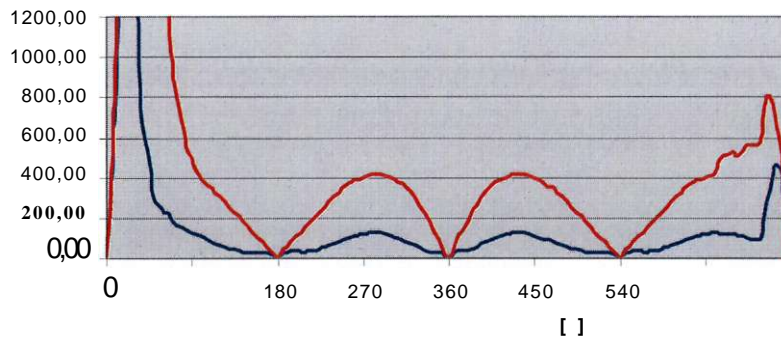


μ 3.1 . $\mu\mu$ μ μ -
 μ $\mu /$ 2000rpm-
 1



μ 3.2 $\mu\mu$ μ -
 2000rpm-1ⁿ

1,1 ,4000rpm, [w]



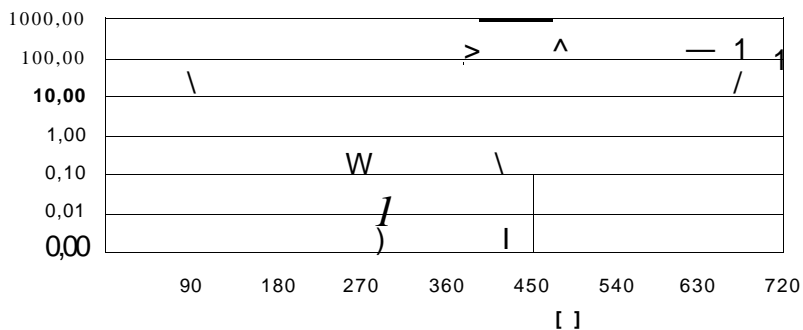
μ 3.3

4000 -1

μμ

1

1,1 ,2000rpm, [w]



μ 3.4

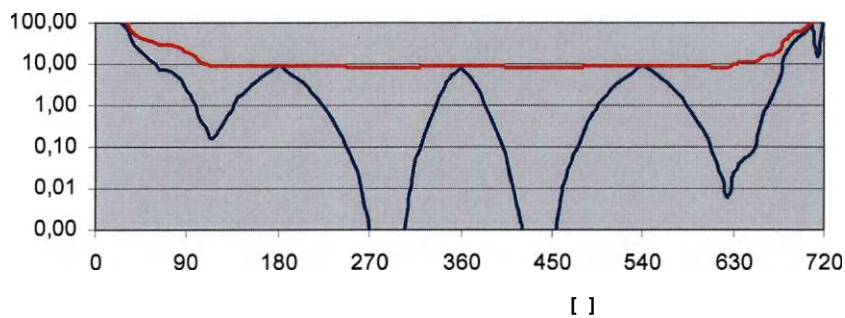
2000rpm-1ⁿ

μμ

1

(μ μ μ).

1,1 ,2000rpm, Fh [μ]



μ 3.5

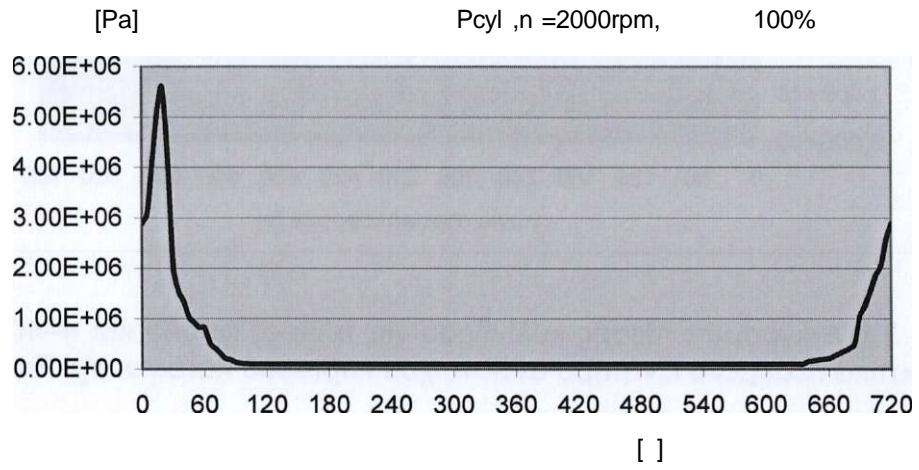
μμ μ
2000rpm-1ⁿ

1

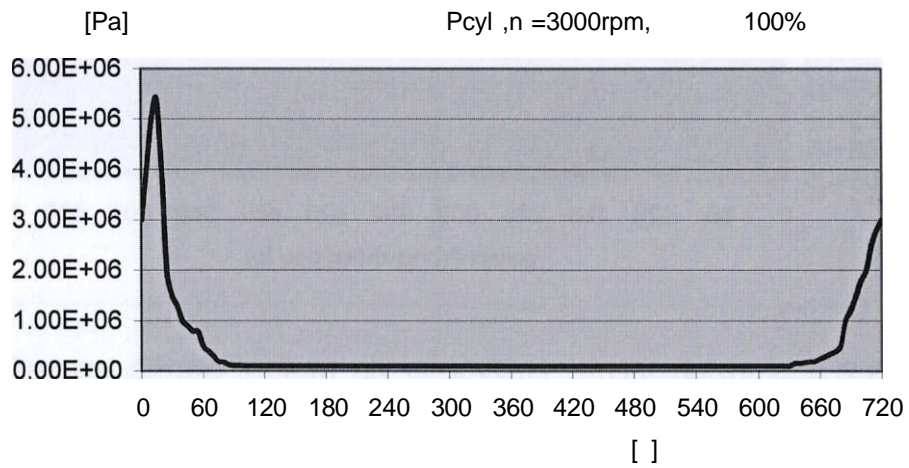
μ).

(μ μ)

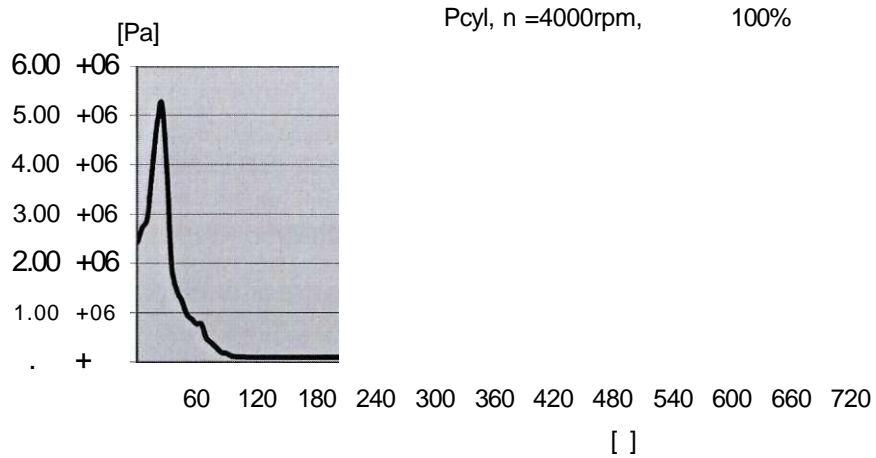
μ Renault μ μ μ μ (μ



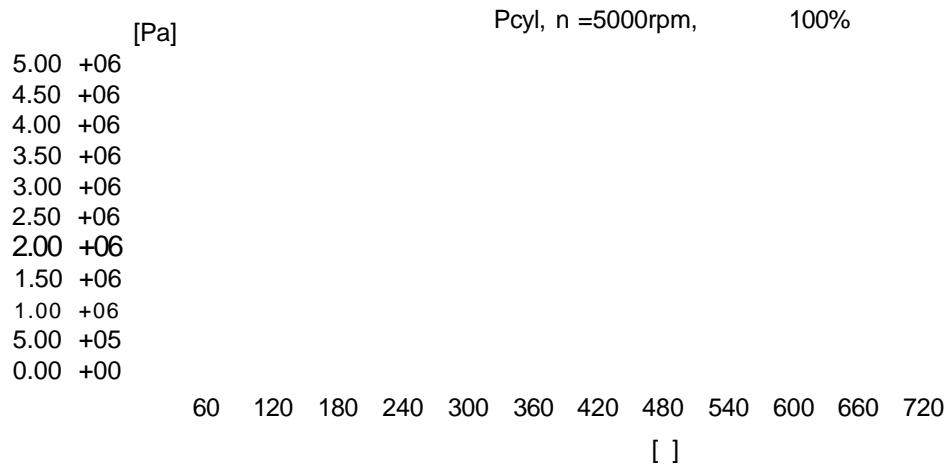
μ 3.6 μ μ n=2000 rpm. Renault.



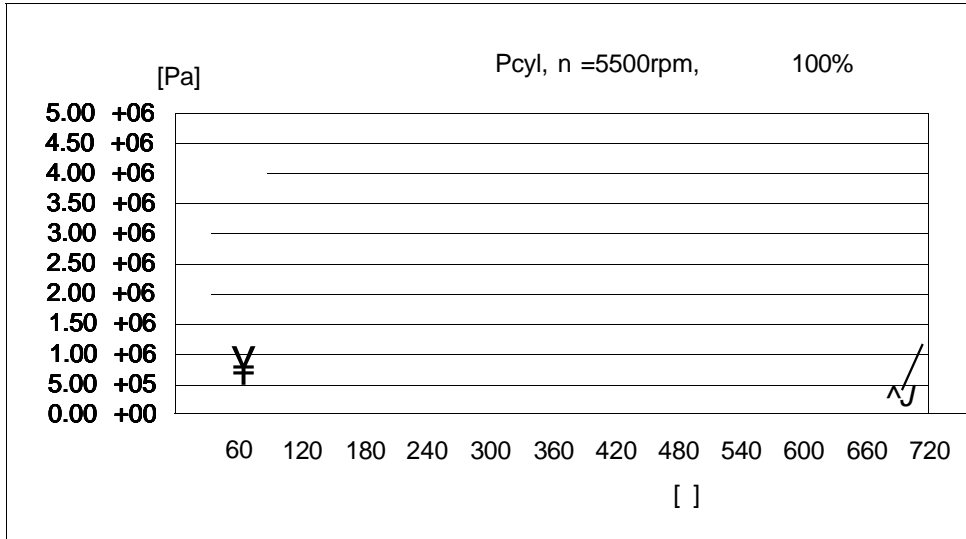
μ 3.7 μ μ n=3000 rpm. Renault



μ 3.8 $\mu\mu$ μ n=4000 rpm.
 μ μ Renault



μ 3.9 $\mu\mu$ μ n=5000 rpm.
 μ μ Renault

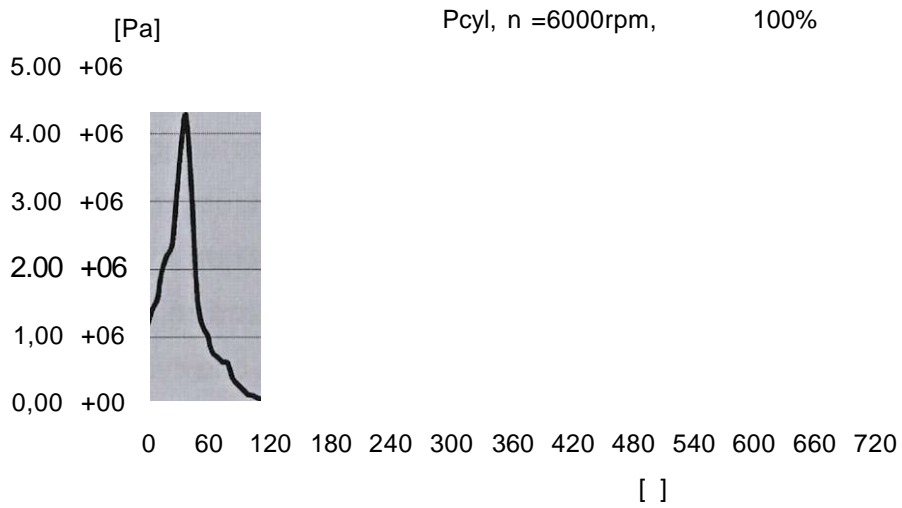


μ 3.10
 μ

$\mu\mu$
 μ

μ

n=5500 rpm.
Renault



μ 3.11
 μ

$\mu\mu$
 μ

μ

n=6000 rpm.
Renault

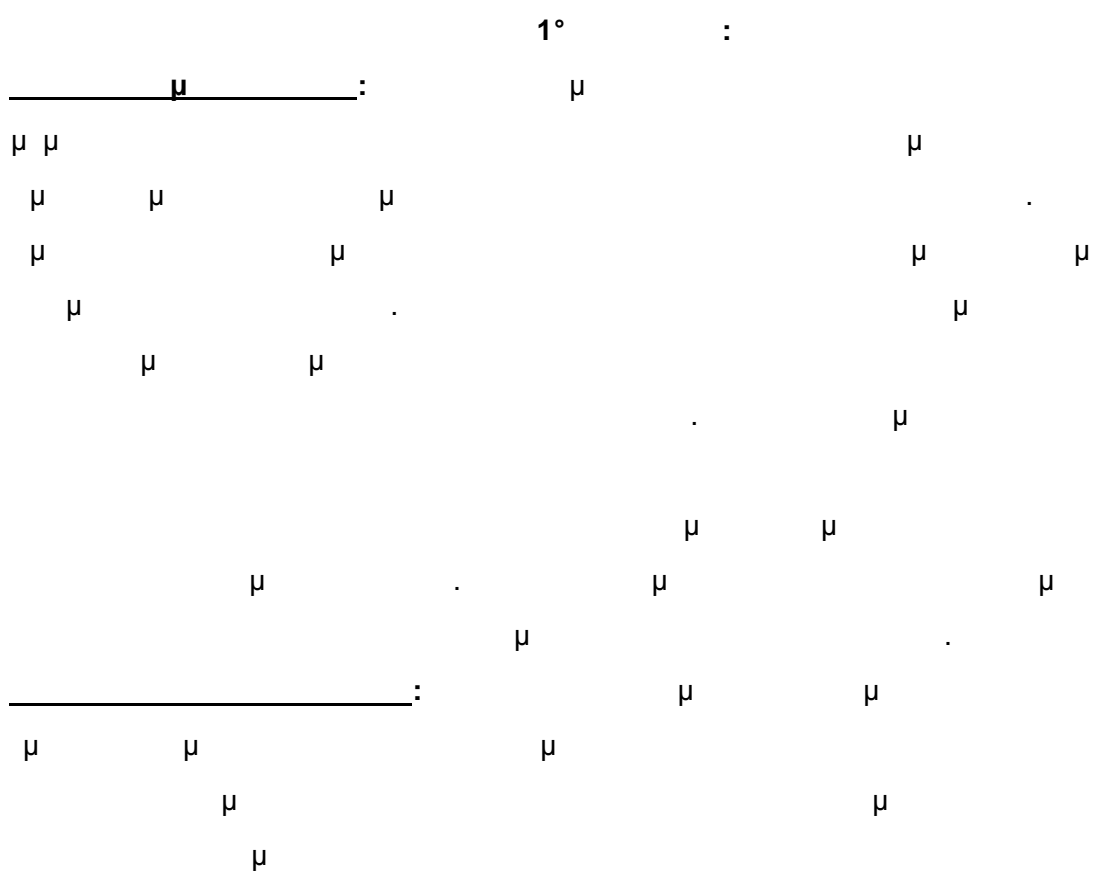
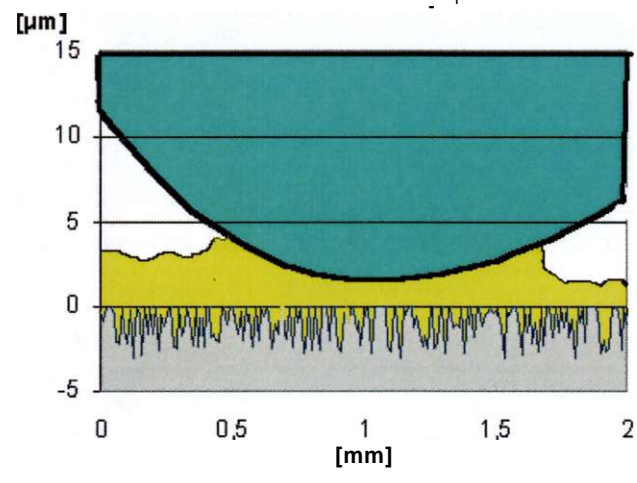
μ

μ

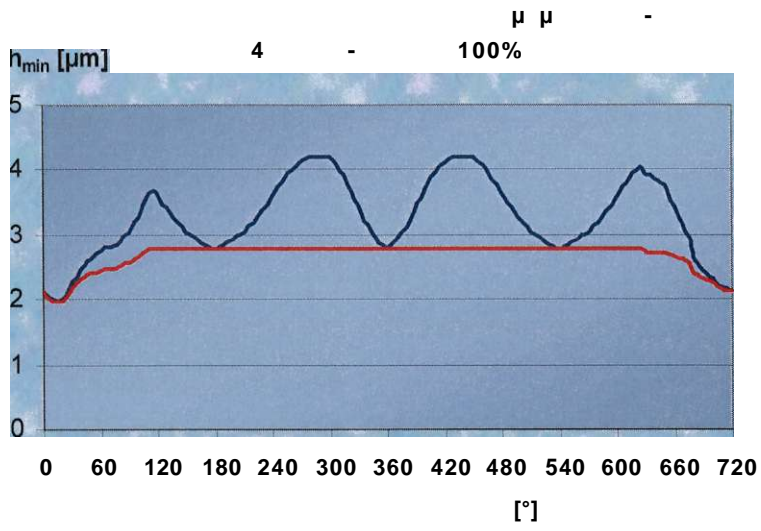
1°,2°

3°

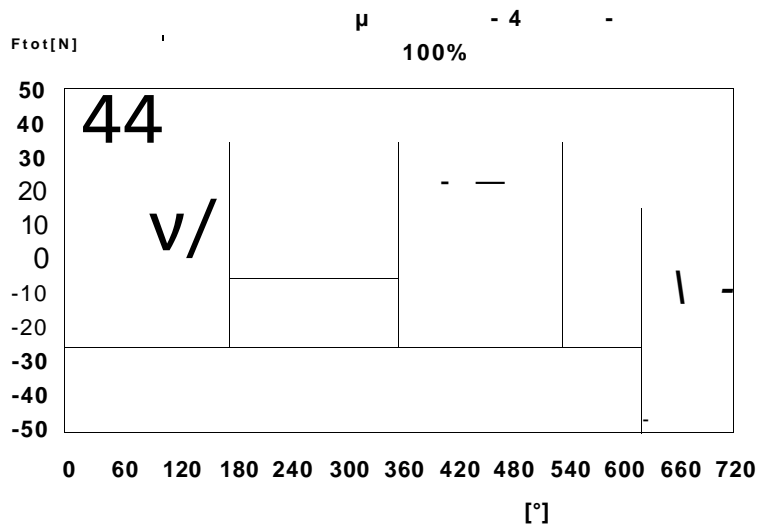
1ος ΔΑΚΤΥΛΙΟΣ - 2000 rpm - ΠΛΗΡΕΣ ΦΟΡΤΙΟ



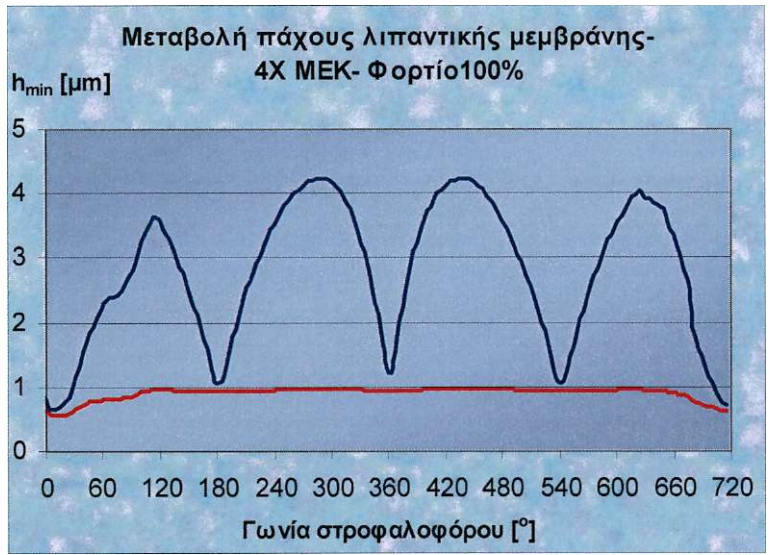
2000 -100% * μ μ



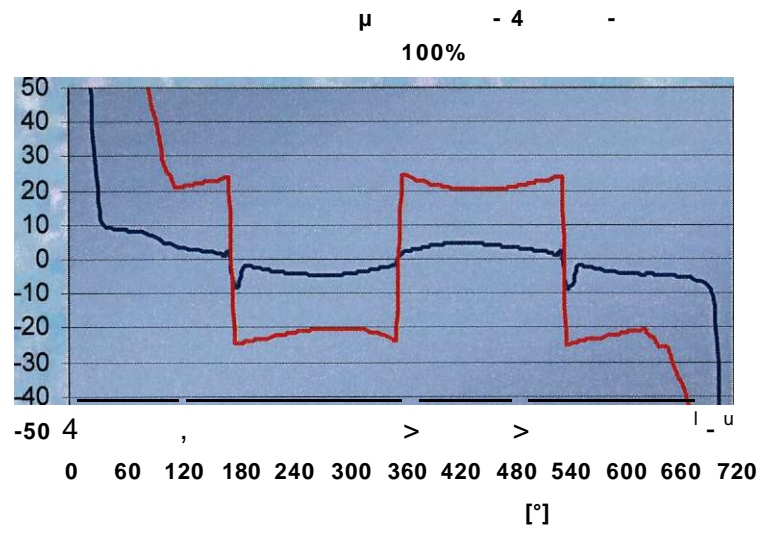
μ 3.12 μ μ -
μ 2000rpm-
1



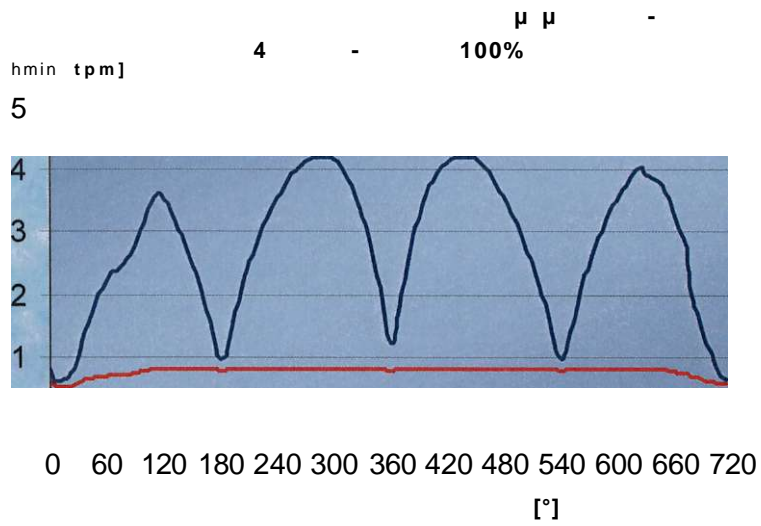
μ 3.13 μ μ -
1 2000rpm-



2 μ 3.14 $\mu\mu$ μ μ μ - 2000rpm-

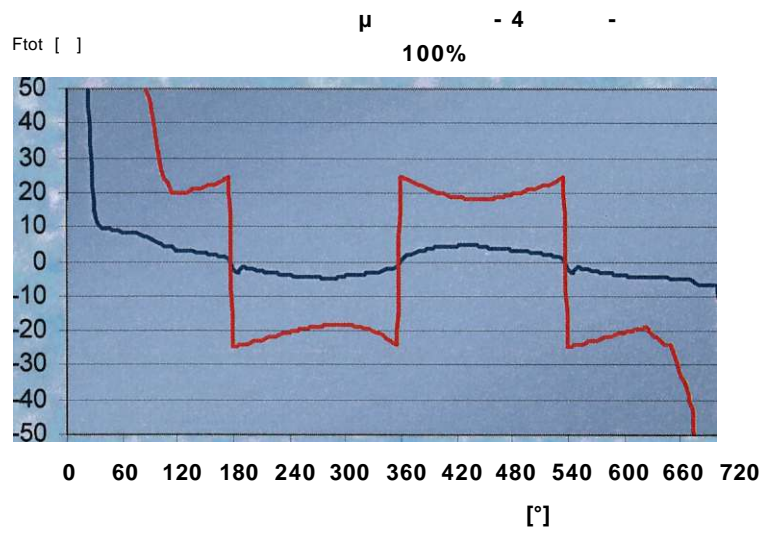


2 μ 3.15 $\mu\mu$ μ - 2000rpm-



μ 3.16 μ μ -
μ 2000rpm-

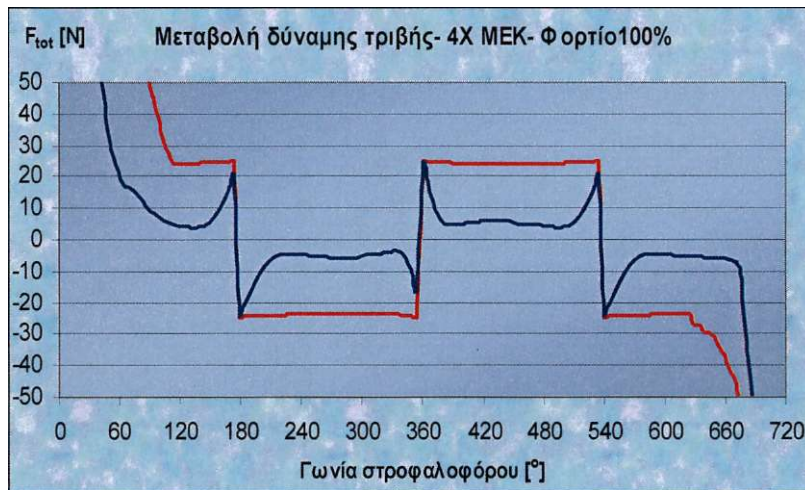
3



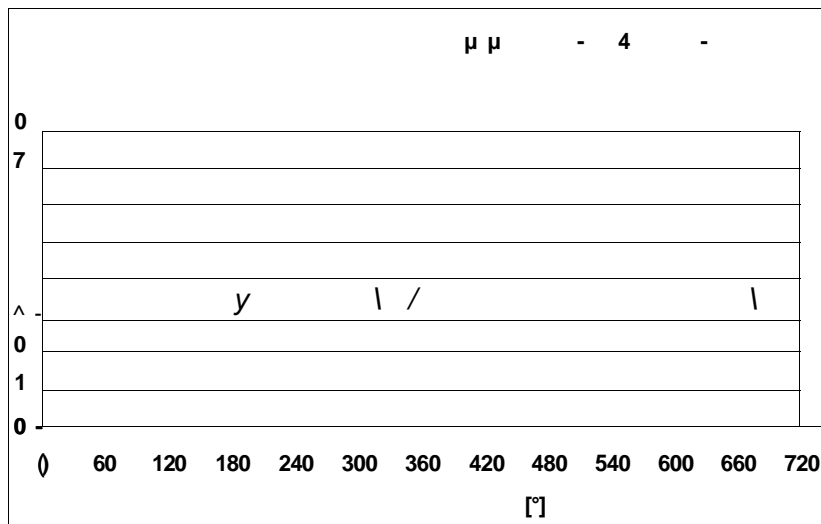
μ 3.17 μ μ -
μ 2000rpm-

3

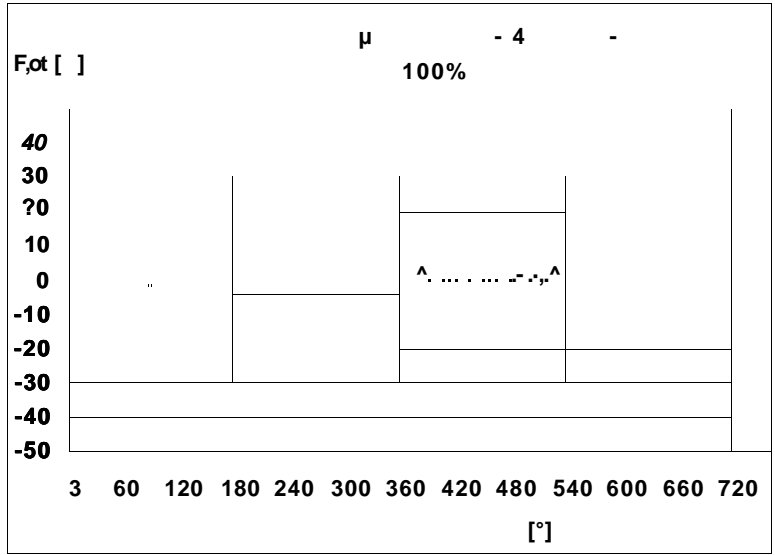
1ος ΔΑΚΤΥΛΙΟΣ - 3000 rpm - ΠΛΗΡΕΣ ΦΟΡΤΙΟ



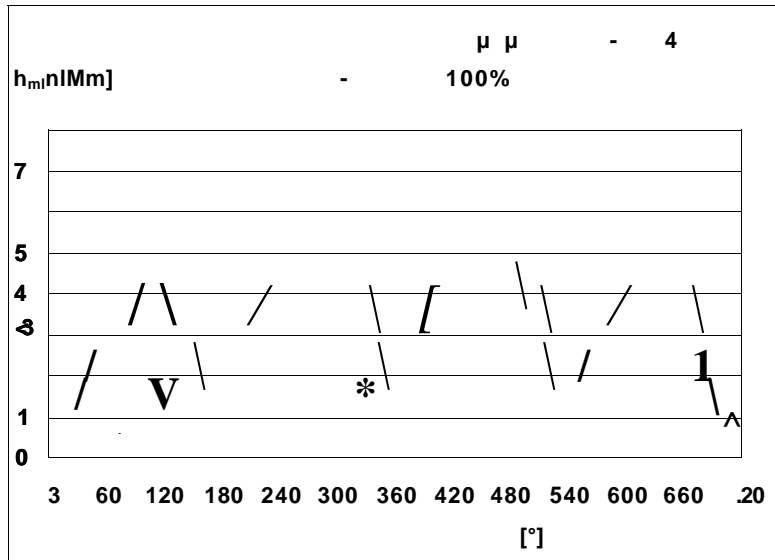
μ 3.18 (μ) - μ (μ μ).



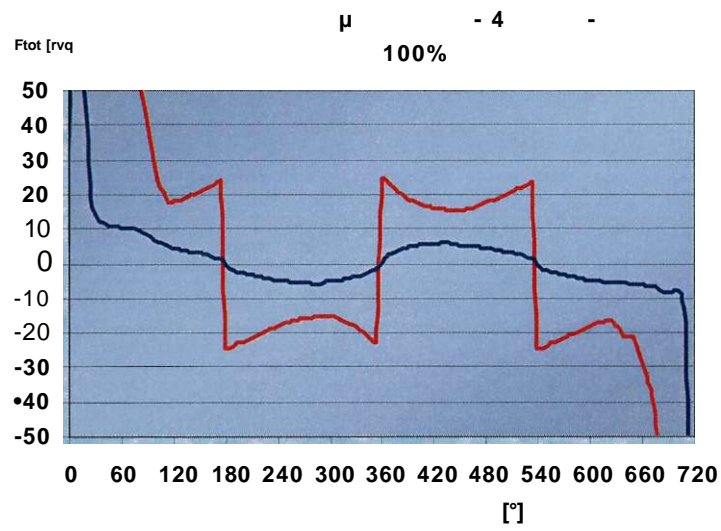
μ μ 3.19 (μ μ) - μ (μ μ).



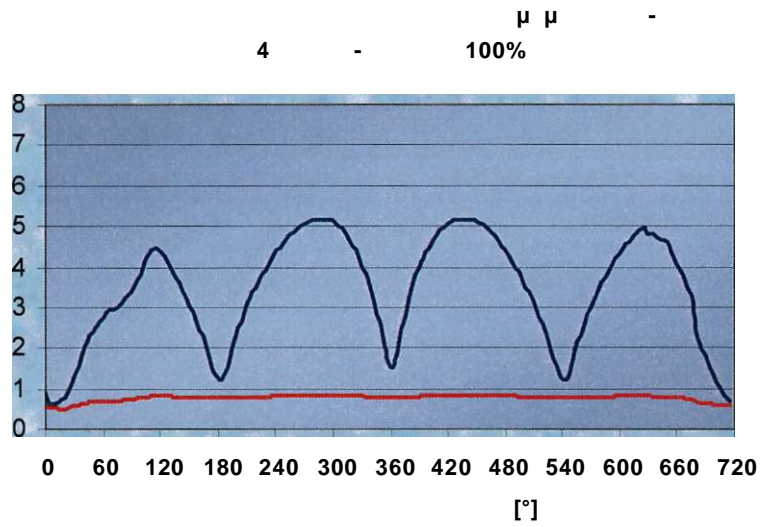
μ 3.20 (μ) - μ (μ μ). μ



μ 3.21 μ (μ μ) - μ (μ μ). μ

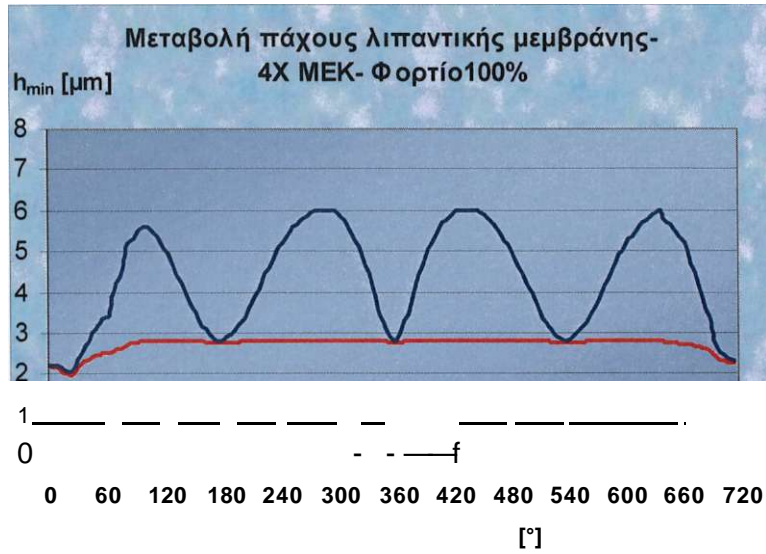


μ 3.22 (μ) - μ (μ μ). μ

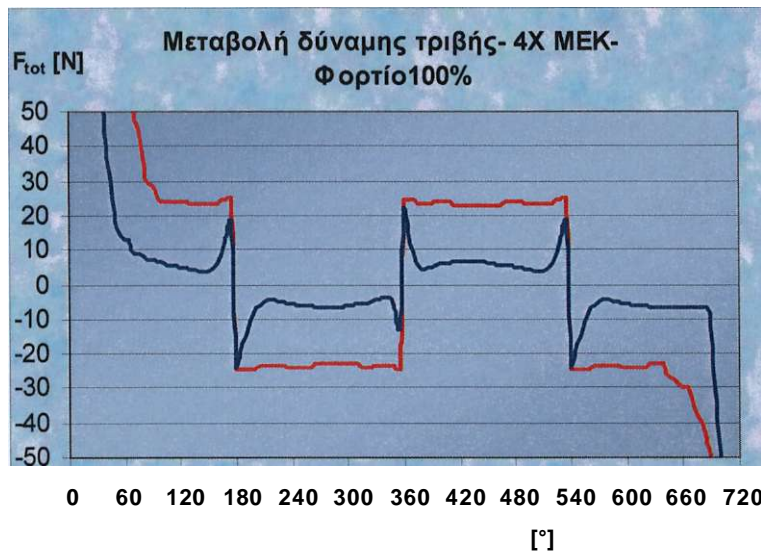


μ μ 3.23 (μ) - μ (μ). μ

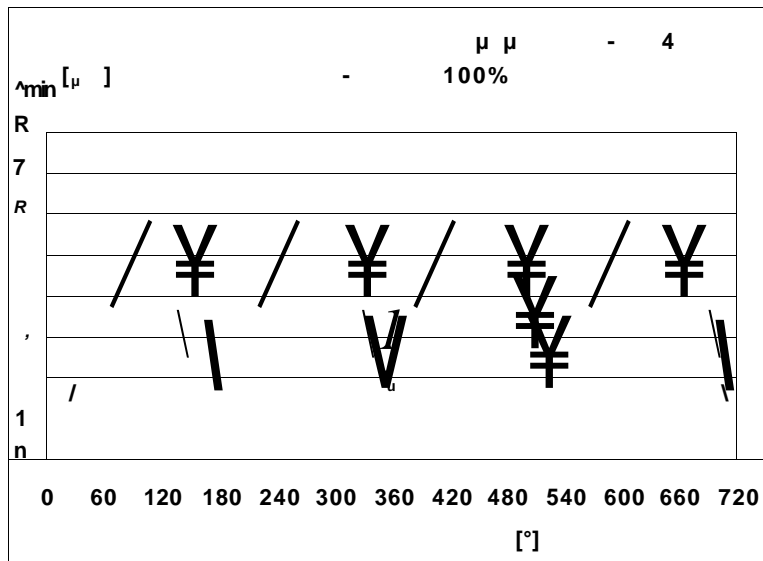
$mMMmrn - \gg DUU^{\wedge} wmw^{\wedge} Q^{\wedge} tlqj$



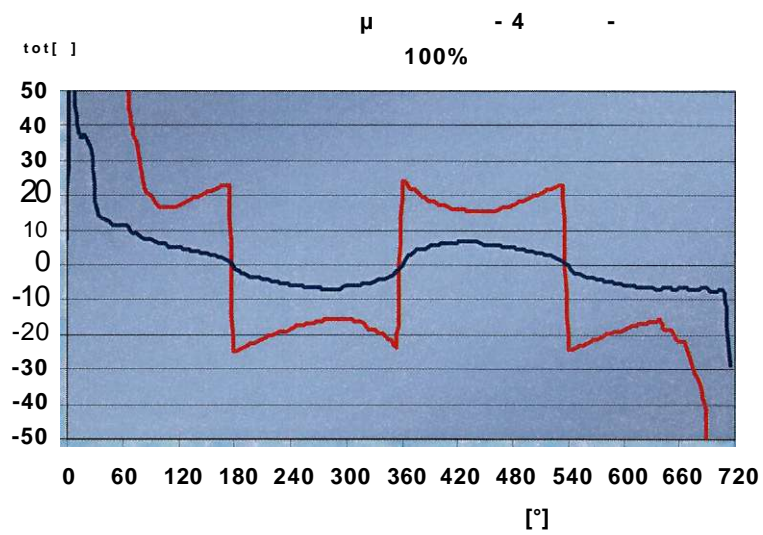
μ 3.24 (μ) - μ (μ).



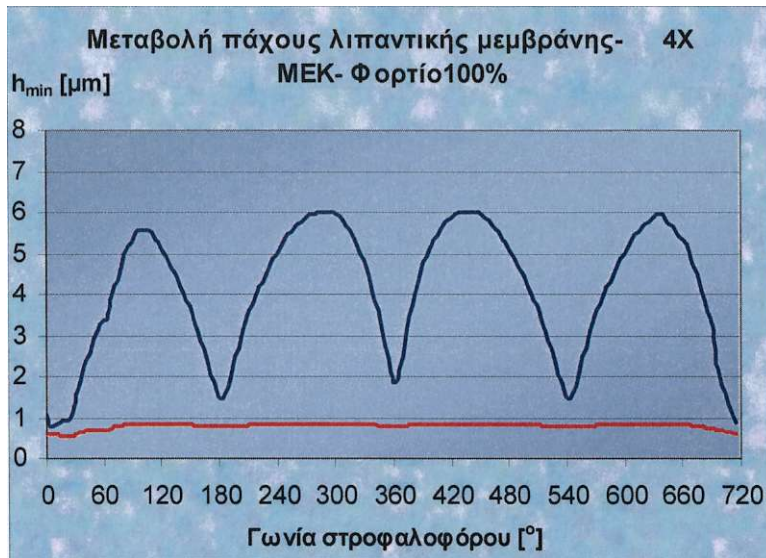
μ 3.25 (μ) - μ (μ) μ .



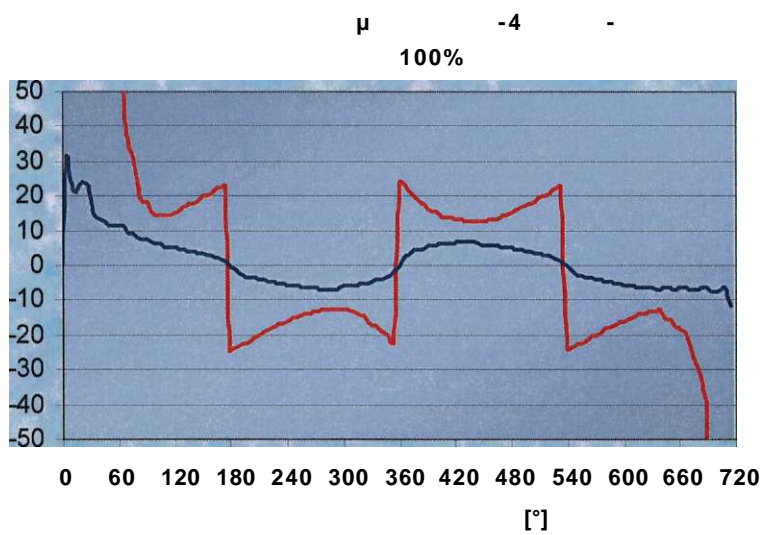
μ 3.26 μ
 $\mu \mu$ ($\mu \mu$) - μ (μ)
 μ).



μ 3.27 μ
 (μ) - μ ($\mu \mu$)

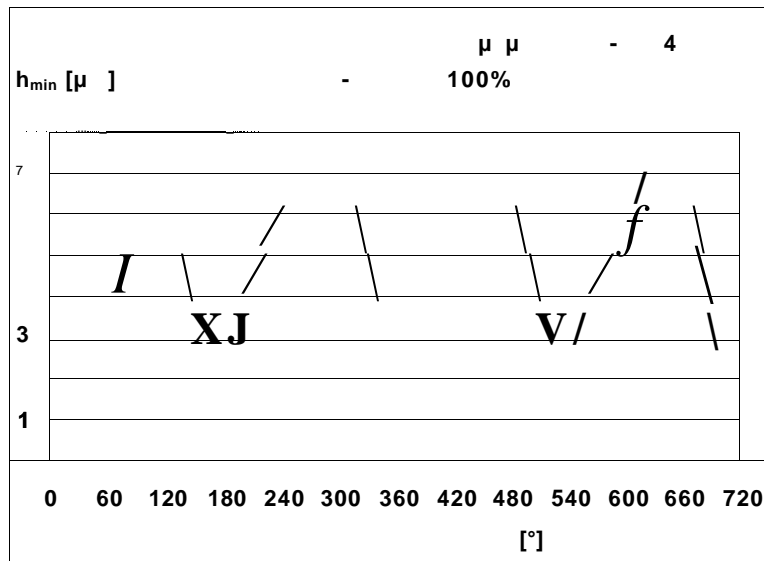


μ μ 3.28 (μ) - μ (μ).

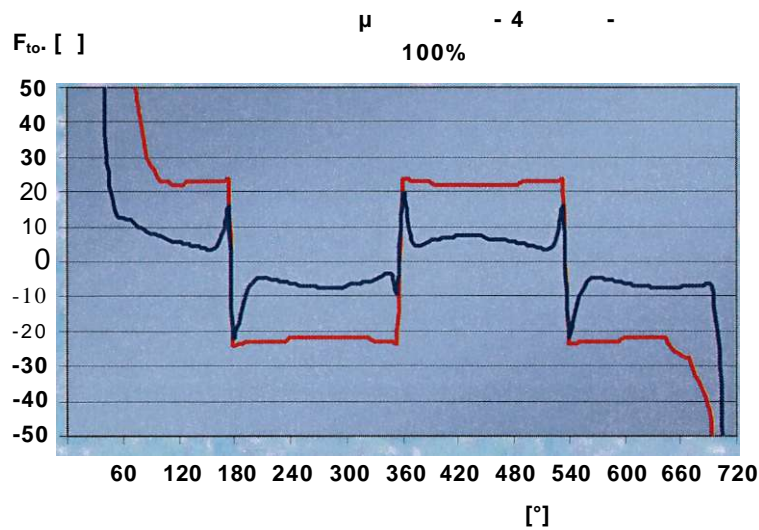


μ 3.29 (μ) - μ (μ). μ

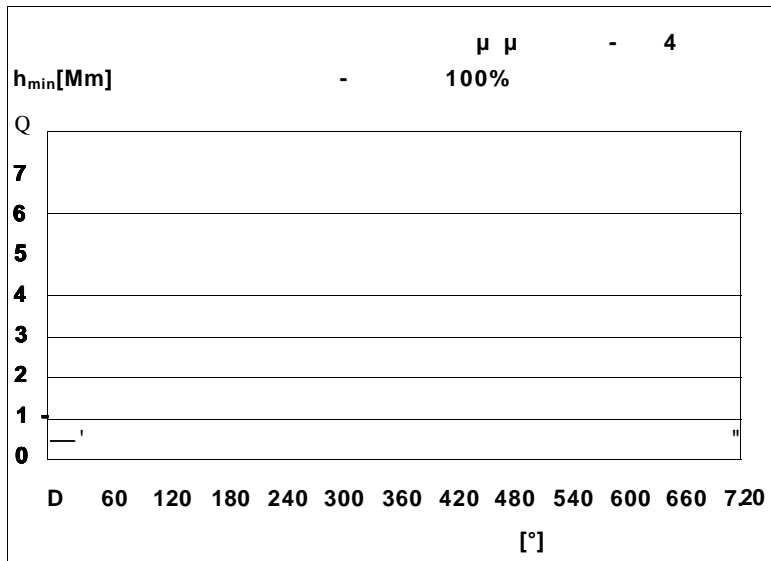
1ος ΔΑΚΤΥΛΙΟΣ - 5000 rpm- ΠΛΗΡΕΣ ΦΟΡΤΙΟ



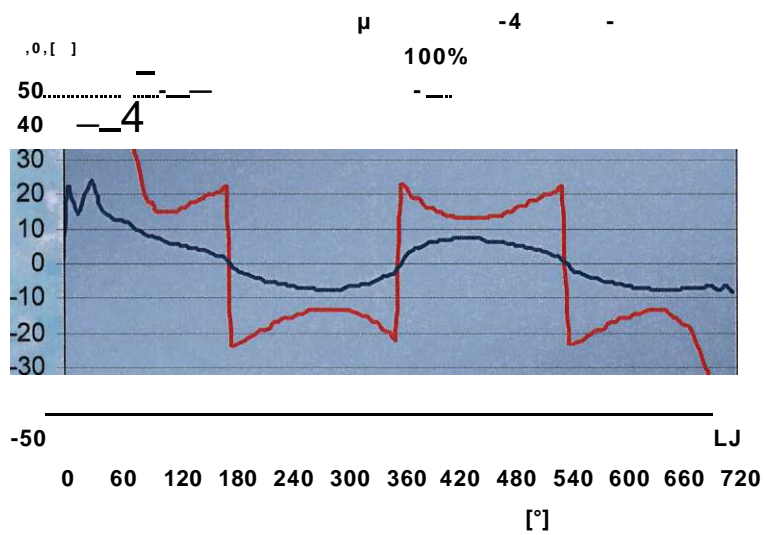
$\mu \mu$ 3.30 ($\mu \mu$) - μ (μ).



μ 3.31 ($\mu \mu$) - μ ($\mu \mu$) μ

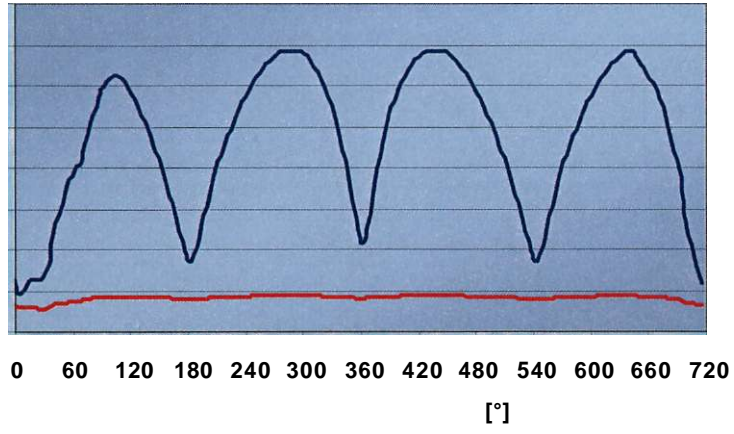


μ 3.32 μ (μ) - μ (μ)

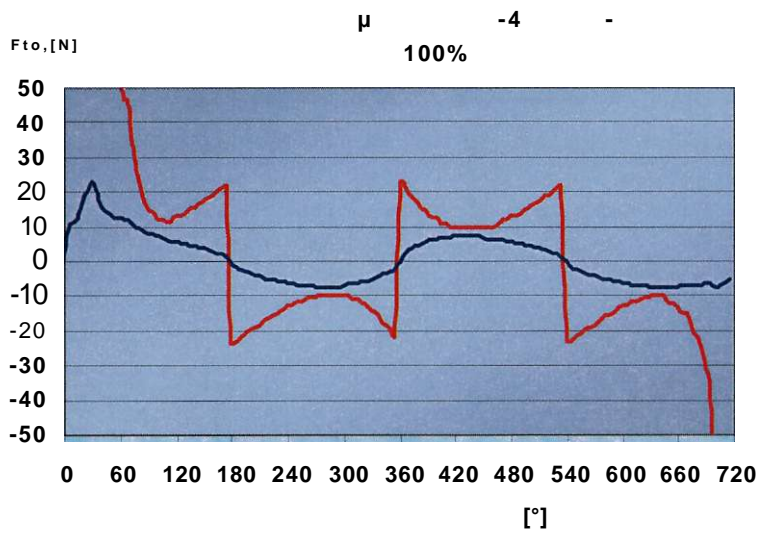


μ 3.33 (μ) - μ (μ) μ

- μ μ - 4
100%

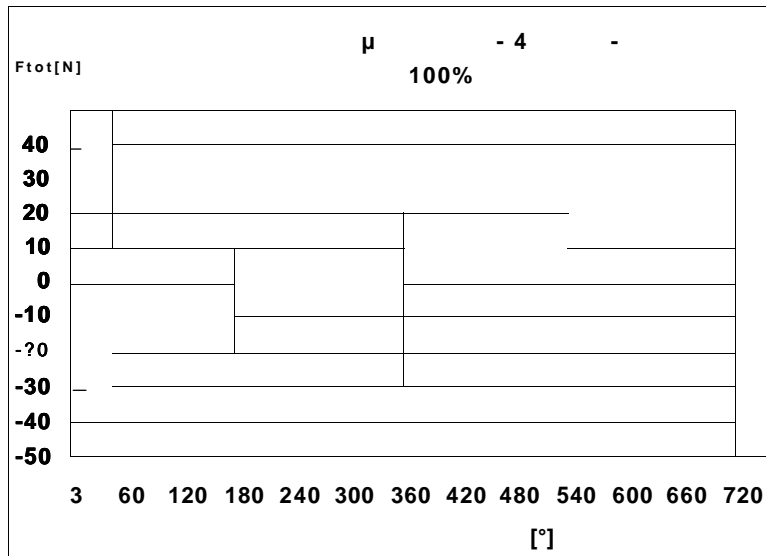


μ μ 3.34 (μ) - μ (μ).

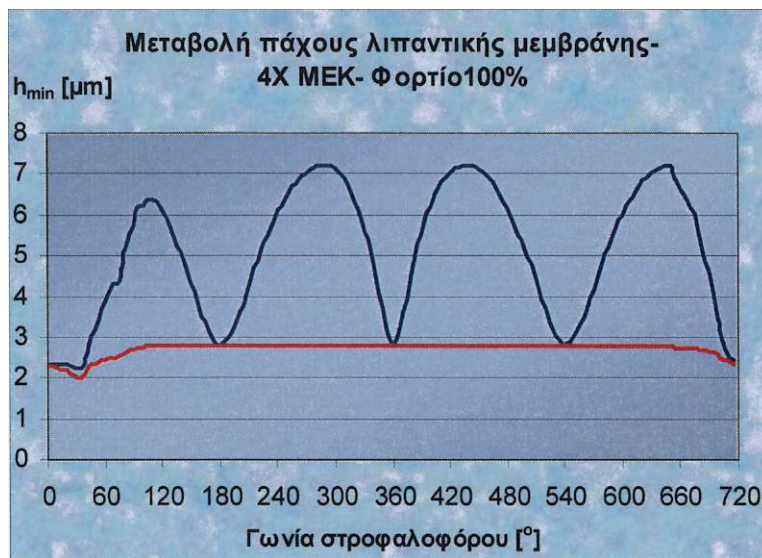


μ 3.35 (μ) - μ (μ) μ

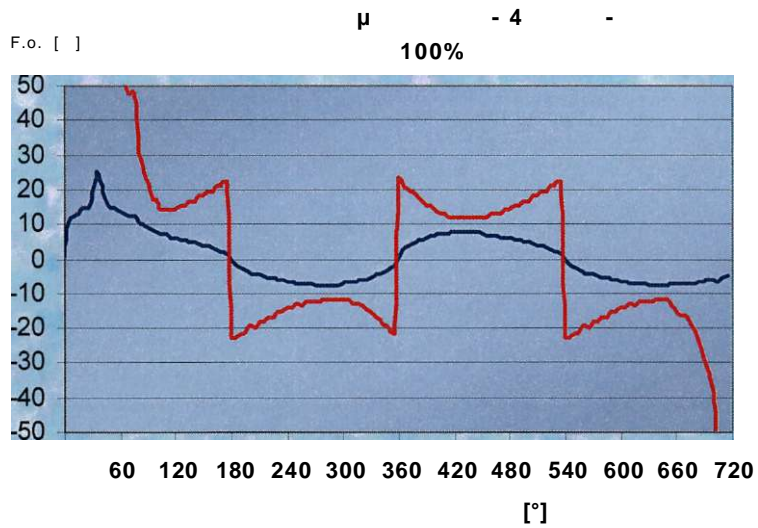
1ος ΔΑΚΤΥΛΙΟΣ - 5500 rpm - ΠΛΗΡΕΣ ΦΟΡΤΙΟ



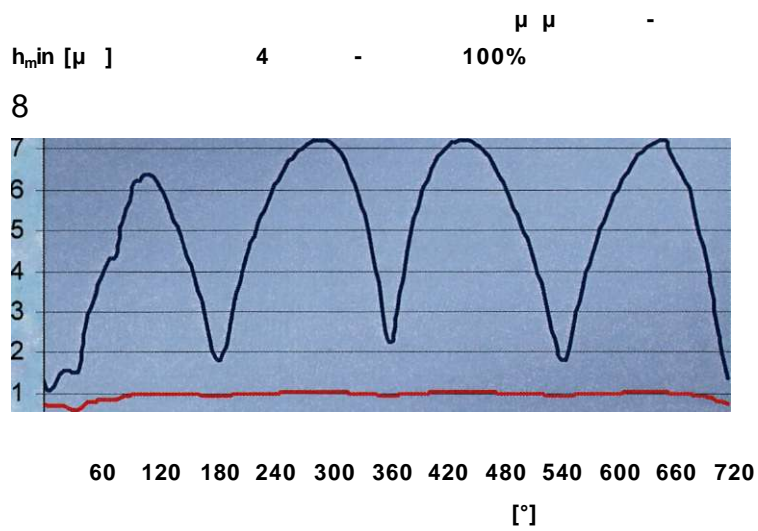
μ 3.36 (μ) - μ (μ μ). μ



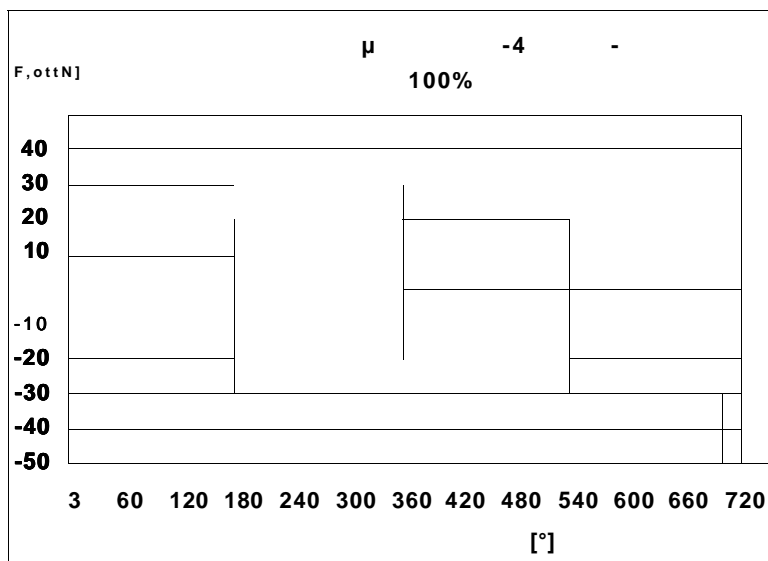
μ μ 3.37 (μ μ) - μ (μ).



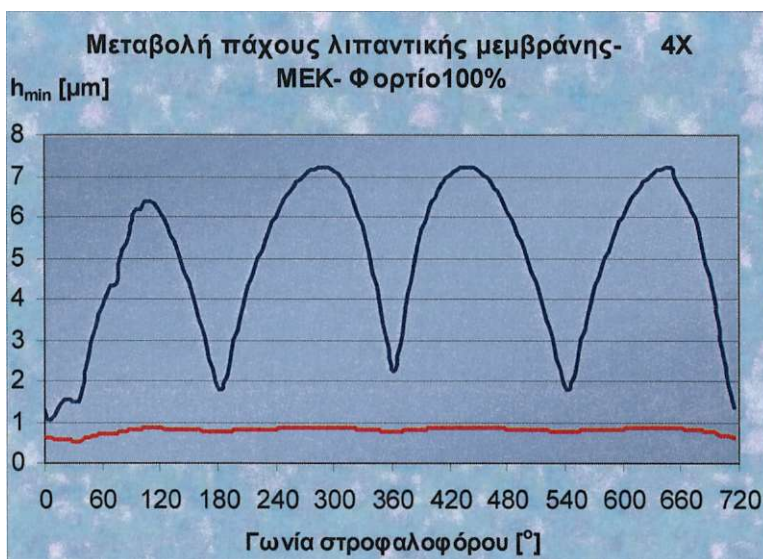
μ 3.38 (μ) - μ (μ μ).



μ 3.39 μ (μ μ) - μ (μ μ).



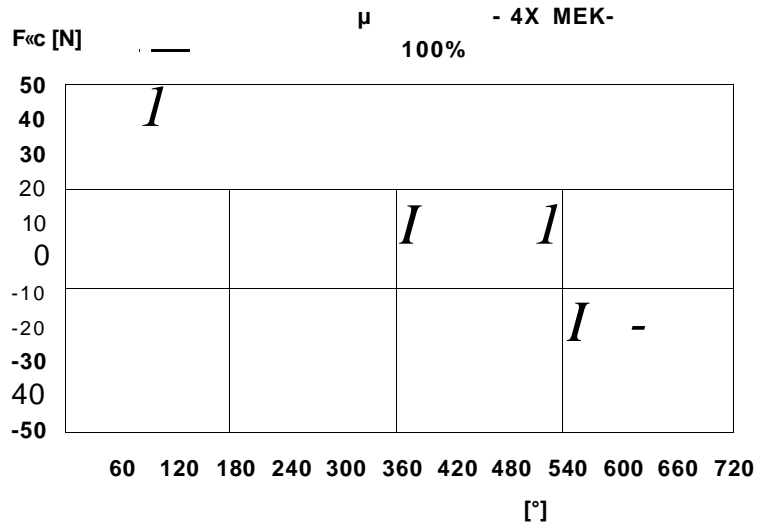
μ 3.40 (μ) - μ (μ μ).



μ 3.41 (μ) - μ (μ).

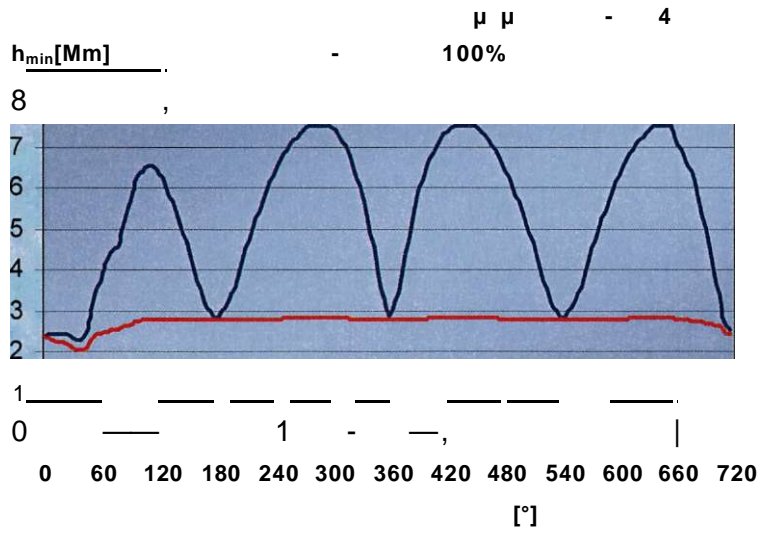
m

$u_{ir}^1 m \setminus$



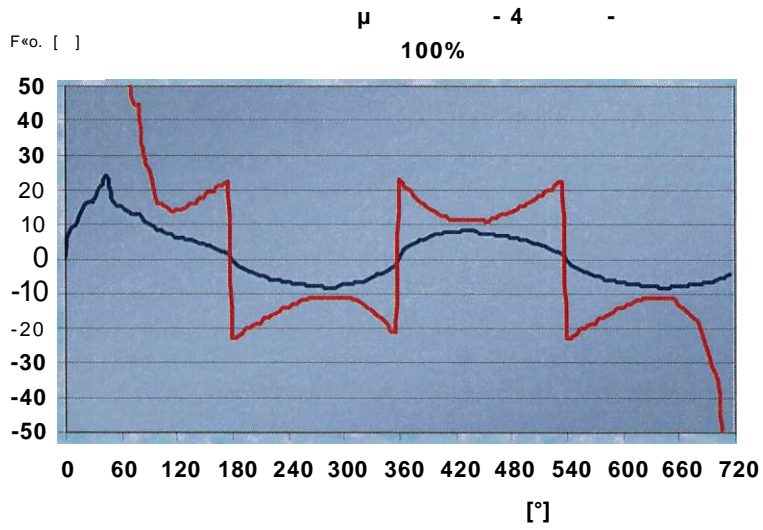
μ 3.42

(μ) - μ (μ μ). μ

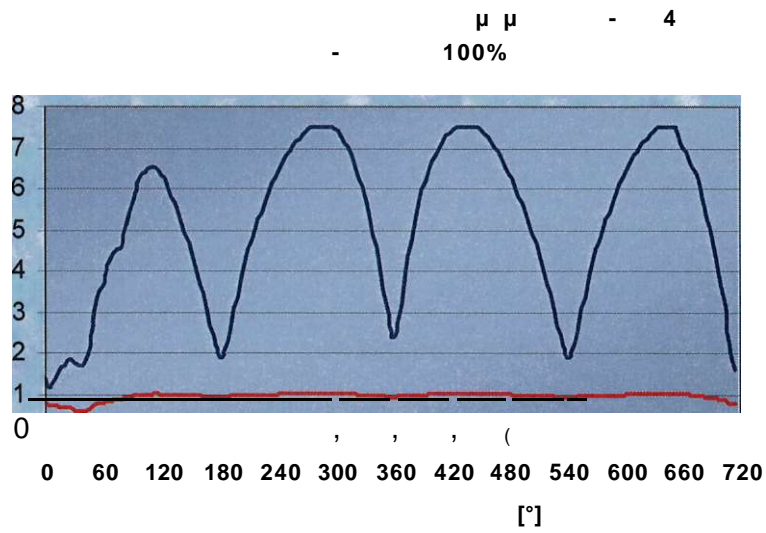


$\mu \mu$ μ 3.43

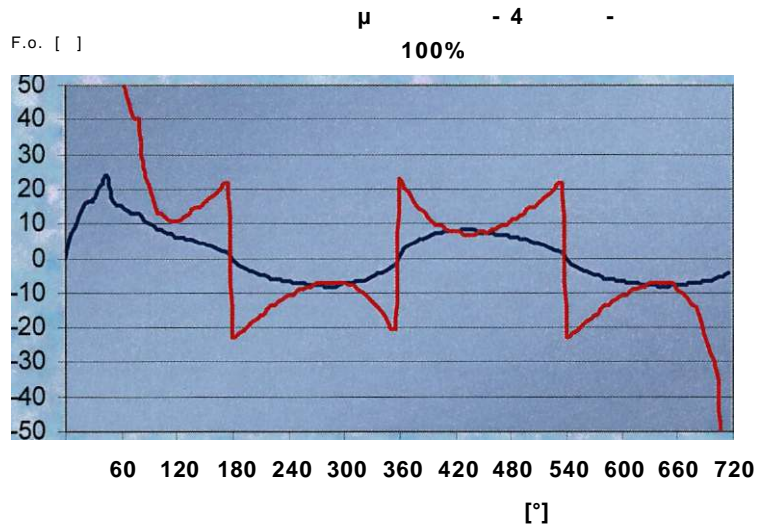
(μ) - μ (μ). μ



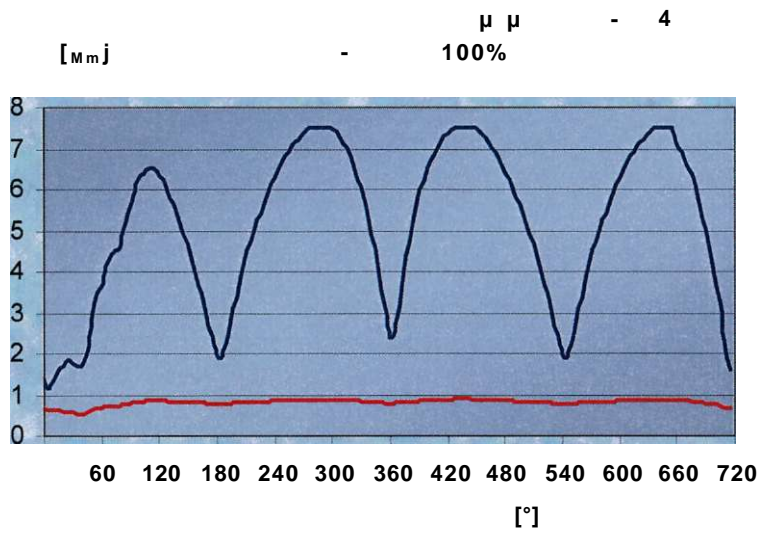
μ 3.44 (μ) - μ (μ μ) . μ



μ 3.45 μ (μ μ) - μ (μ μ) .



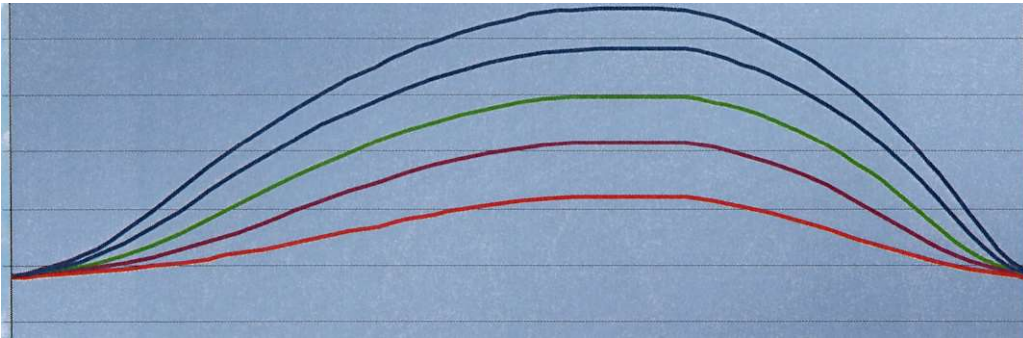
μ 3.46
 (μ) - μ (μ) μ



μ μ μ 3.47
 (μ) - μ (μ)

$h_{min} [\mu]$

$\mu \mu - 4 - 100\%$
 $n=2000-3000-4000-5000-6000 \text{ rpm}$



$[\circ]$

$\mu \quad 3.48$
 μ

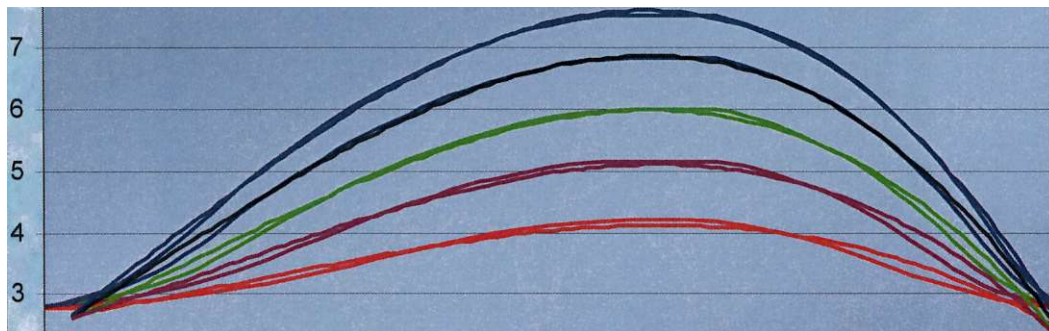
$\mu\mu$

$\mu \mu -$
 $2000-6000 \text{ rpm-}$

1

$h_{min} [>]$

$\mu \mu - 4 - 100\%$
 $n=2000-3000-4000-5000-6000 \text{ rpm}$



180

225

270

315

360

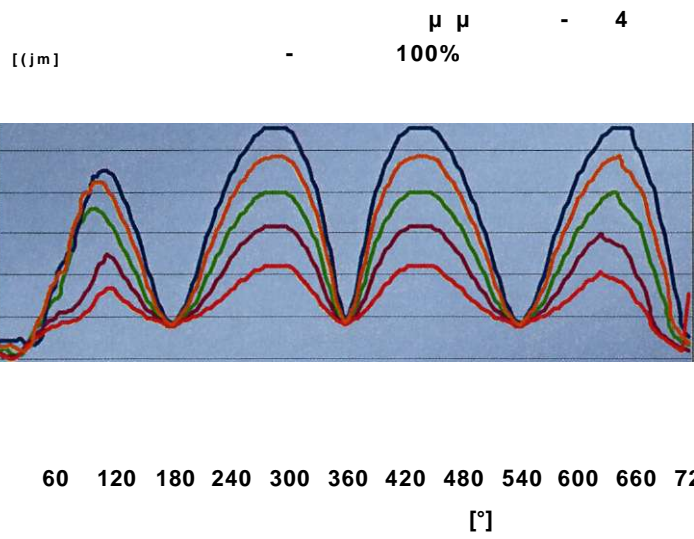
$[\circ]$

$\mu \quad 3.49$
 6000rpm-1^n

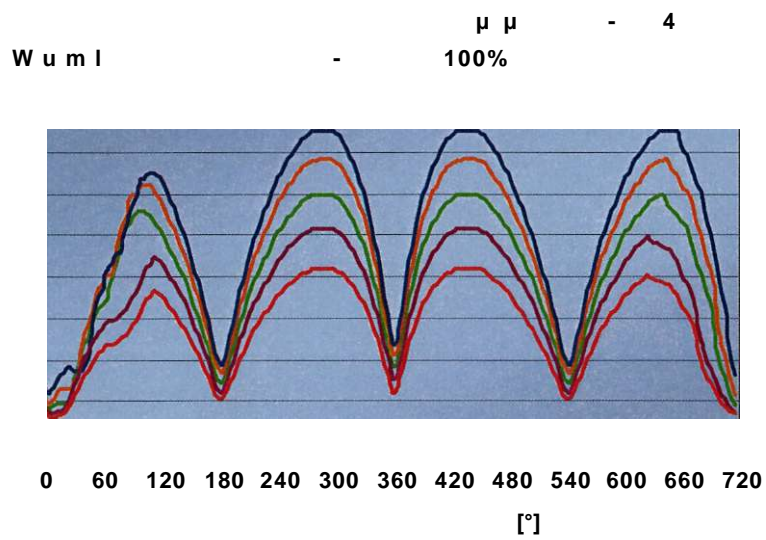
$\mu\mu$
 μ

$\mu\mu$

$\mu \mu -$
 $2000-$

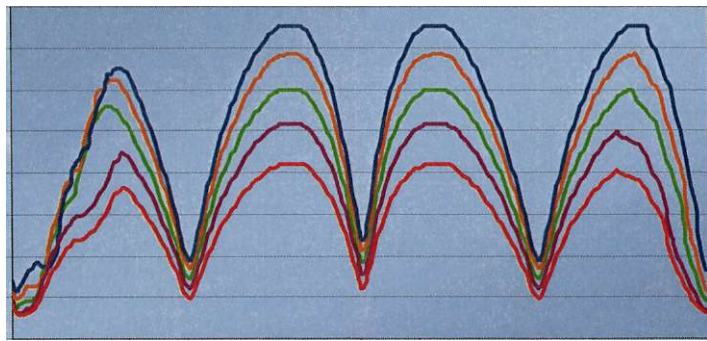


μ 3.50 $\mu\mu$ $\mu\mu$ -
 μ 2000-6000rpm-
 1



μ 3.51 $\mu\mu$ $\mu\mu$ -
 μ 2000rpm-
 2

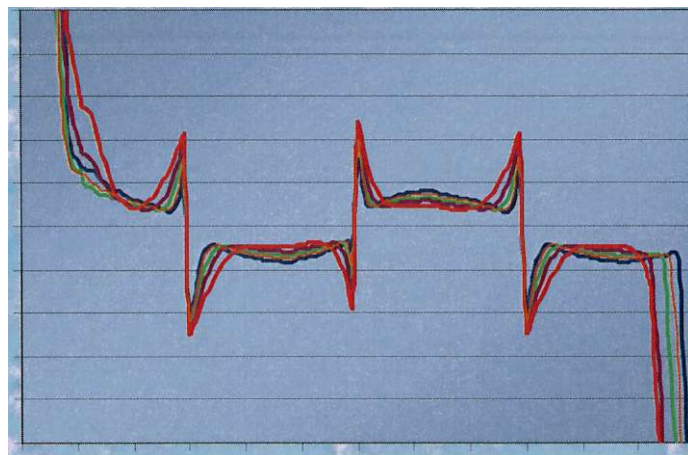
- μ μ - 4
100%



0 60 120 180 240 300 360 420 480 540 600 660 720
[°]

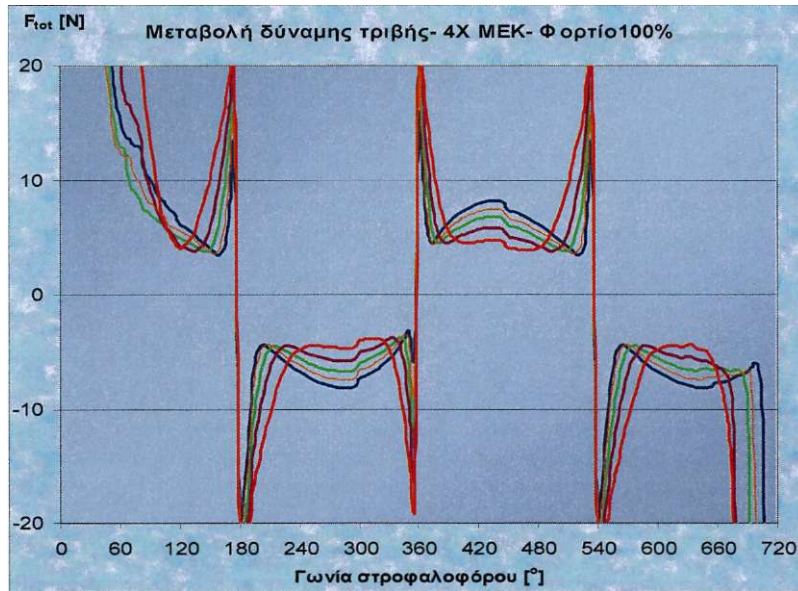
μ 3.52 μ μ μ μ -
μ 2000-6000 -
3ⁿ

F₀ [] μ -4 -
100%



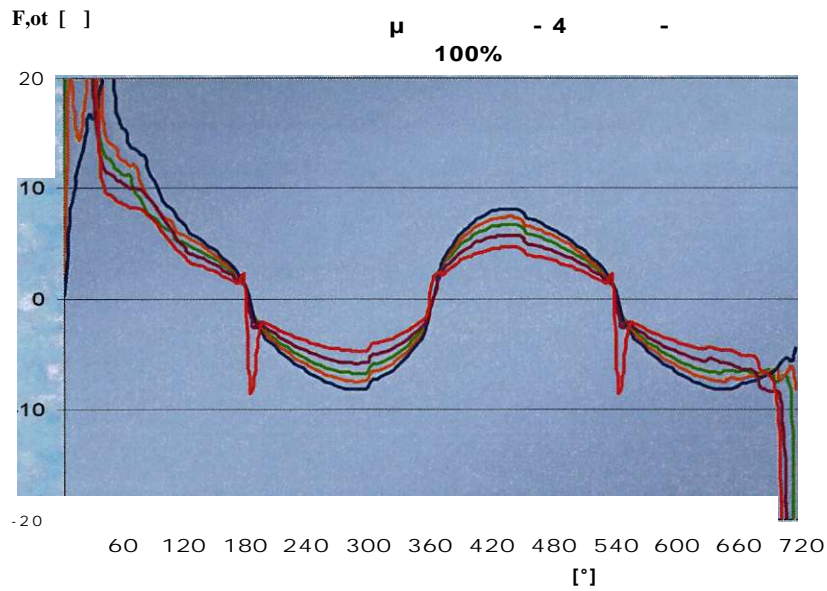
60 120 180 240 300 360 420 480 540 600 660 720
[°]

μ 3.53 μ μ μ
n = 2000-3000-4000-5000-5500-6000rpm-
1



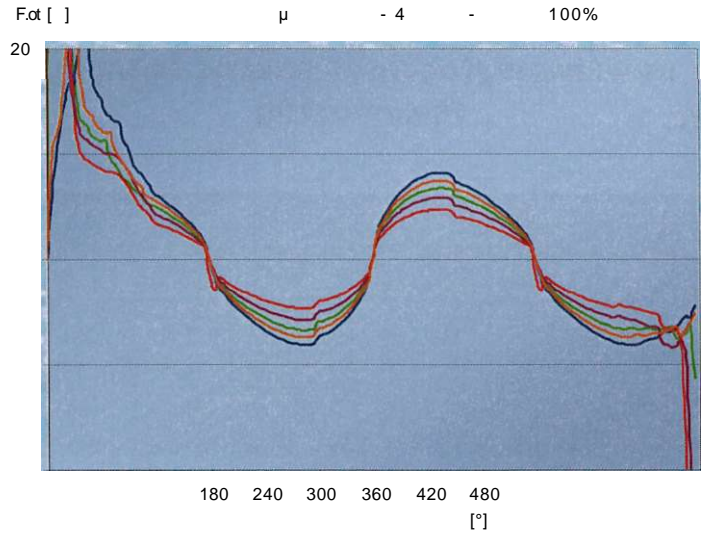
μ 3.54
 $n = 2000-3000-4000-5000-5500-6000 \text{rpm}$
 (μ) .

1ⁿ



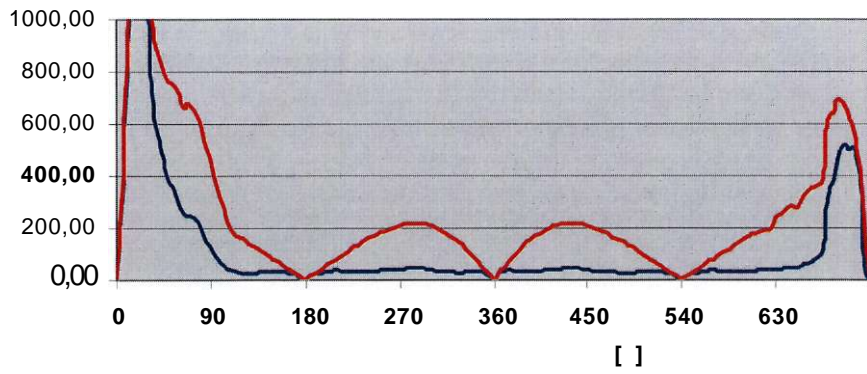
μ 3.55
 $n = 2000-3000-4000-5000-5500-6000 \text{rpm}$
 (μ) .

2



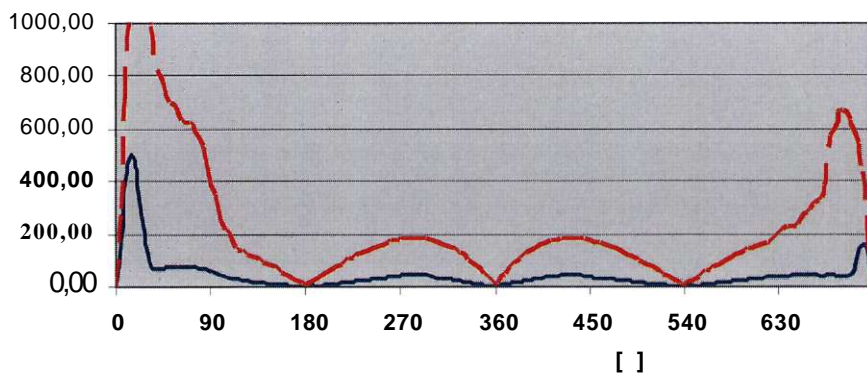
μ 3.56
 $\mu\mu$ μ
 n= 2000-3000-4000-5000-5500-6000rpm-
 3

1,1 3000rpm,
[W] 1



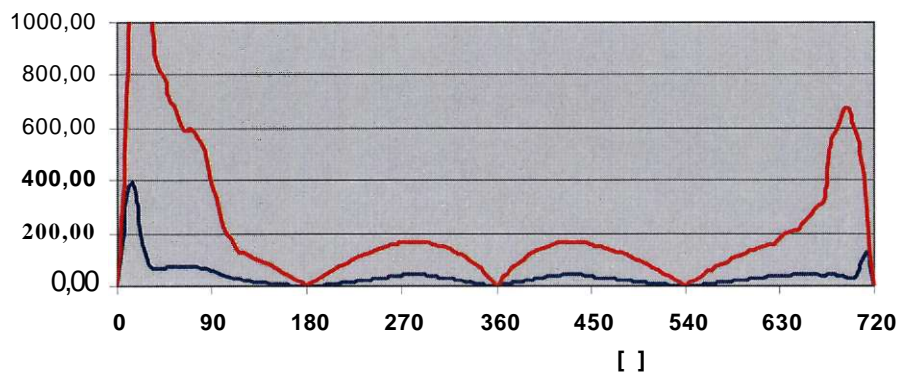
()

2,1 2000rpm,
[W] 2



()

3,1 2000rpm,
[W] 3



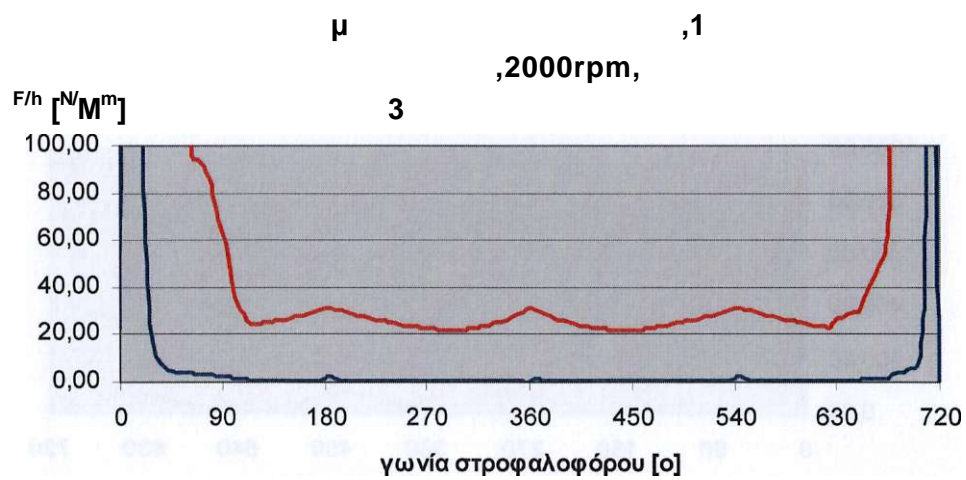
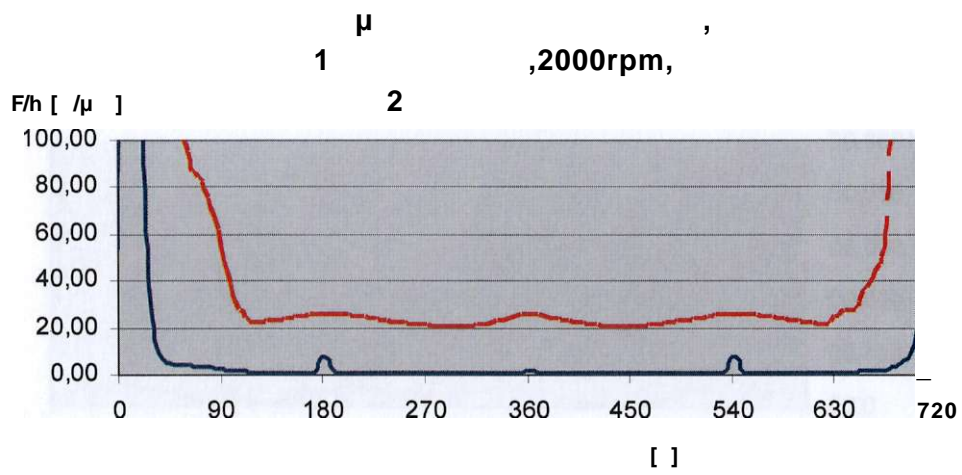
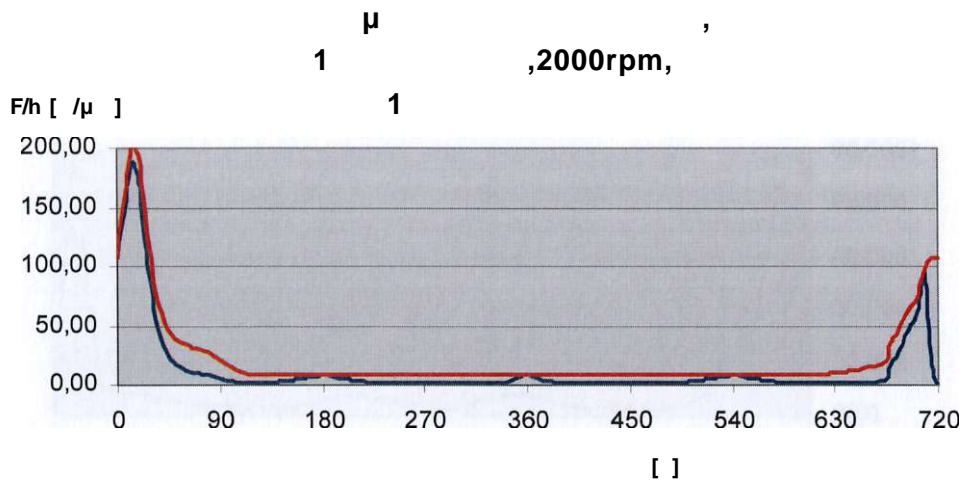
()

μ 3.57

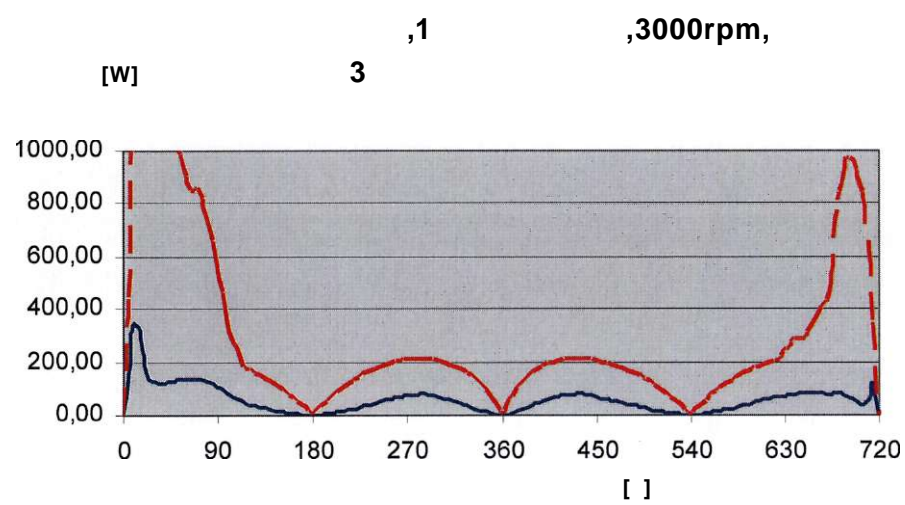
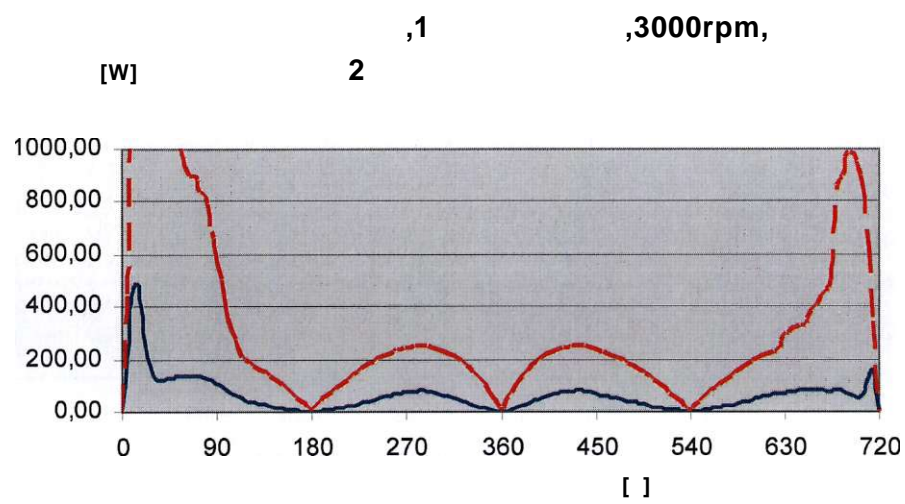
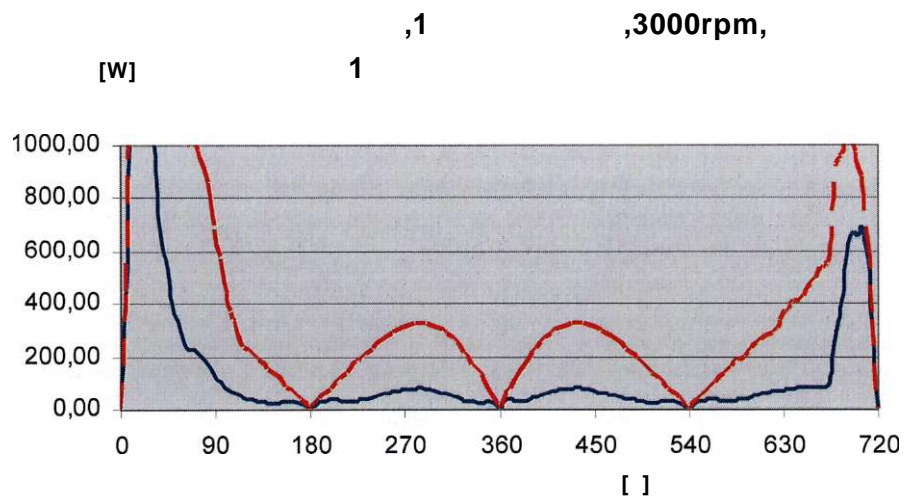
$\mu\mu$

1
(1, 2, 3)

μ
n=2000 rpm



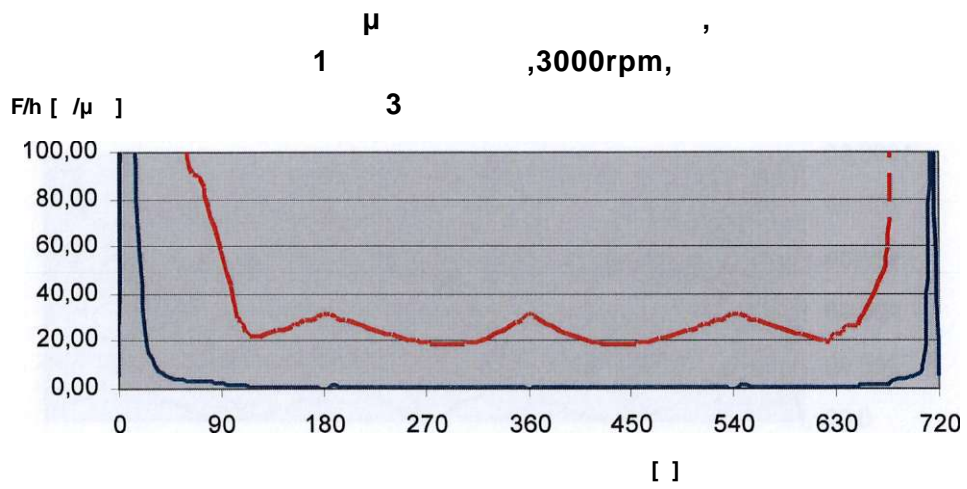
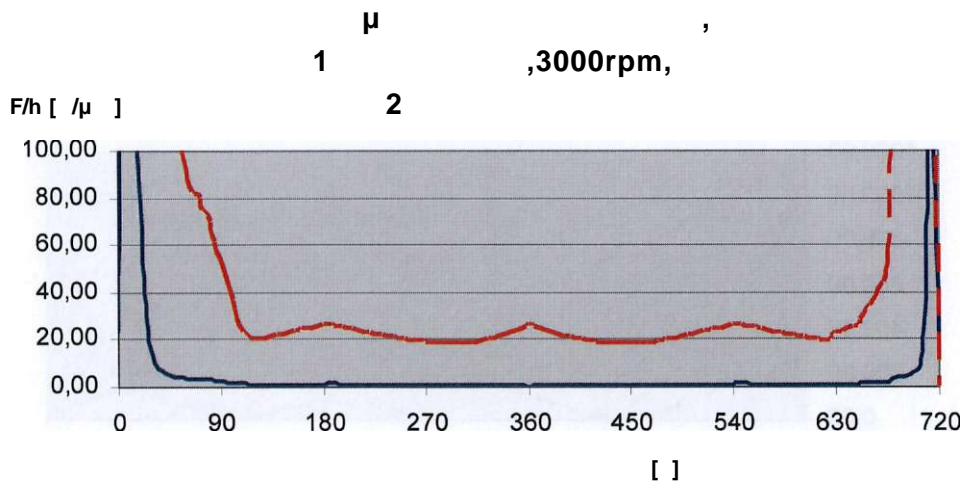
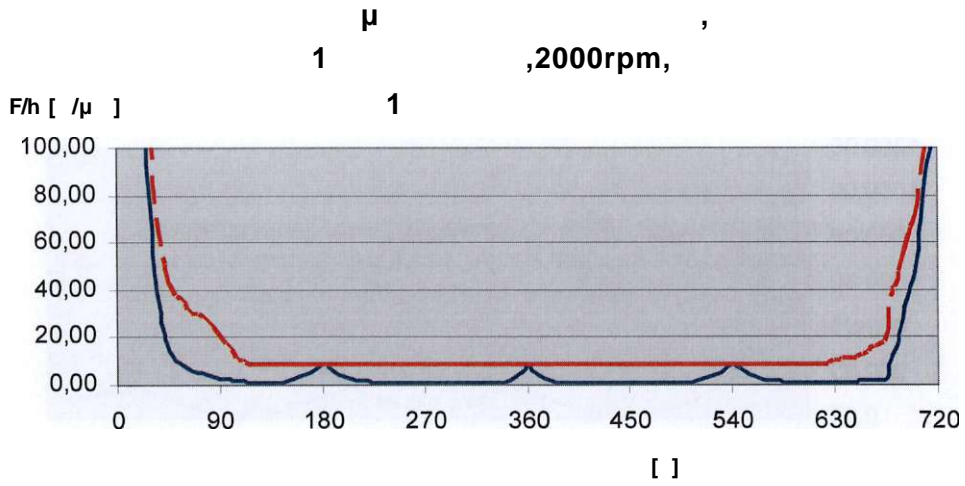
μ 3.58 μ μ 1 μ
n=2000 rpm



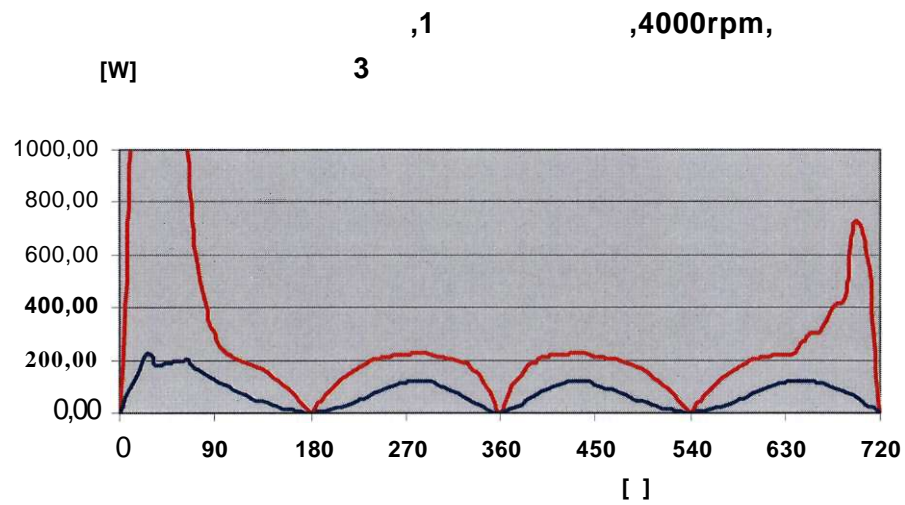
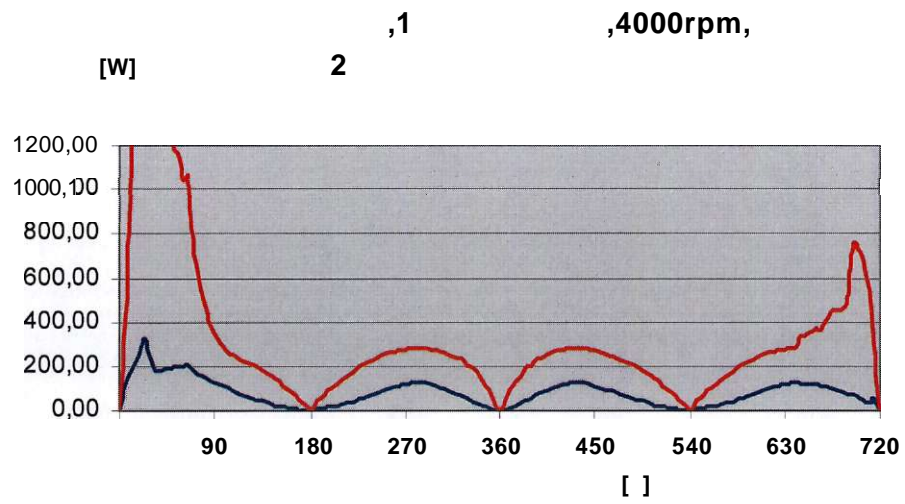
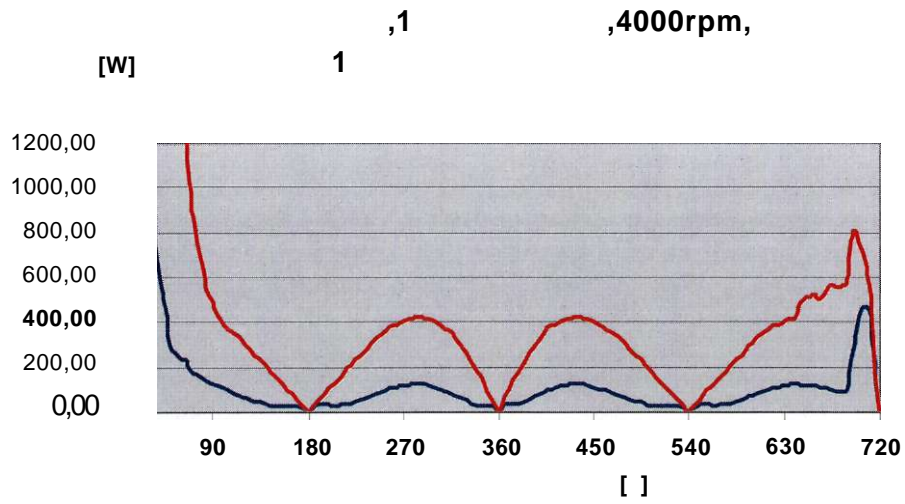
μ 3.57

$\mu\mu$

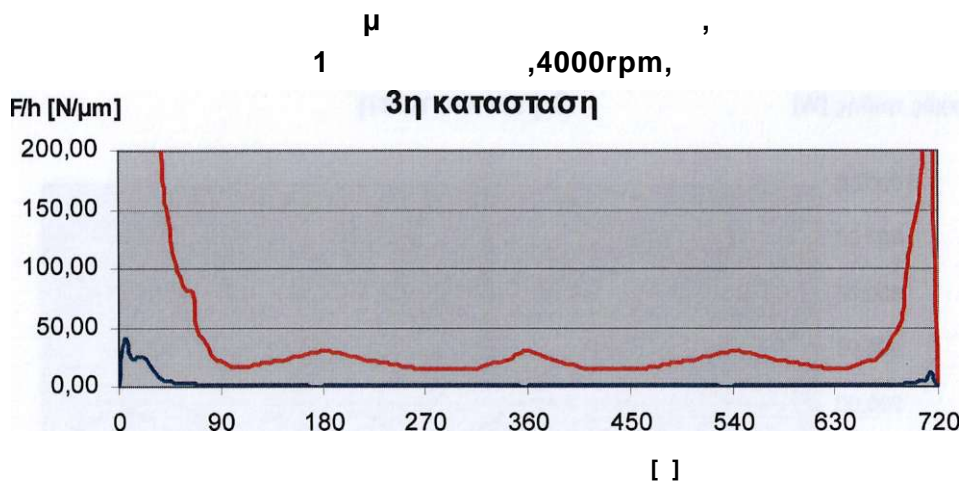
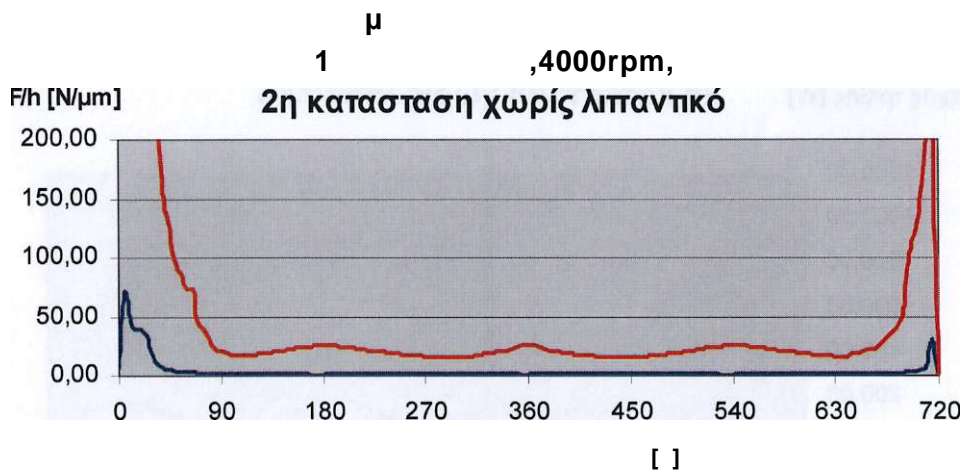
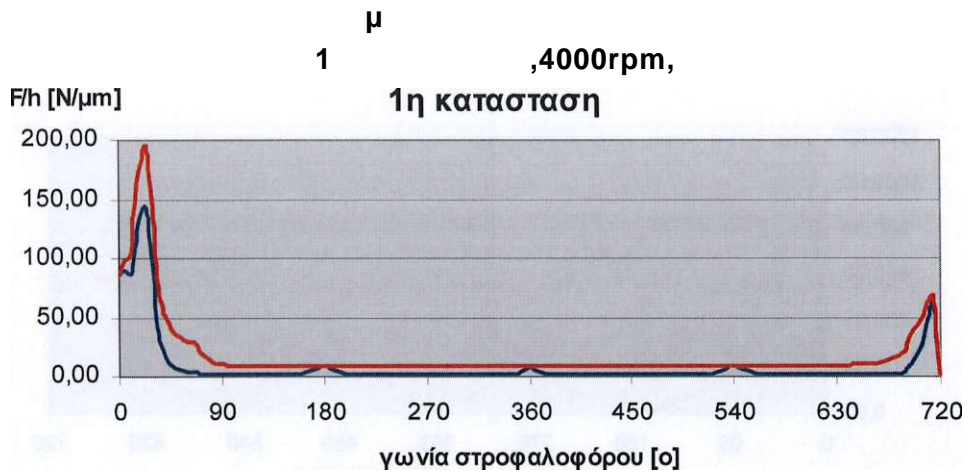
1
(1, 2, 3) μ
n=2000rpm



μ 3.58 $\mu\mu$ μ 1 μ
n=2000 rpm

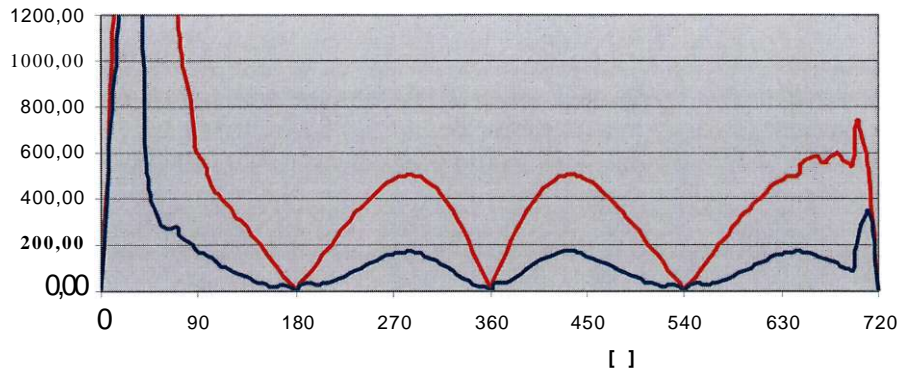


μ 3.61 μμ 1 μ
n=4000 rpm

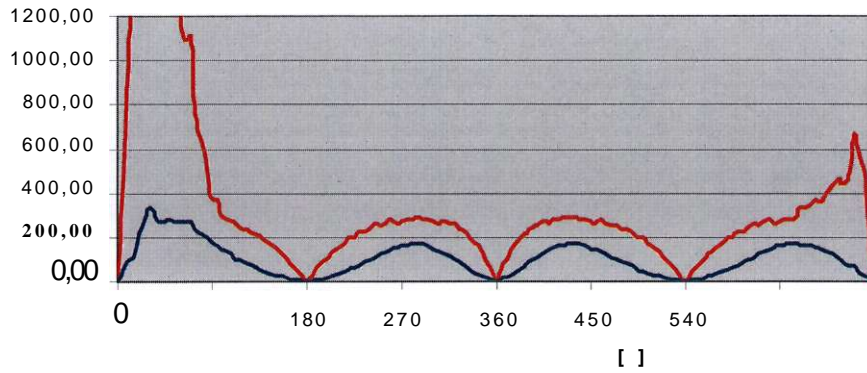


μ 3.62 $\mu\mu$ μ 1 μ
n=4000 rpm

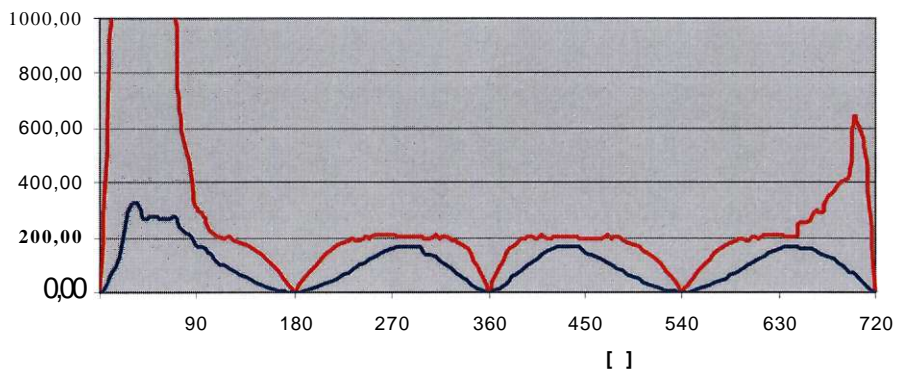
,1 ,3000rpm,
[W] 1



,1 ,5000rpm,
[W] 2



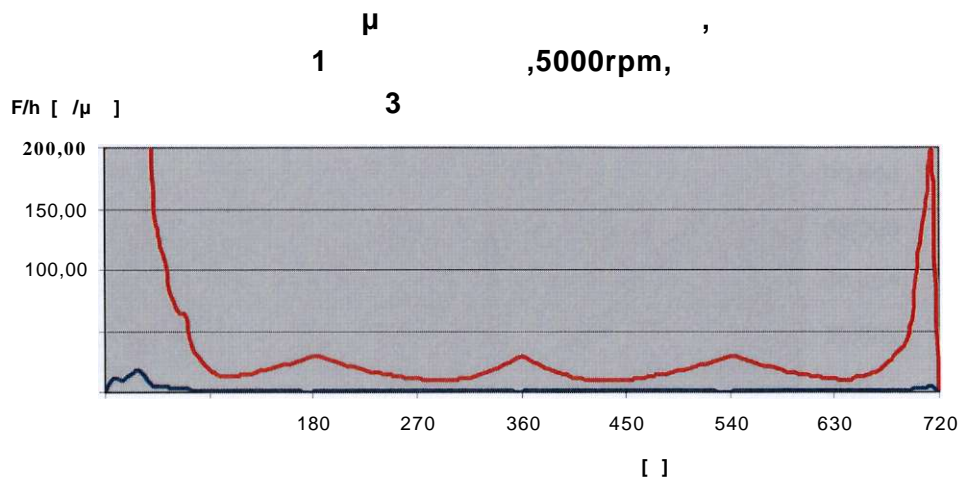
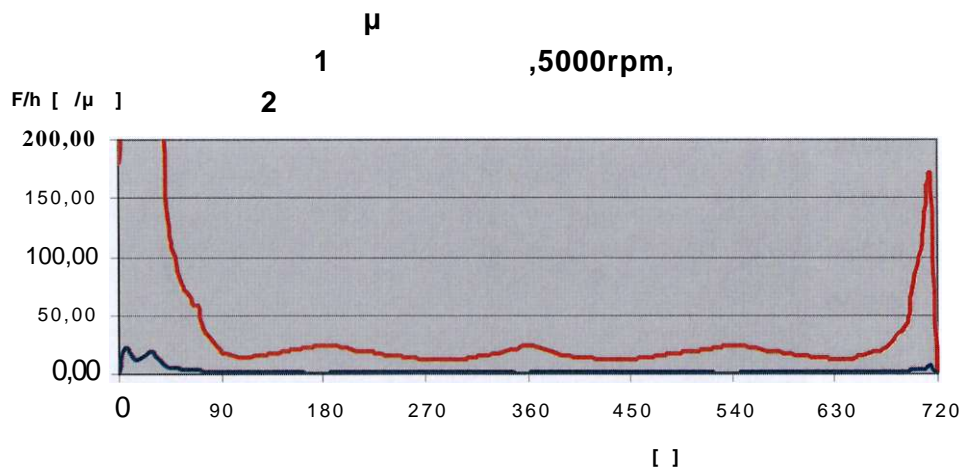
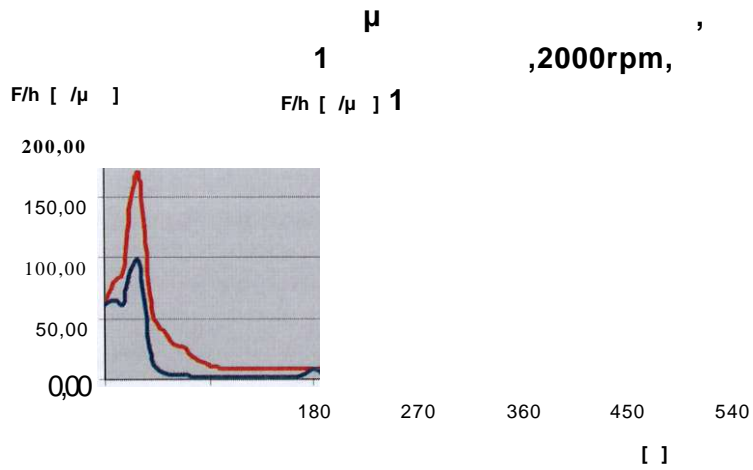
,1 ,5000rpm,
[W] 3



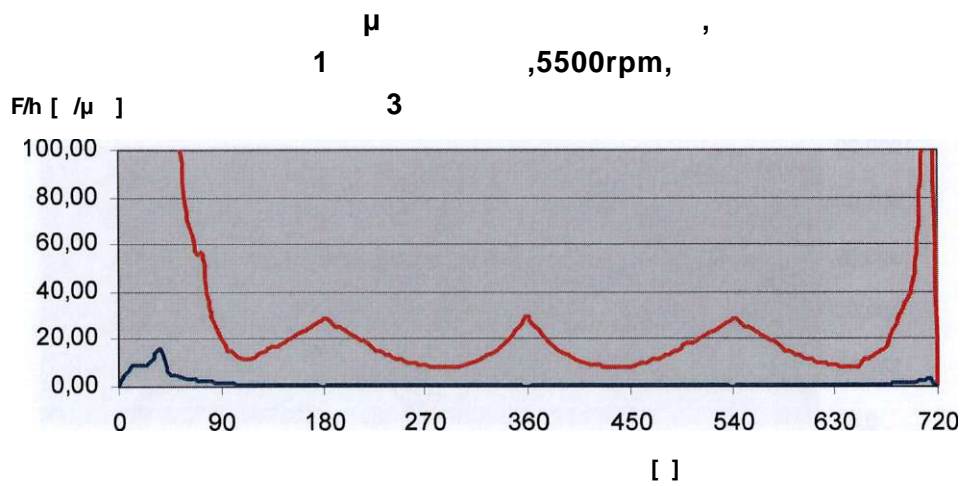
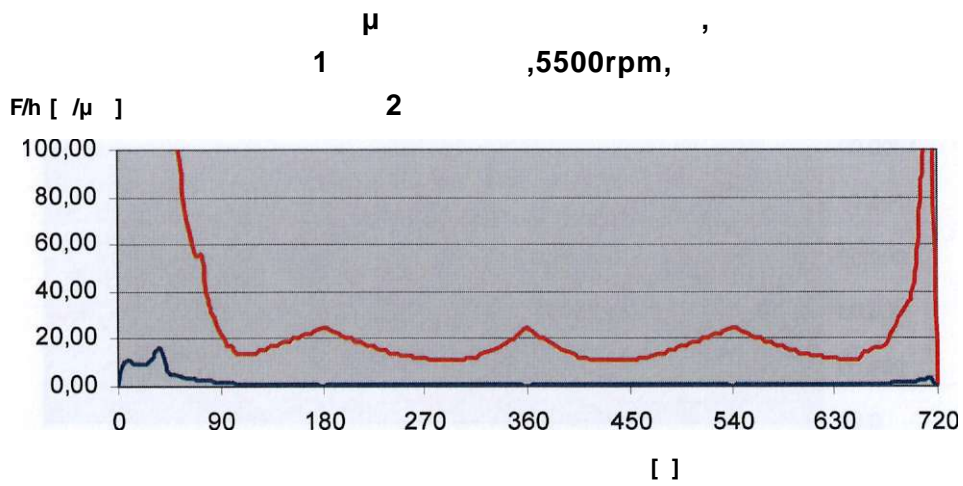
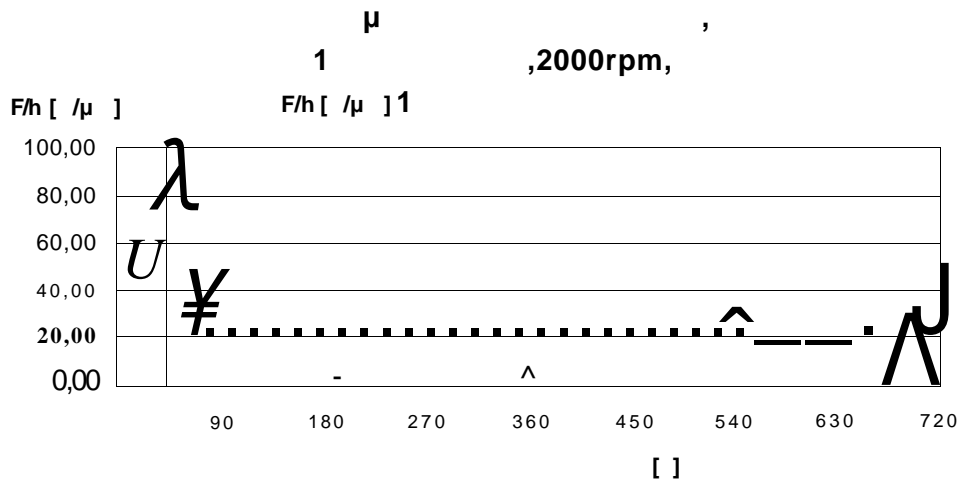
μ 3.57

$\mu\mu$

1
 (1, 2, 3) μ
 n=2000rpm

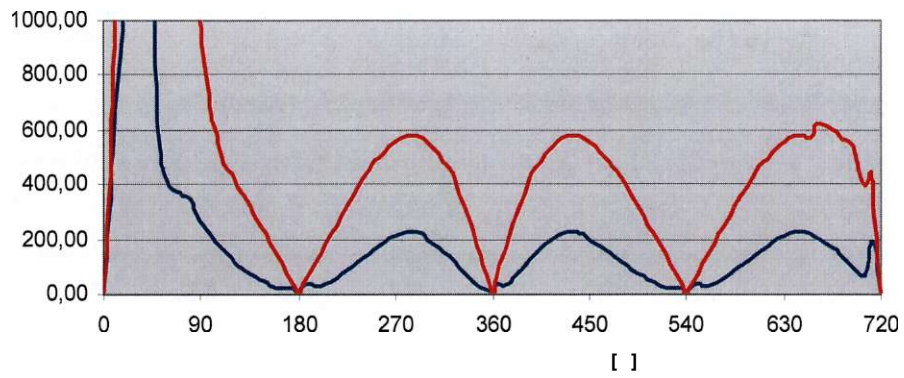


μ 3.58 $\mu\mu$ μ 1 μ
n=2000 rpm

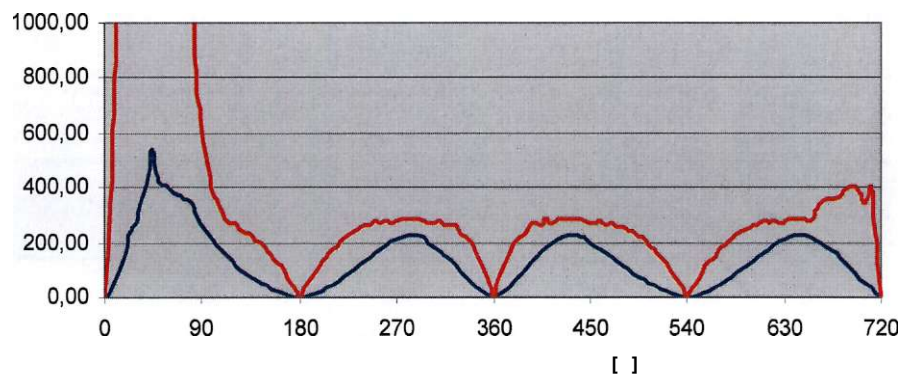


μ 3.58 $\mu\mu$ μ 1 μ
n=2000 rpm

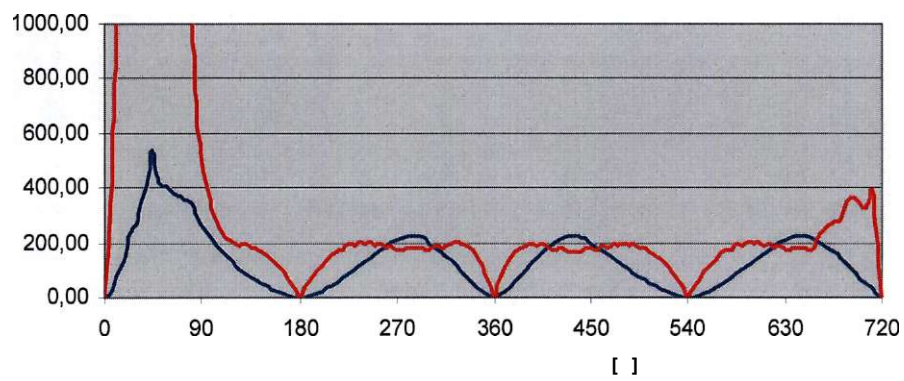
1,1 ,3000rpm,
[W]



2,1 ,6000rpm,
[W]



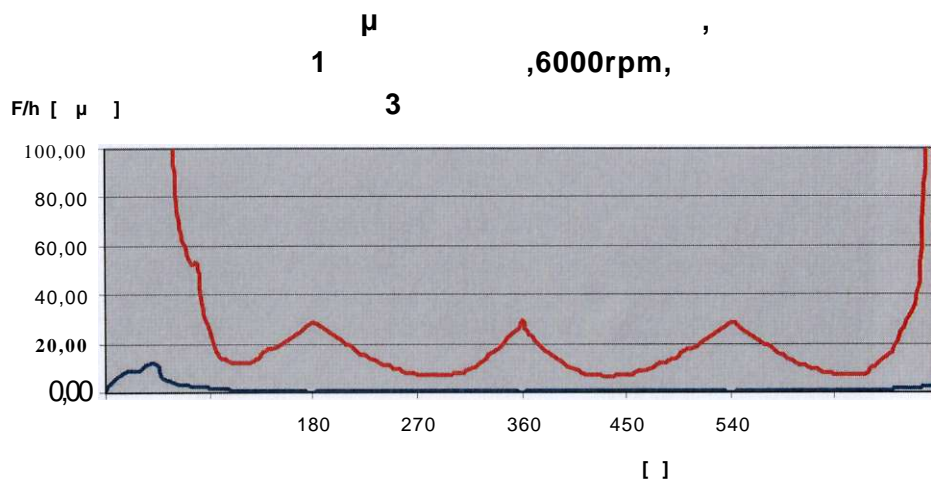
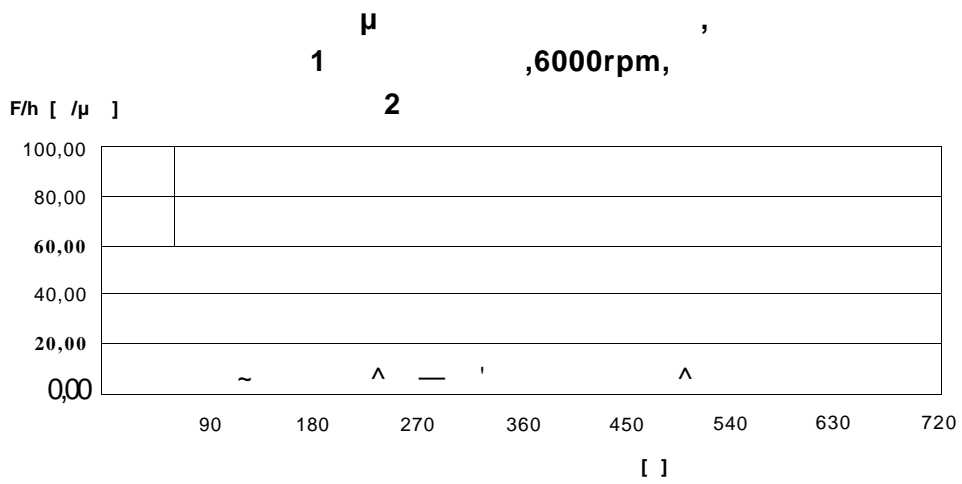
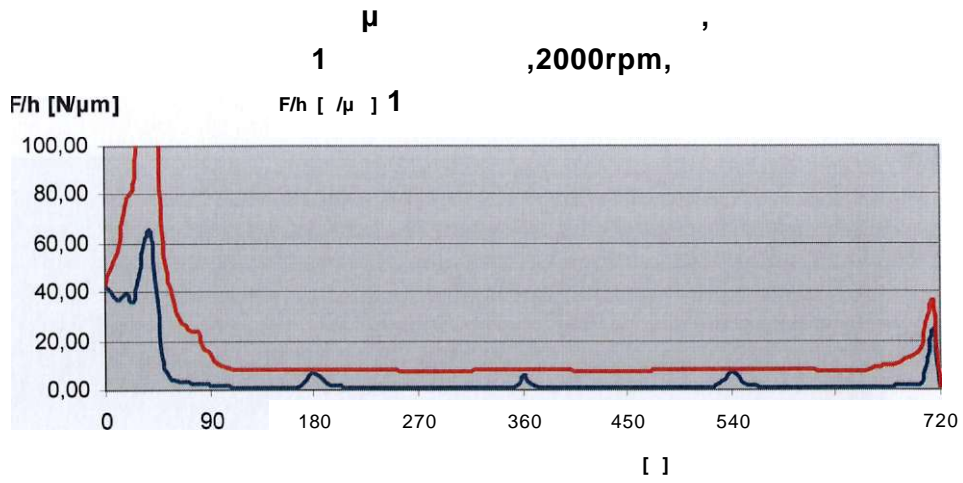
3,1 ,6000rpm,
[W]



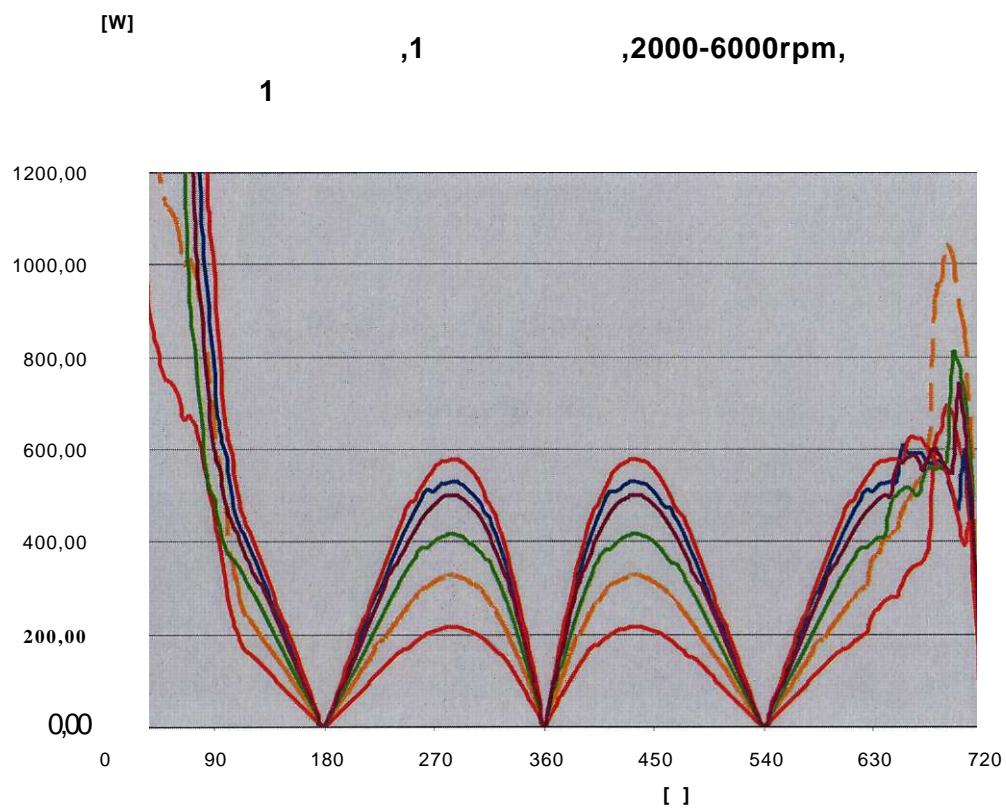
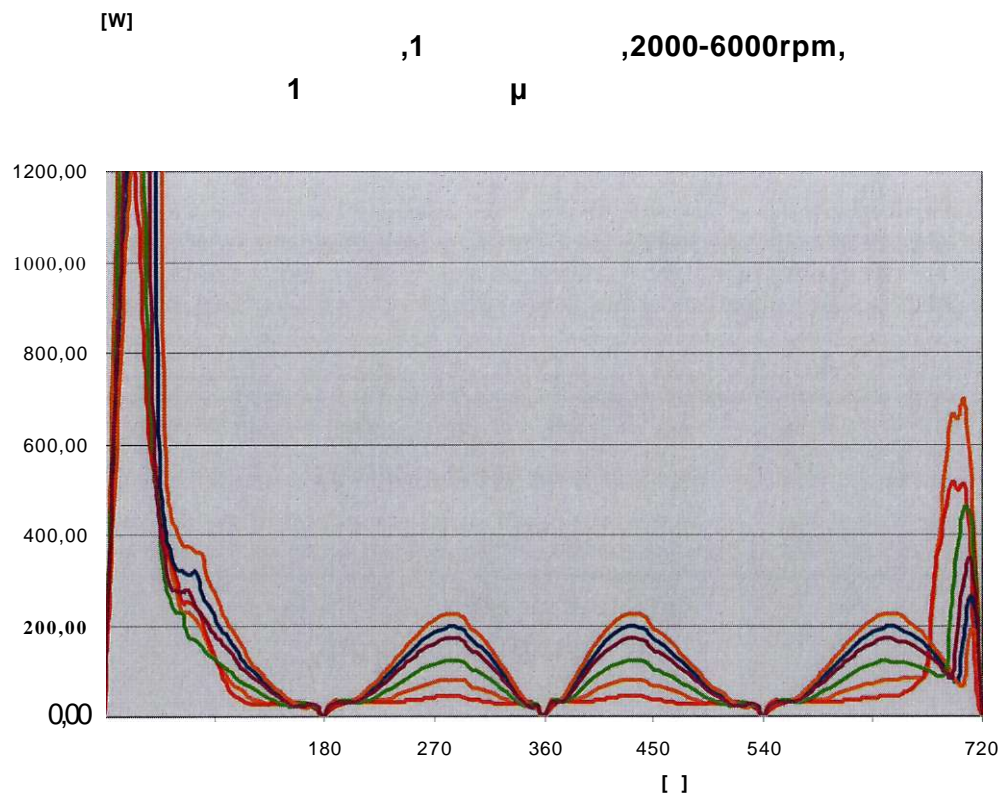
μ 3.57

$\mu\mu$

1
(1, 2, 3) μ
n=2000rpm



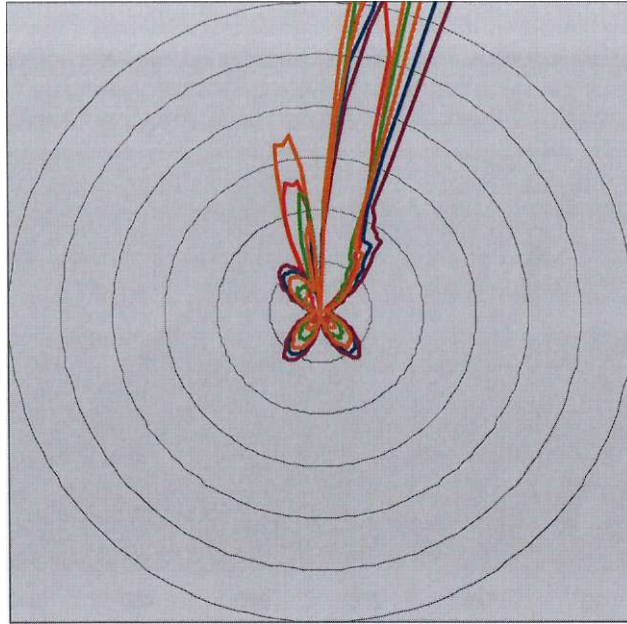
μ 3.58 $\mu\mu$ μ 1 μ
n=2000 rpm



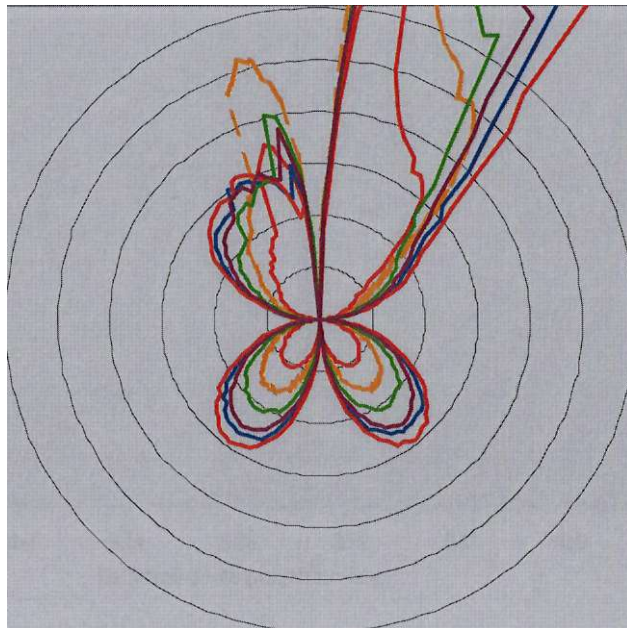
μ 3.69 μμ 1 μ

1 n=2000-6000 rpm

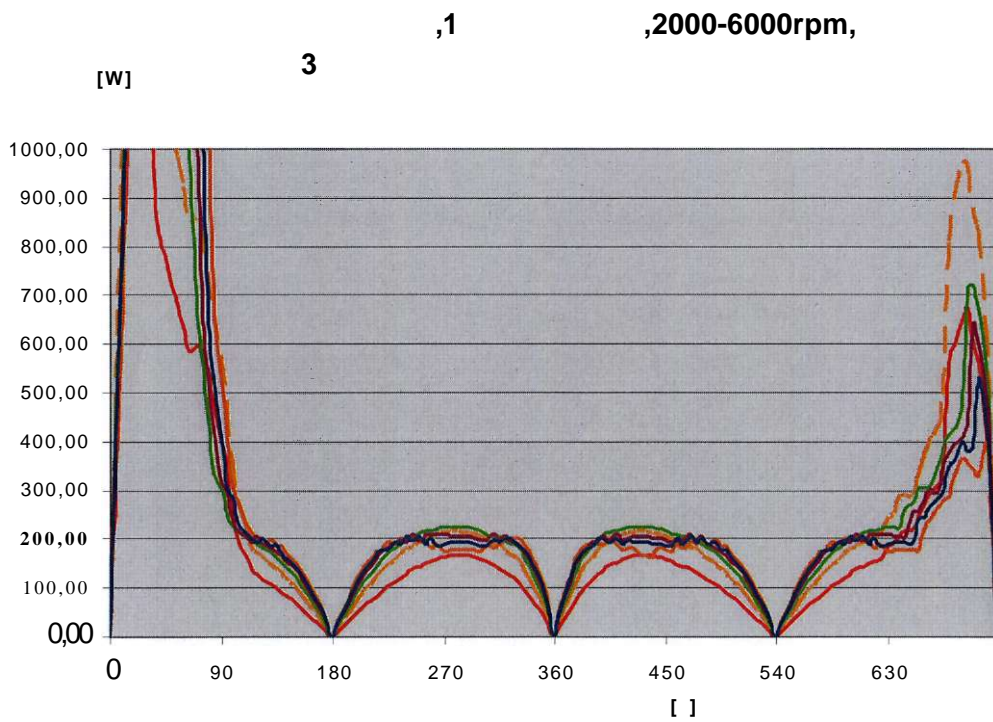
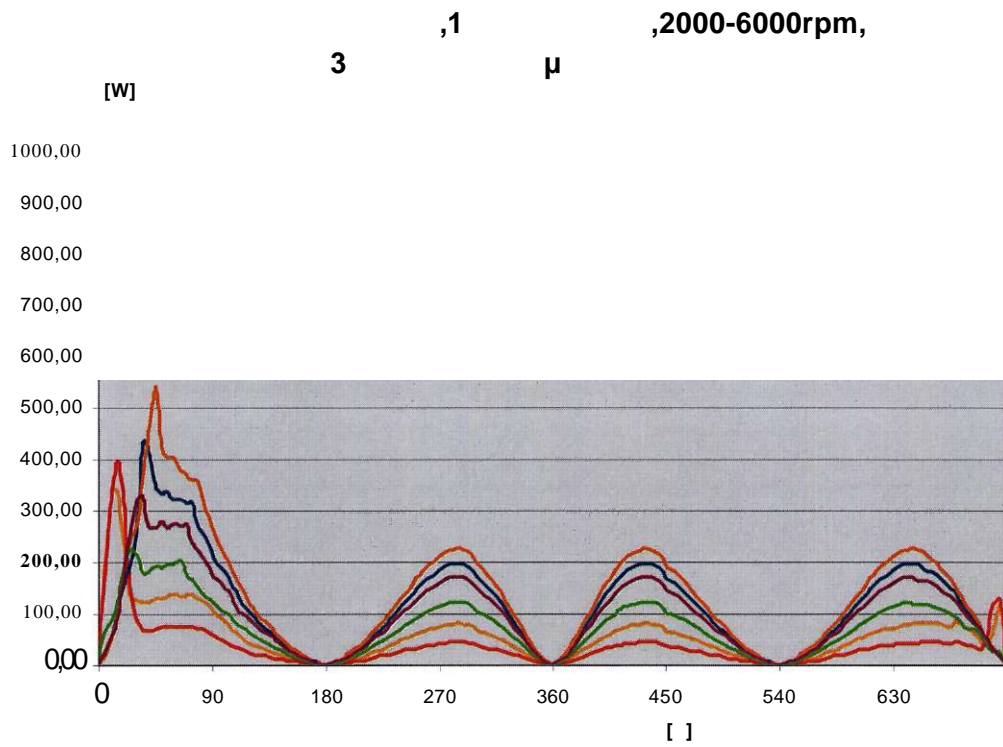
,1 ,2000-6000rpm,
1



,1 ,2000-6000rpm,
1

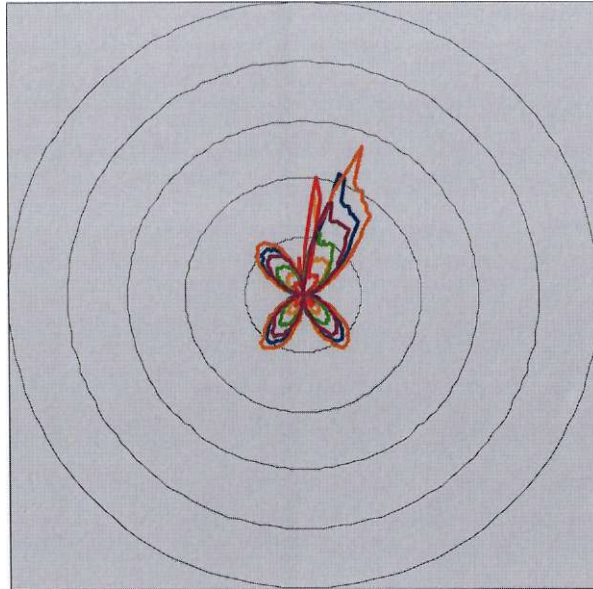


μ 3.70 μμ
1 μ

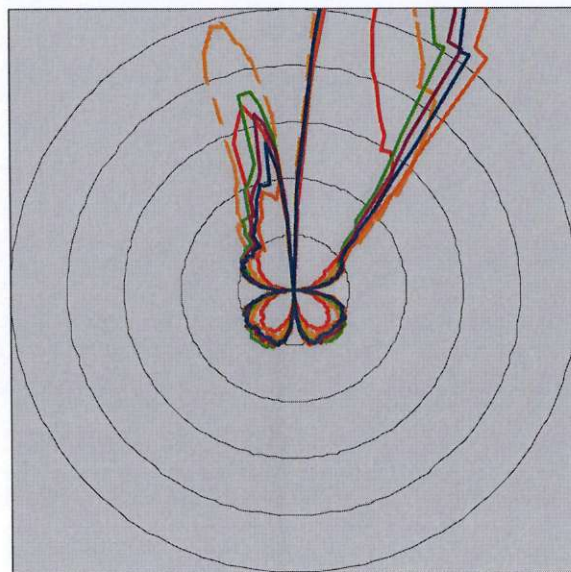


μ 3.71 μ μ 1 μ
3 n=2000-6000 rpm

3,1, ,2000-6000rpm,
μ



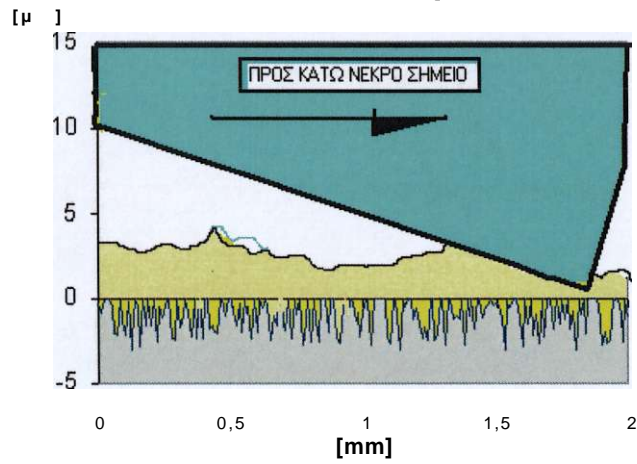
απώλειες ισχύος ,1ος δακτύλιος,2000-6000rpm,
3η κατασταση χωρίς λιπαντικό



Σχήμα 3.72 Πολικό διάγραμμα απωλειών ισχύος για διαφορετικές ταχύτητες –
3 μ



2ος ΔΑΚΤΥΛΙΟΣ - 2000 rpm - ΠΛΗΡΕΣ ΦΟΡΤΙΟ



2° :

_____ :

μ μ

μ

μ μ μ μ

μ

μ μ μ μ

μ

_____ :

μ μ μ μ

[Jm] 4 - μ μ - 00%



60 120 180 240 300 360 420 480 540 600 660 720
[°]

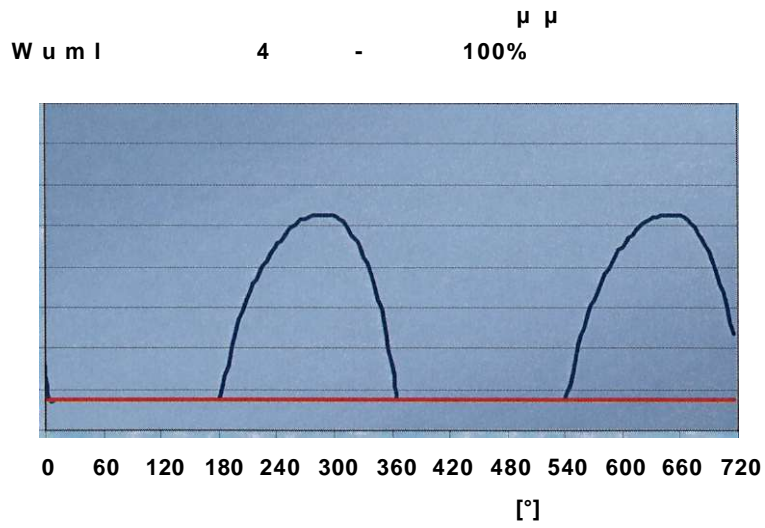
μ μ 3.73
(μ) - μ (μ).

F_{θ} [] μ - 4 - 100%

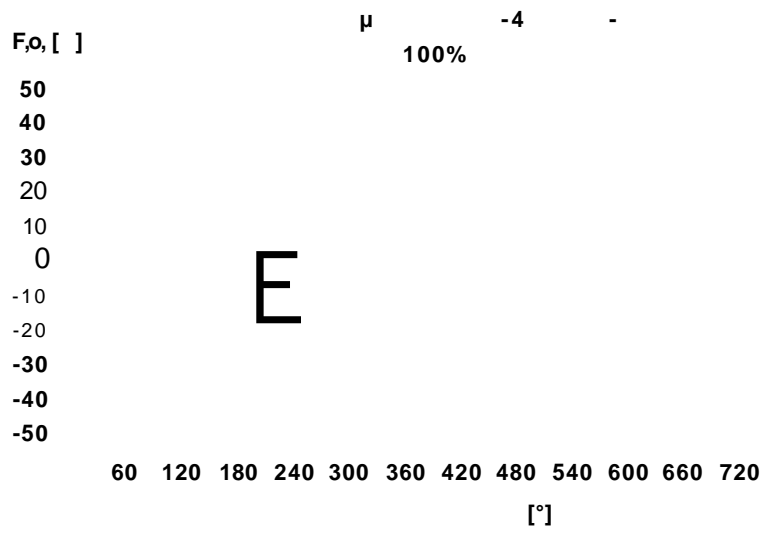
50
40
30
20
10
-10
-20
-30
-40
-50

60 120 180 240 300 360 420 480 540 600 660 720
[°]

μ 3.74
(μ) - μ (μ μ).

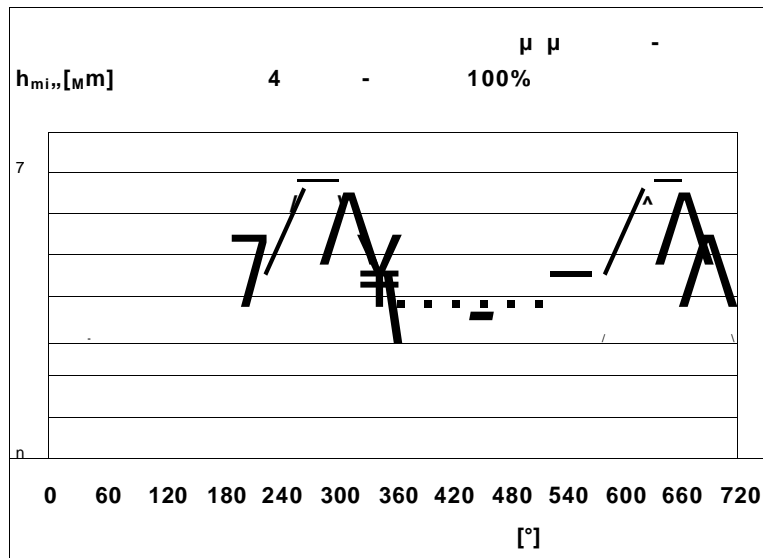


μ μ 3.75 (μ) - μ (μ).

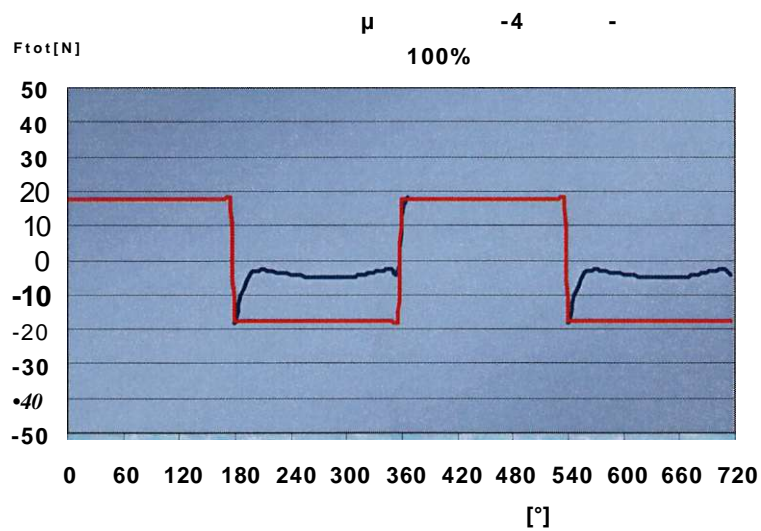


μ 3.76 (μ) - μ (μ) μ).

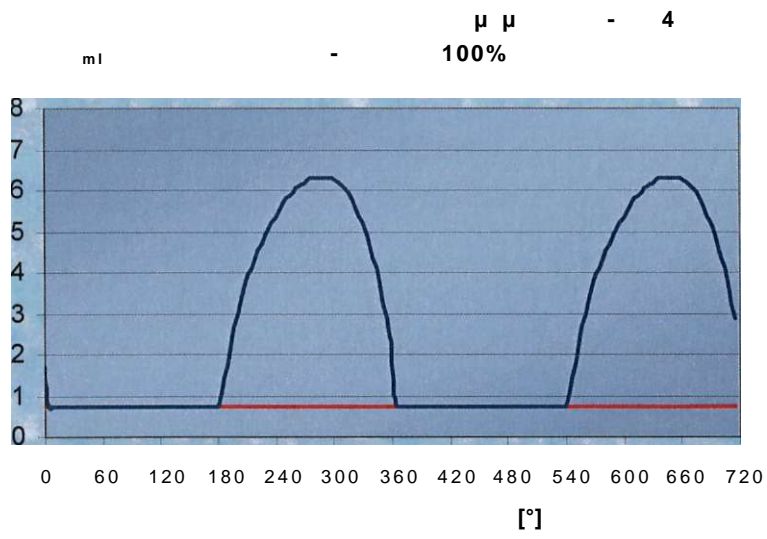
2ος ΔΑΚΤΥΛΙΟΣ - 3000 rpm - ΠΛΗΡΕΣ ΦΟΡΤΙΟ



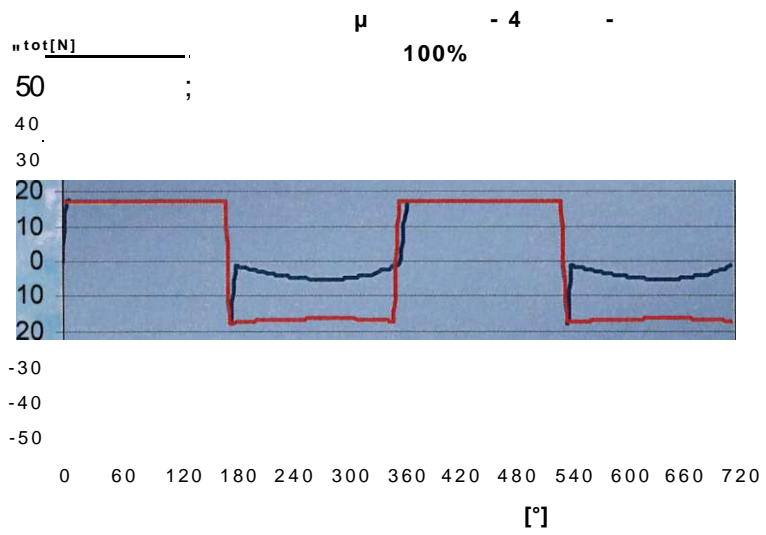
μ μ 3.77 (μ) - μ (μ).



μ 3.78 (μ) - μ (μ).

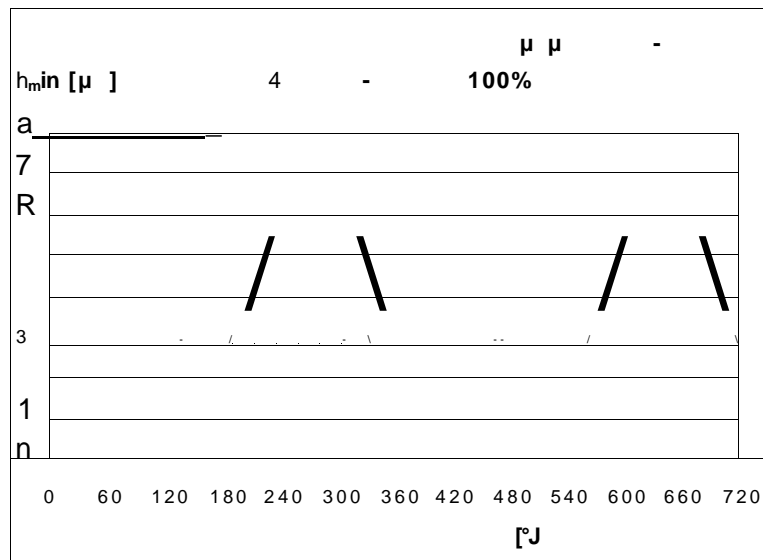


μ μ 3.79 (μ) - μ (μ).

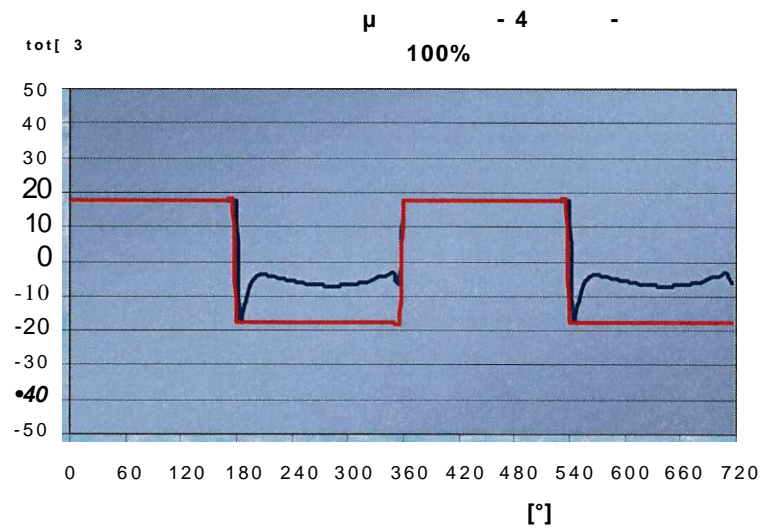


μ 3.80 (μ) - μ (μ μ).

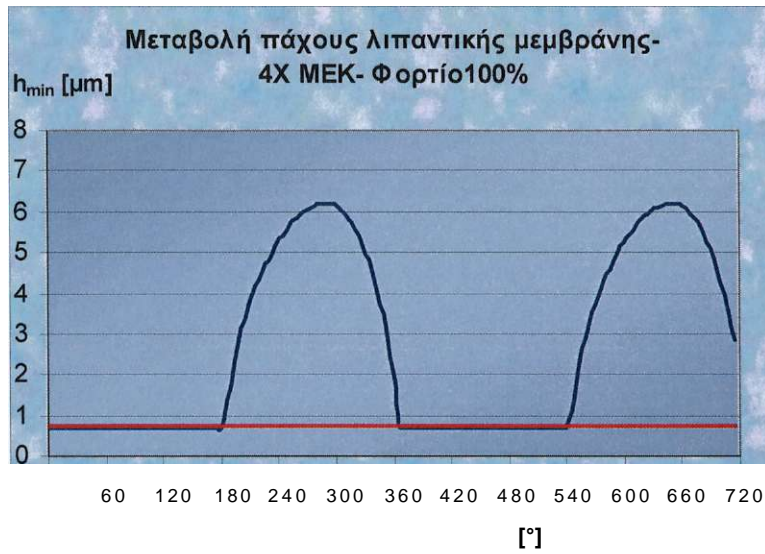
M m m m m i m - - m q i sijut. S B I « m i a o)



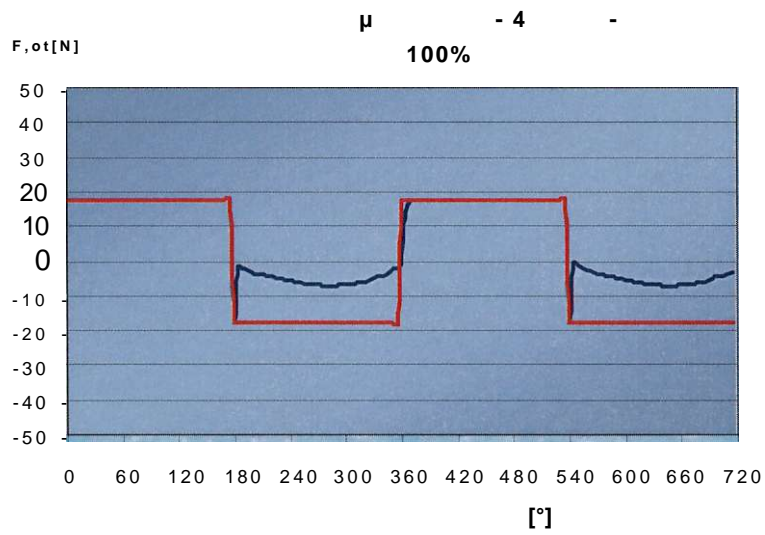
μ μ 3.81 (μ) - μ (μ).



μ 3.82 (μ) - μ (μ μ).

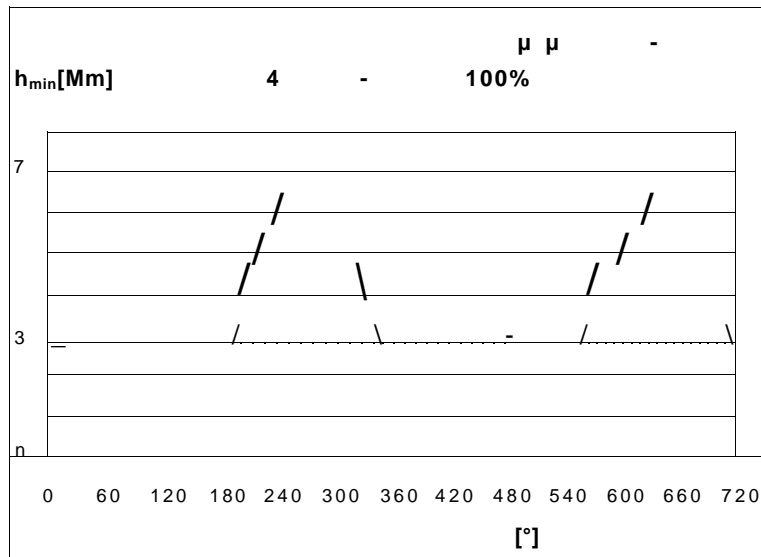


μ μ **3.83** (μ) - μ (μ).

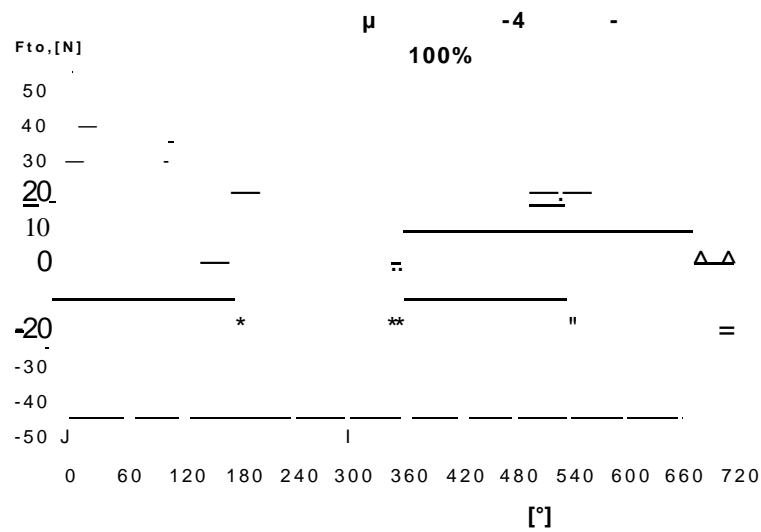


μ **3.84** (μ) - μ (μ).

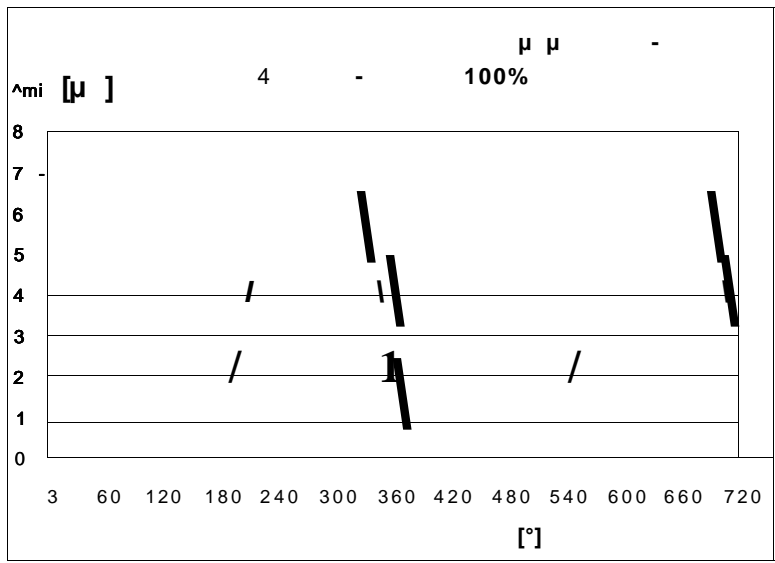
smo) duqip mmw ^)



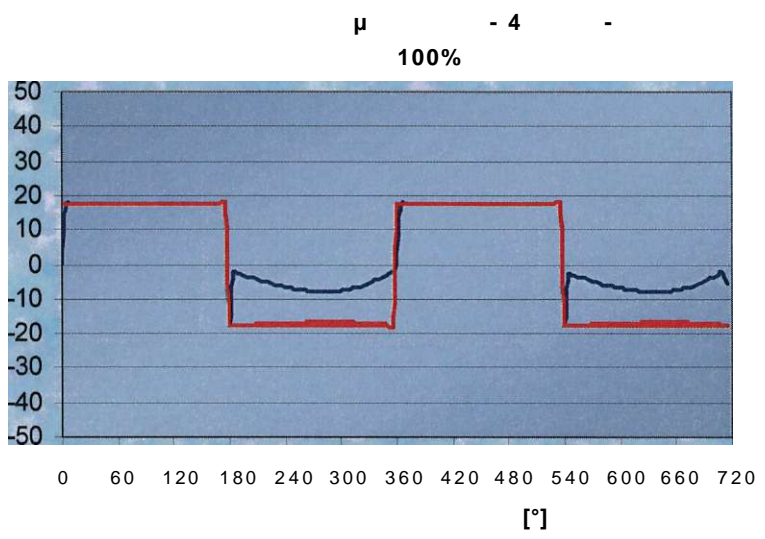
μ μ 3.85 (μ) - μ (μ).



μ 3.86 (μ) - μ (μ μ).

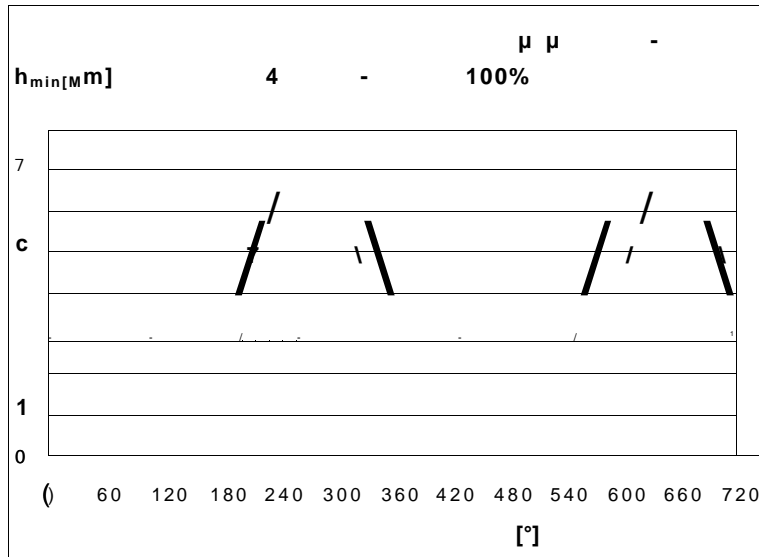


μ μ 3.87 (μ) - μ (μ).

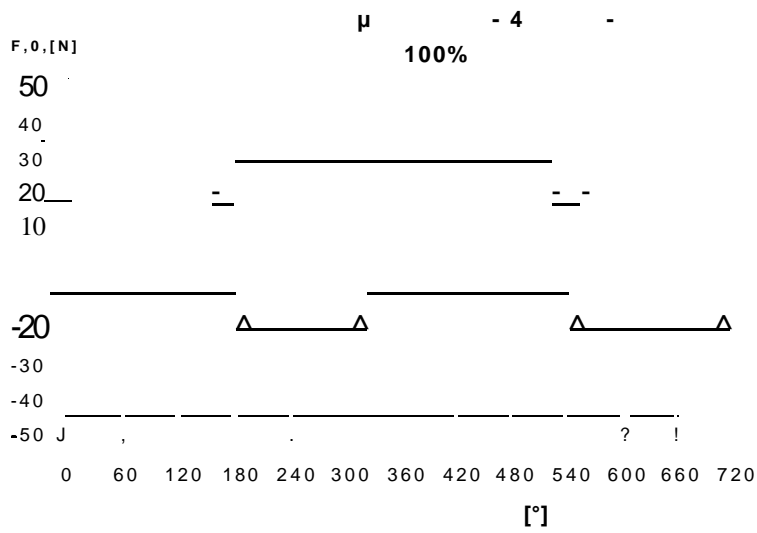


μ 3.88 (μ) - μ (μ).

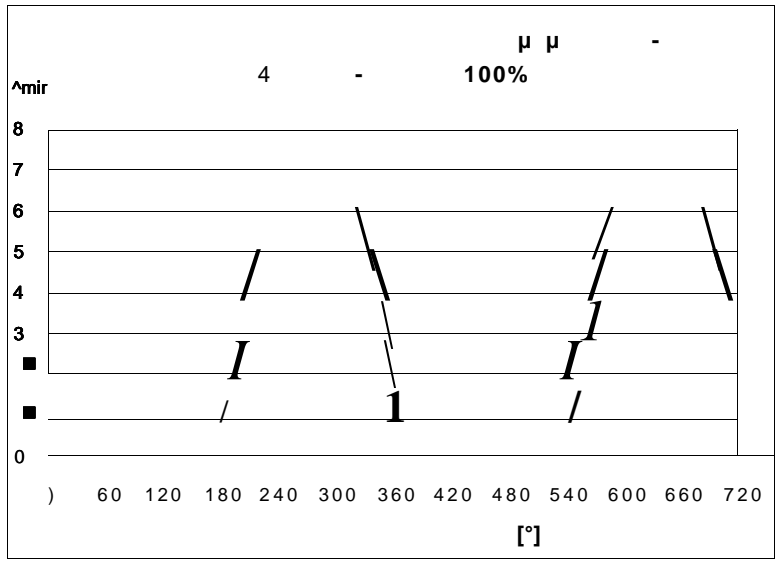
$r_{nmmim} = m m \cdot w m m \wedge a p f i t o i$



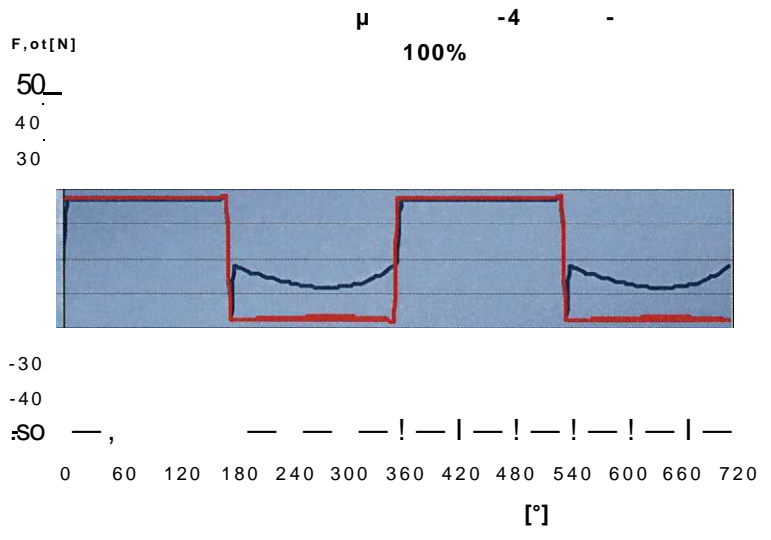
$\mu \mu \quad \mu \quad 3.89$
 $(\quad \mu) - \mu \quad (\quad \mu) .$



$\mu \quad \mu \quad 3.90$
 $(\quad \mu) - \mu \quad (\quad \mu \quad \mu) .$

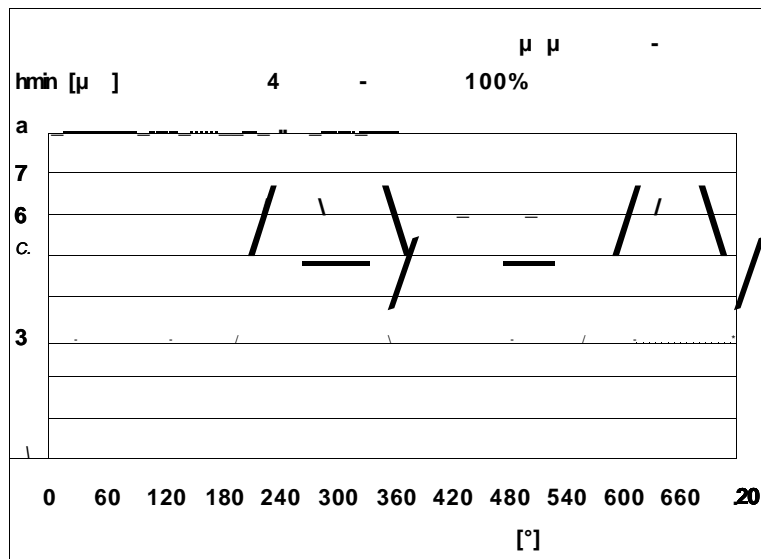


μ 3.91 (μ) - μ (μ).

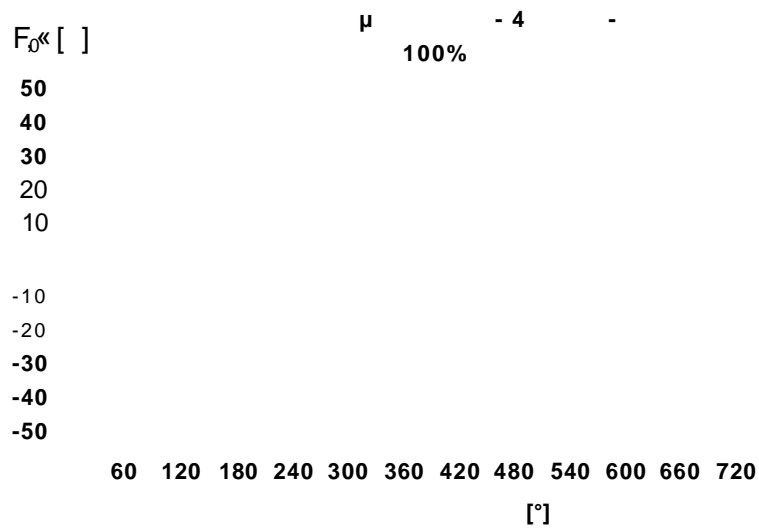


μ 3.92 (μ) - μ (μ μ). μ

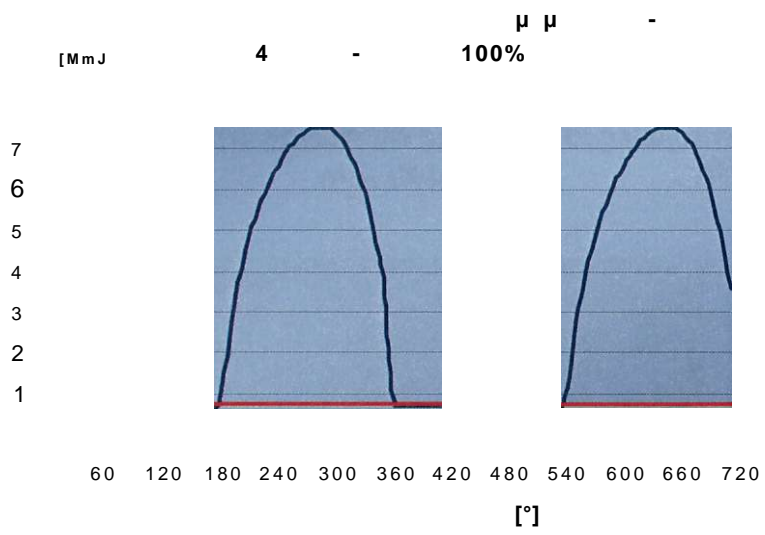
2ος ΔΑΚΤΥΛΙΟΣ - 6000 rpm - ΠΛΗΡΕΣ ΦΟΡΤΙΟ



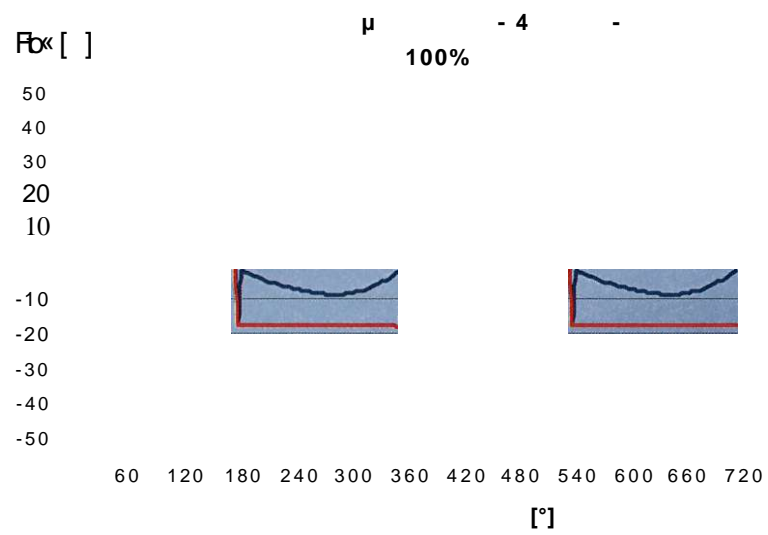
μ μ 3.93 (μ) - μ (μ).



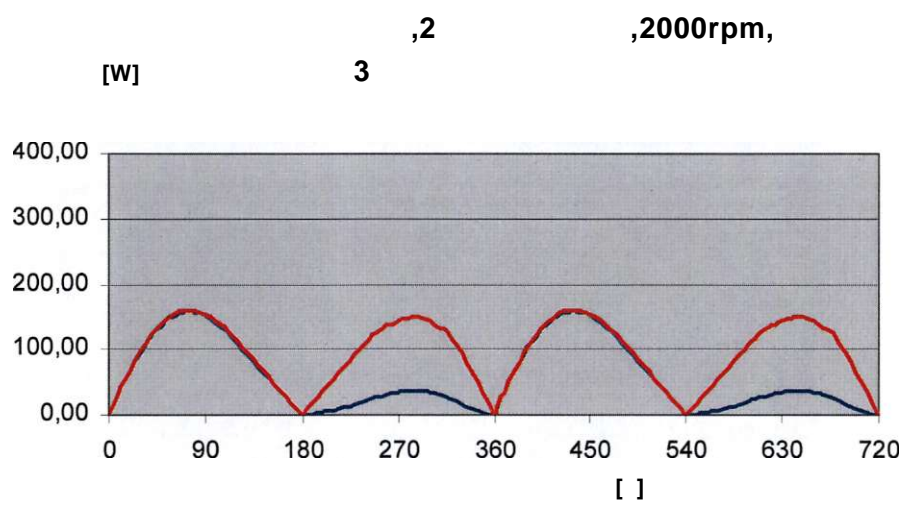
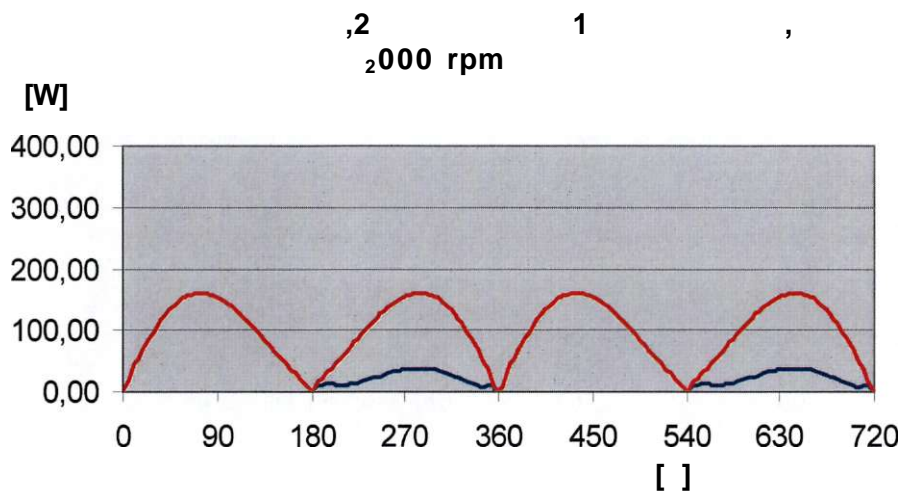
μ 3.94 (μ) - μ (μ μ).



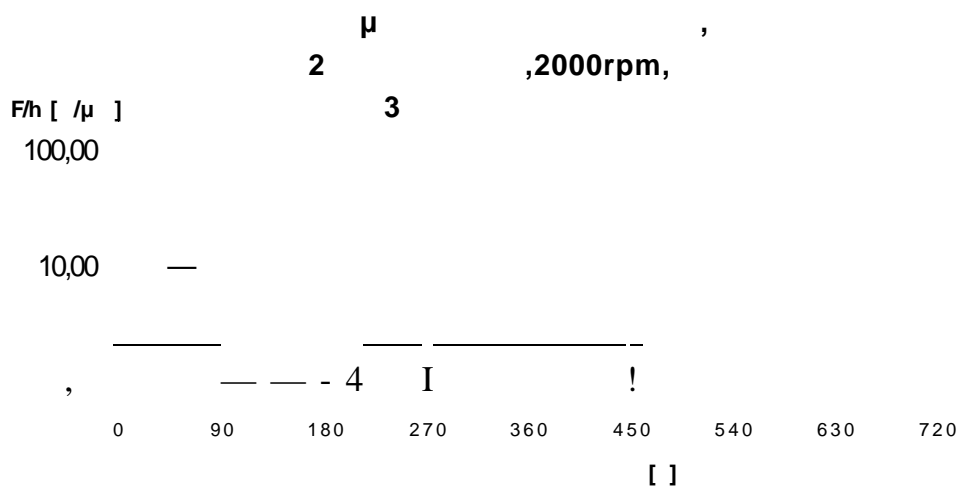
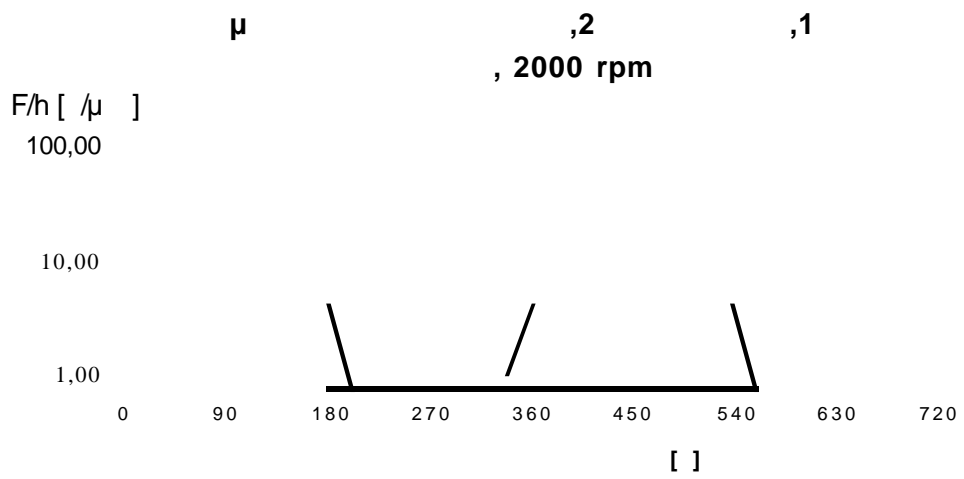
μ μ μ 3.95 μ
 (μ) - μ (μ).



μ 3.96 μ μ
 (μ) - μ (μ μ).

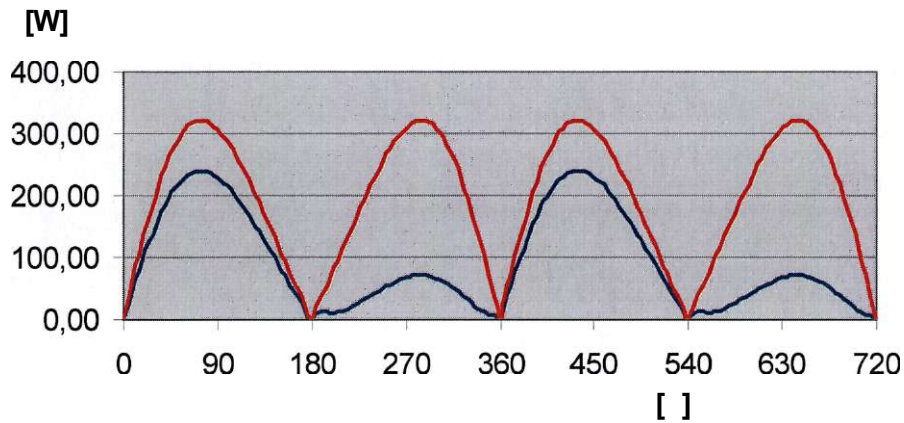


μ 3.97 $\mu\mu$ μ 2
(1, 3) μ n=2000 rpm

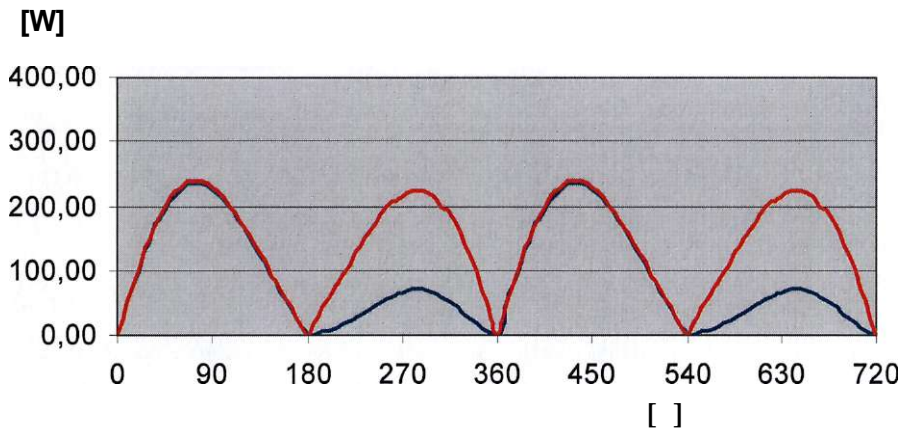


μ 3.98 $\mu\mu$ μ μ 2 μ
 n=2000 rpm

1, 2, 3000rpm,



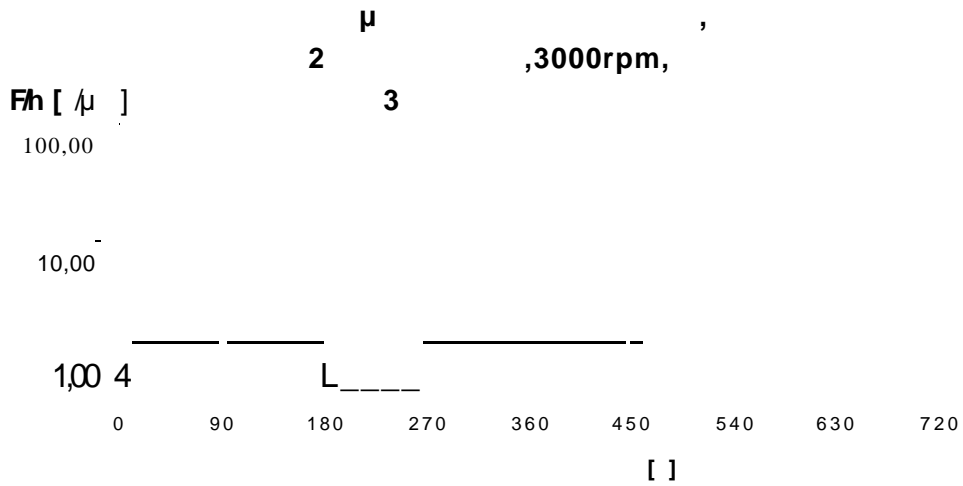
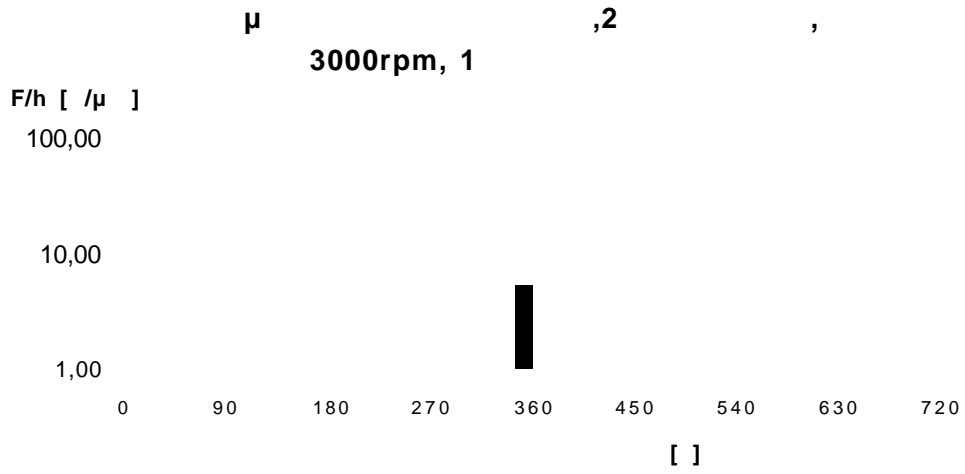
3, 2, 3000 rpm,



μ 3.99

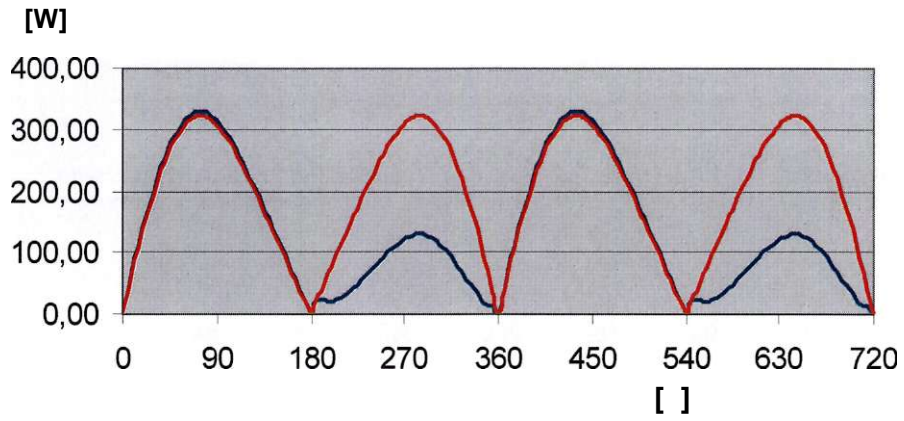
$\mu\mu$

2
(1, 3) μ
n=3000 rpm

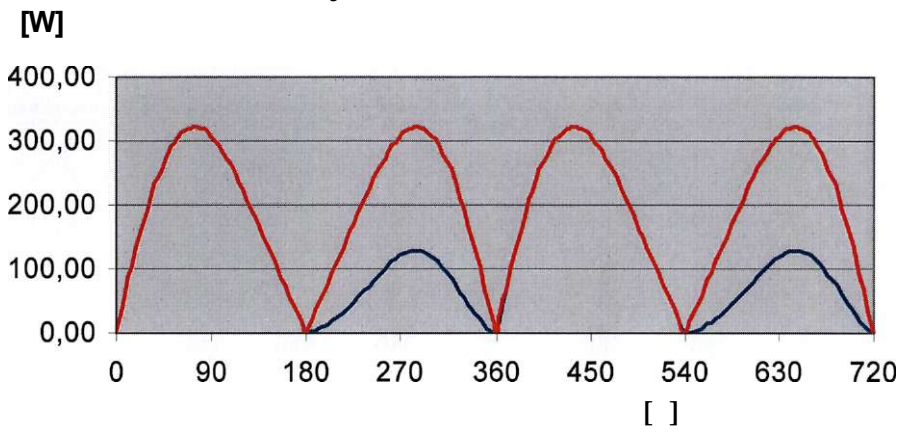


μ 3.100 μ μ μ 2 μ
n=3000 rpm

,2 , 4000rpm, 1



,2 , 4000rpm,
3



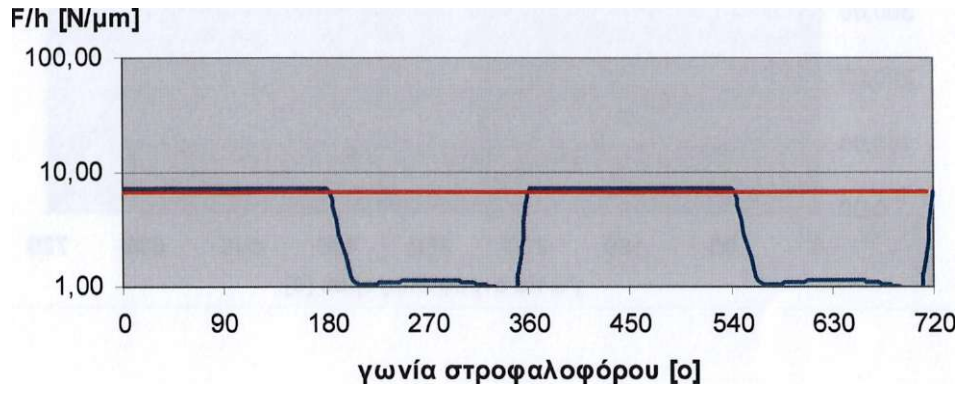
μ 3.101

$\mu\mu$

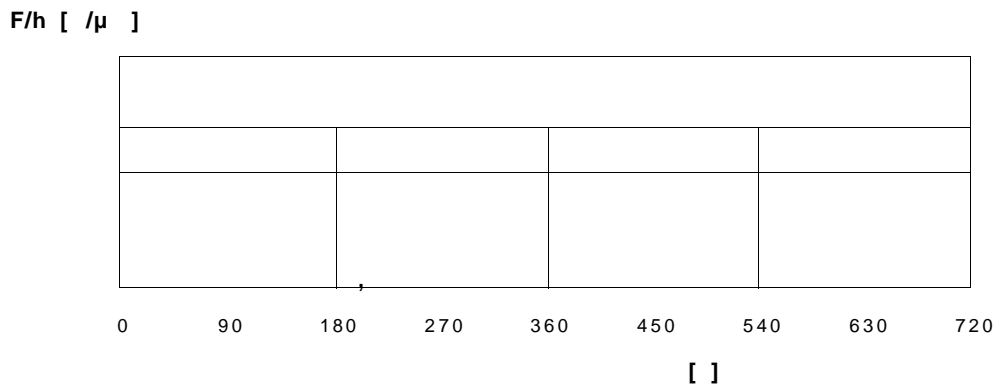
$\frac{2}{(1, 3)}$

μ
n=4000 rpm

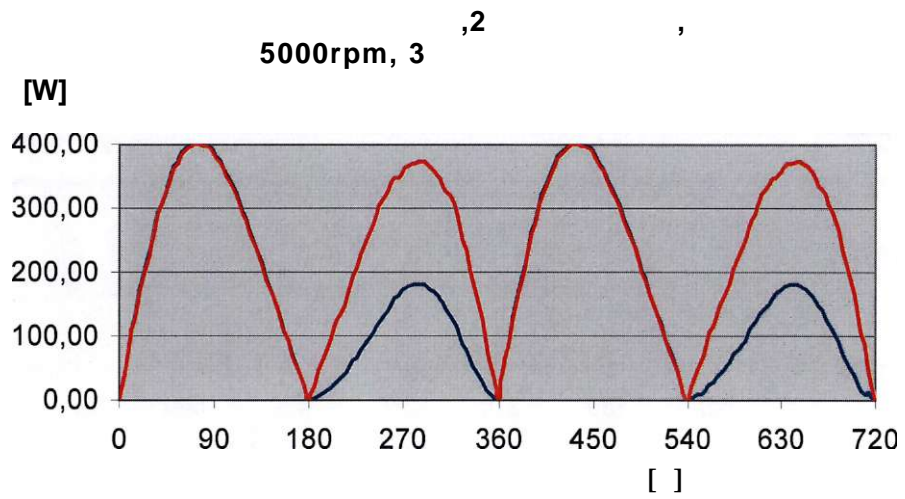
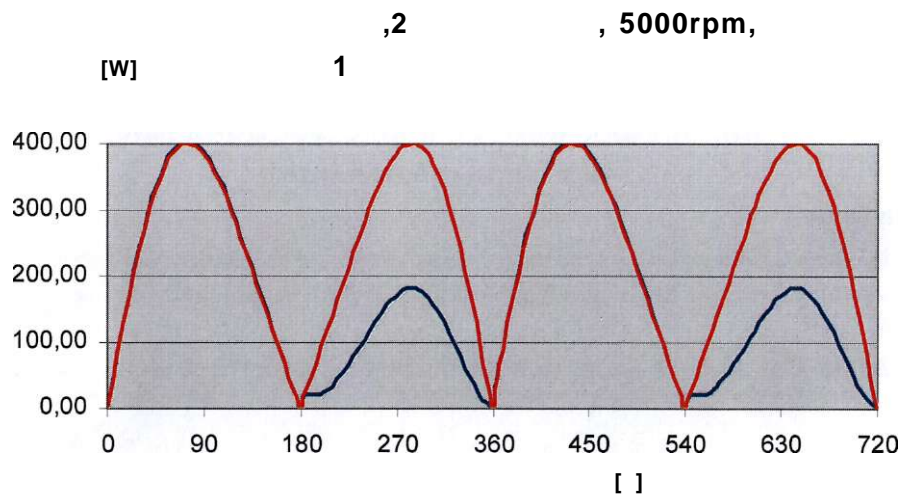
μ ,2 ,
4000 rpm,1



μ ,2 ,
4000rpm, 3



μ 3.102 μ μ 2 μ
n=4000 rpm

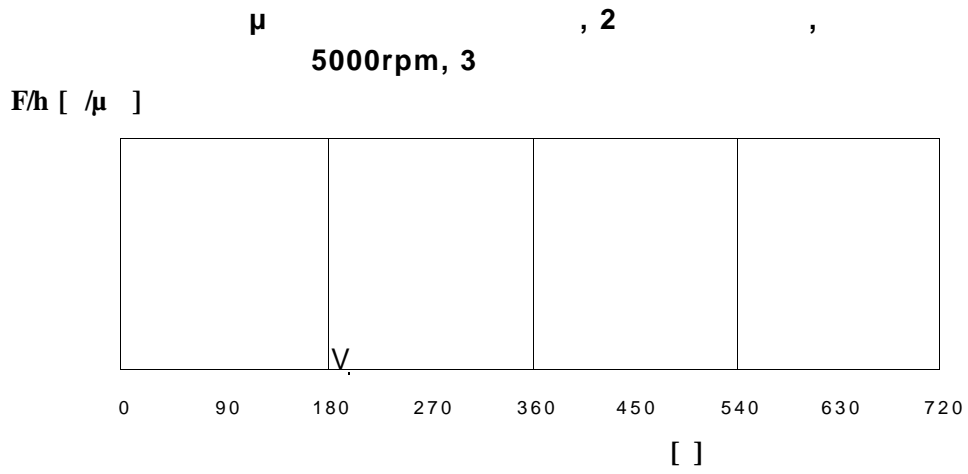
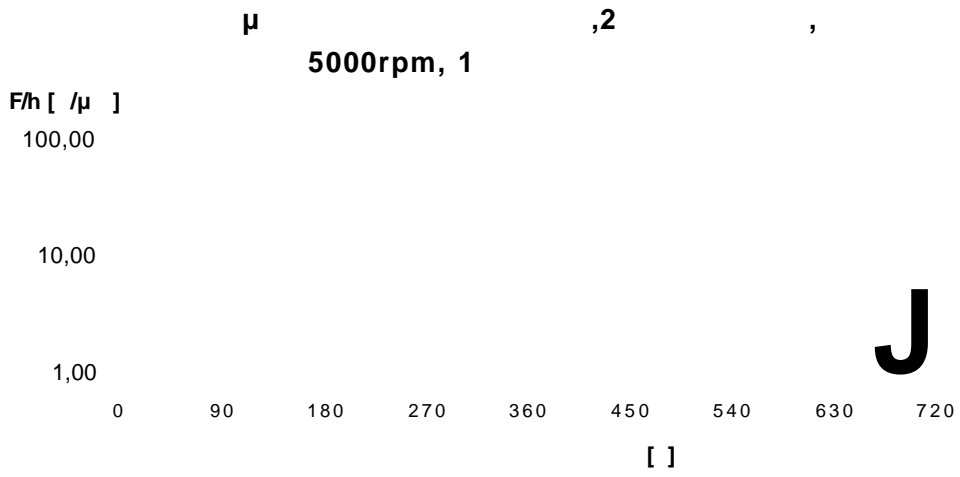


μ 3.103

$\mu\mu$

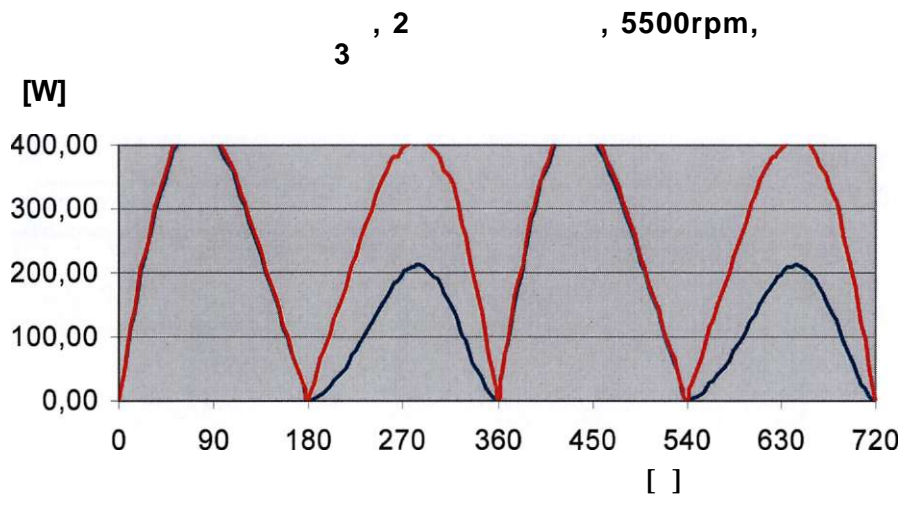
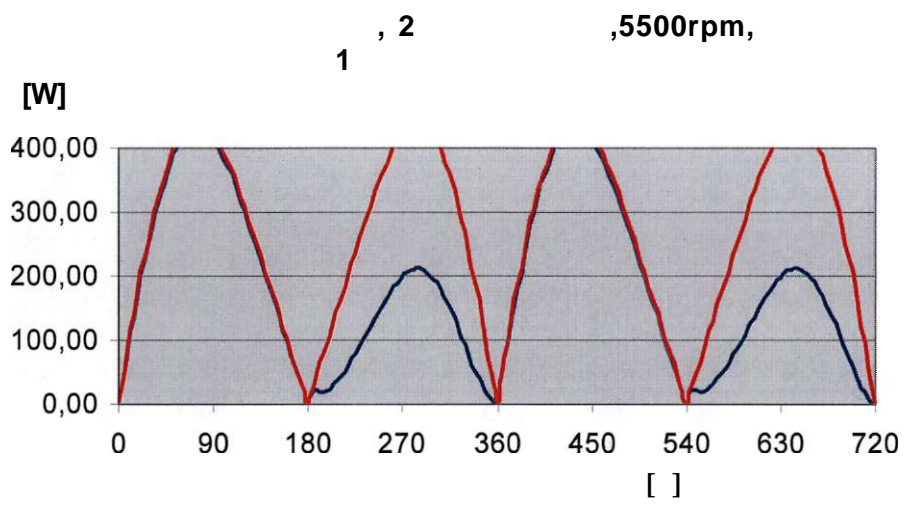
$\frac{2}{(1, 3)}$

μ
n=5000 rpm



μ 3.104 $\mu\mu$ μ 2 μ

n=5000 rpm

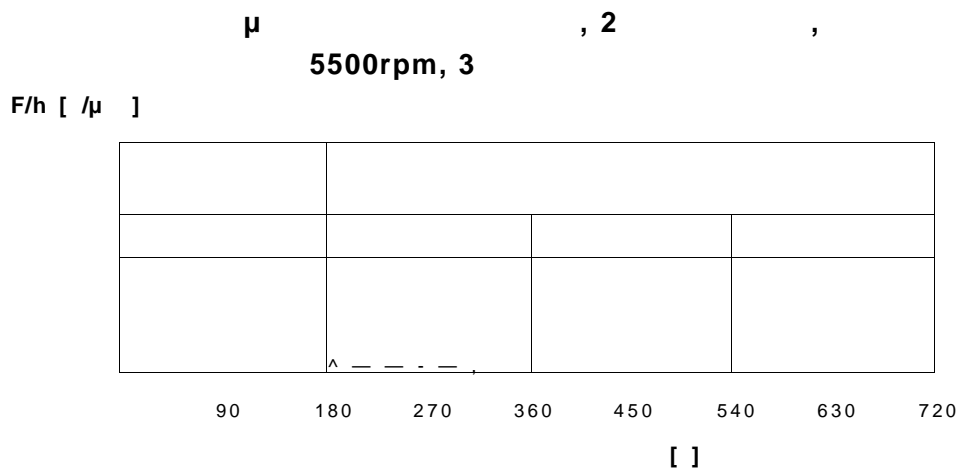
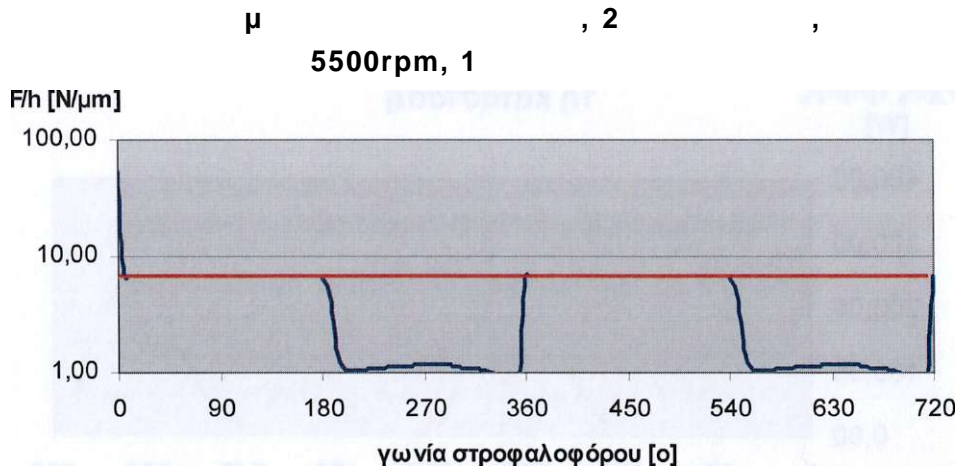


μ 3.105

$\mu\mu$

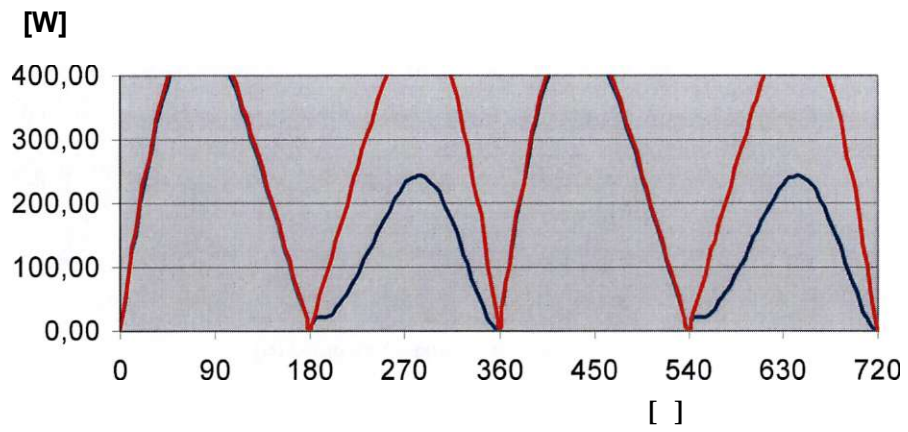
2
(1, 3)

μ
n=5500 rpm

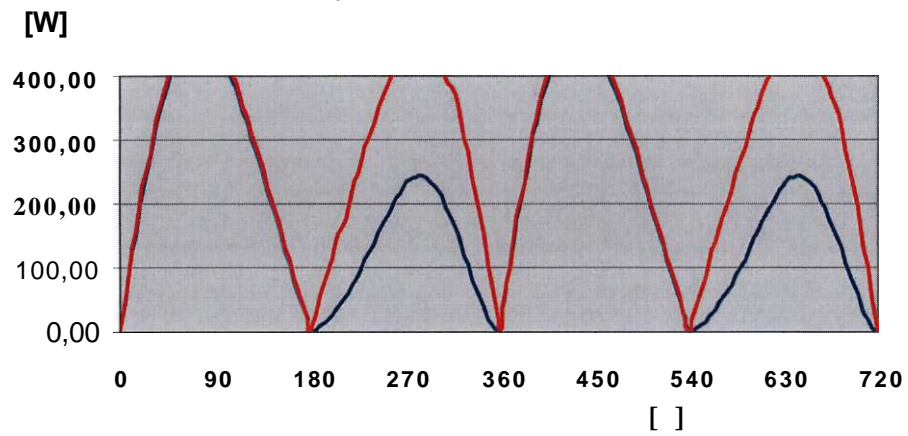


μ 3.106 μ μ 2 μ
n=5500 rpm

1, 2, 6000rpm,



3, 2, 6000rpm,



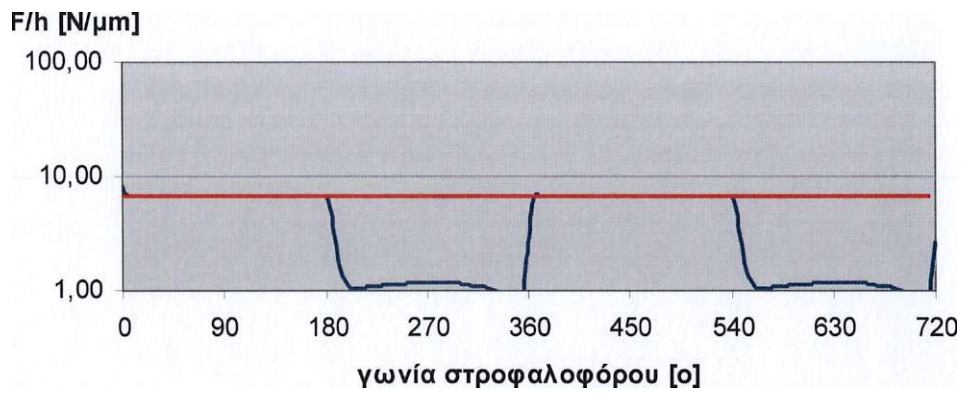
μ 3.107

$\mu\mu$

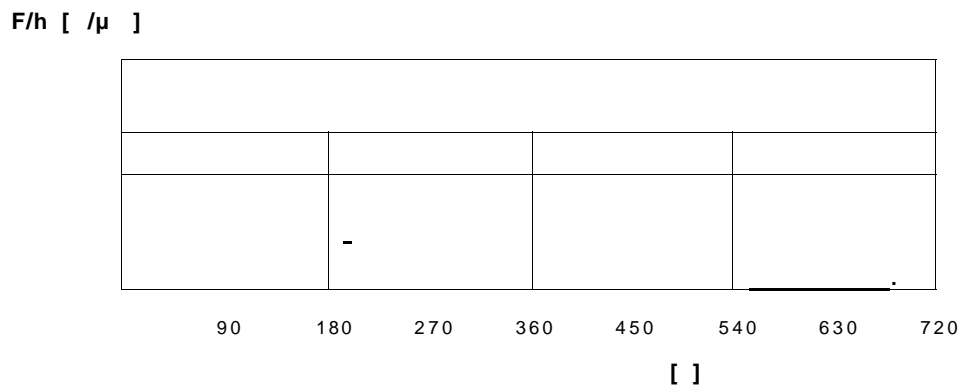
2
(1, 3)

μ
n=6000 rpm

μ , 2 ,
6000rpm, 1

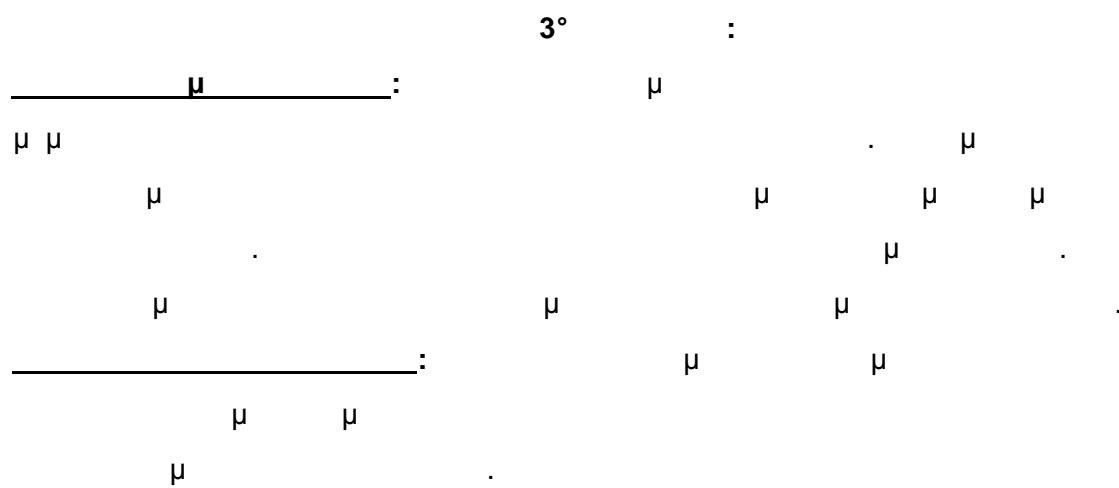


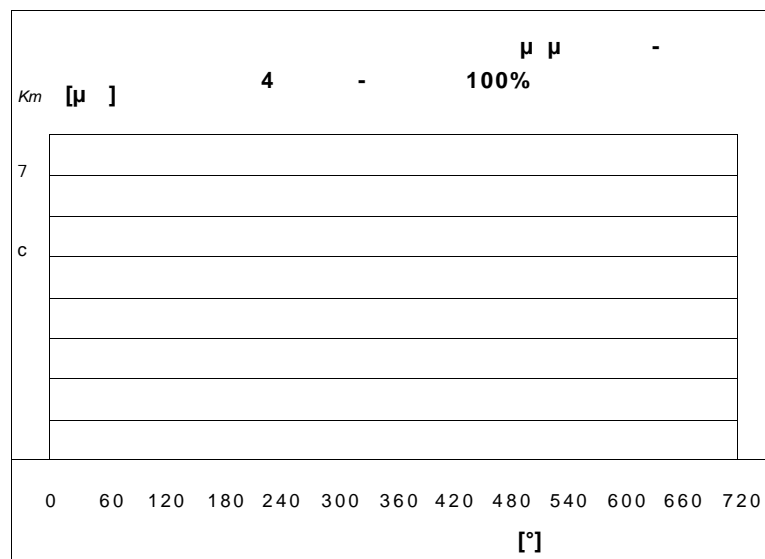
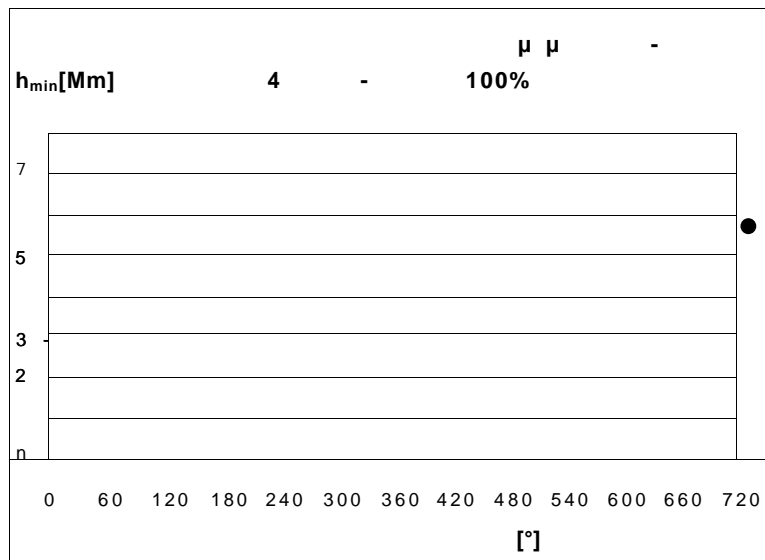
μ , 2 ,
6000rpm, 3



μ 3.108 μ μ μ 2 μ
n=6000 rpm

3ος ΔΑΚΤΥΛΙΟΣ - 2000-6000 γραμ - ΠΛΗΡΕΣ ΦΟΡΤΙΟ





μ 3.109 μ $\mu \mu$ μ -
 1 3 .

Ftot[N]		μ - 4 -											
		100%											
40													
30													
20													
10													
-10													
-20													
-30													
-40													
-50													
	D	60	120	180	240	300	360	420	480	540	600	660	720
	[°]												

μ 3.110

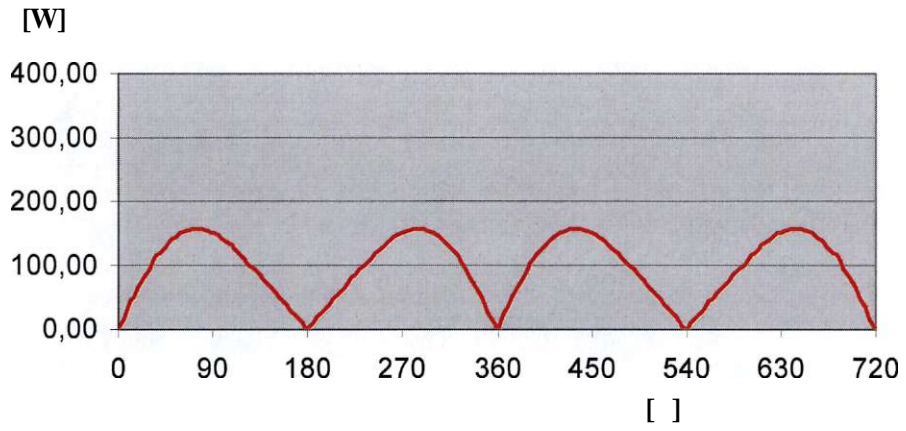
μ

μ -

1

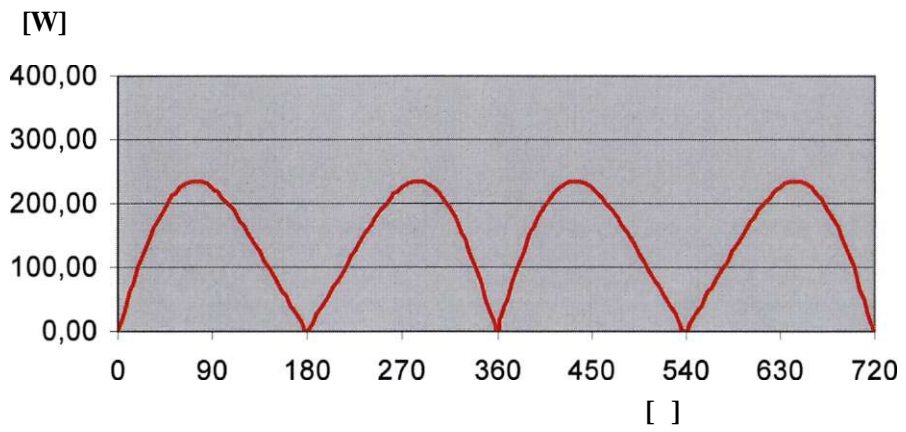
3

1,3, 2000rpm,

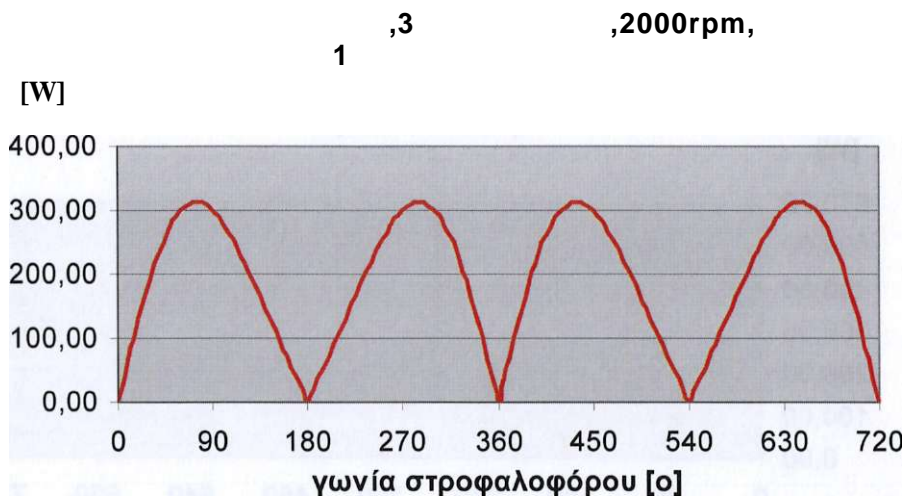


μ 3.111 μμ 3 μ
n=2000rpm.

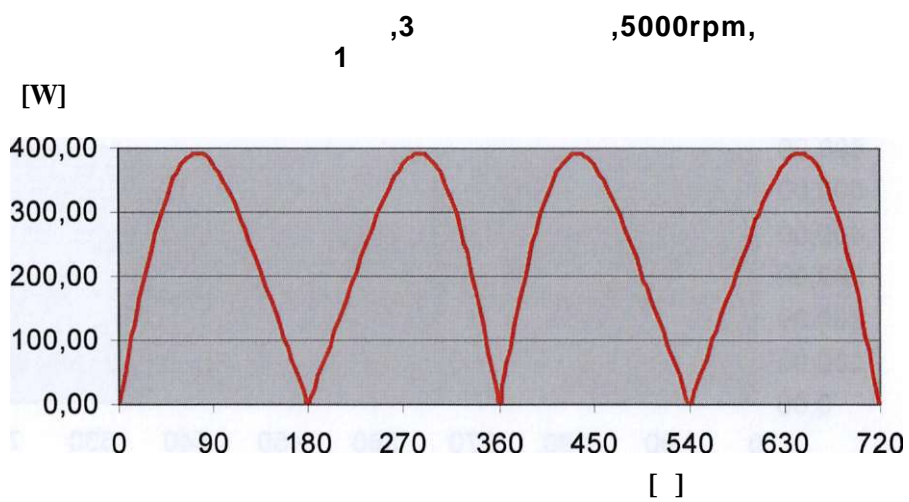
1,3, 3000rpm,



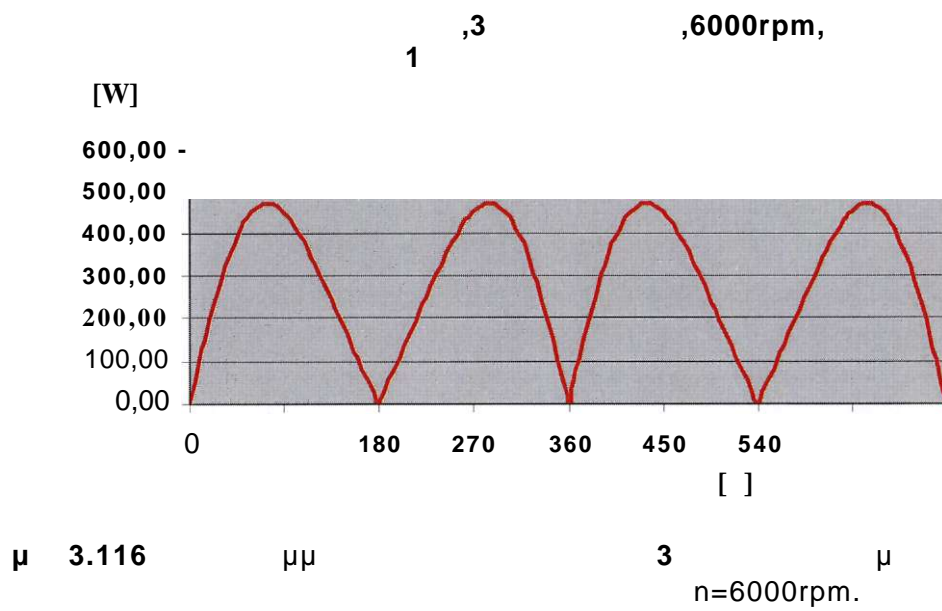
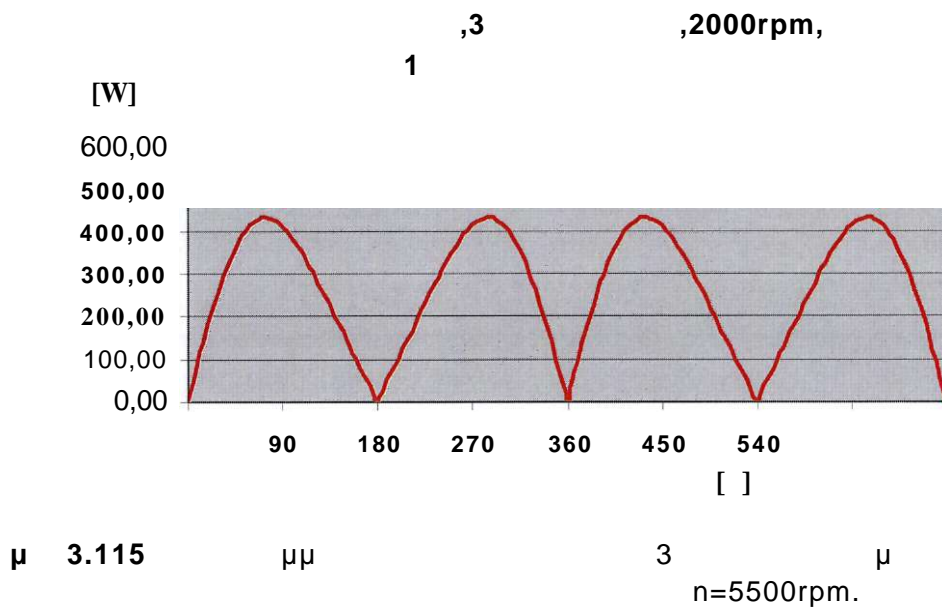
μ 3.112 μμ 3 μ
n=3000rpm.

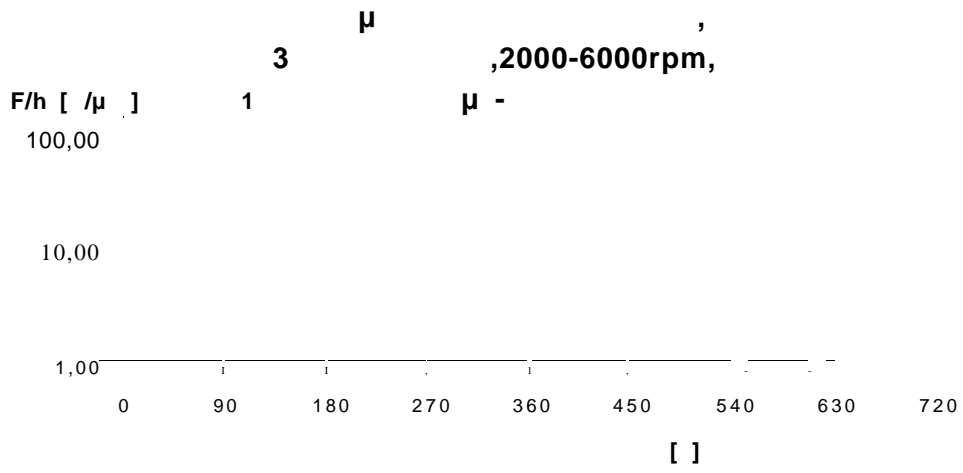


μ 3.113 μμ 3 μ
n=4000rpm.

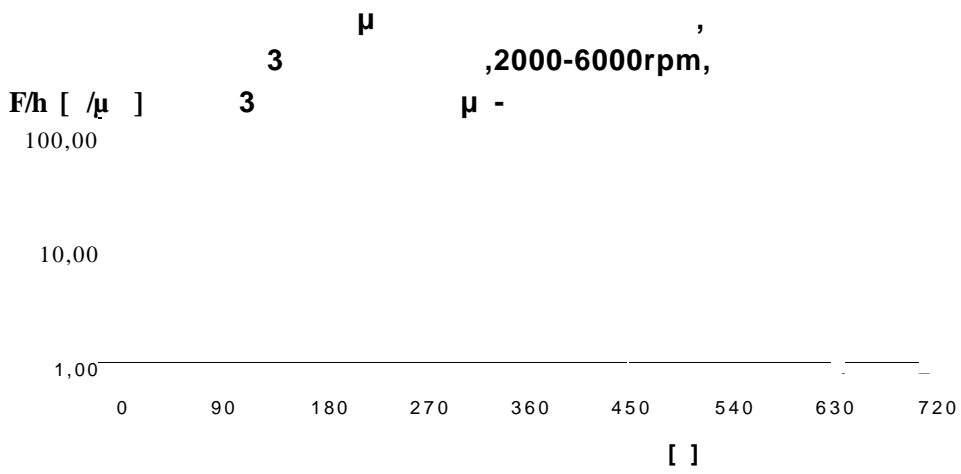


μ 3.114 μμ 3 μ
n=5000rpm.





()

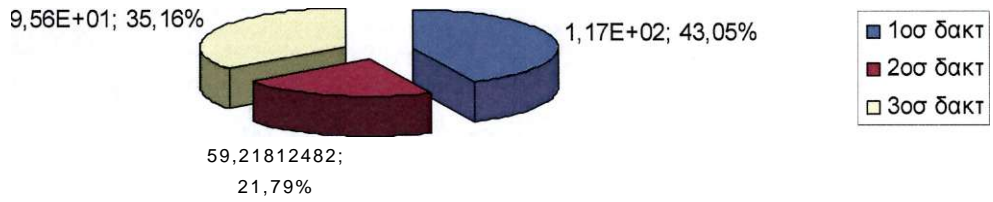


()

μ 3.117 μμ μ μ 3 μ 2000-6000rpm. (,)

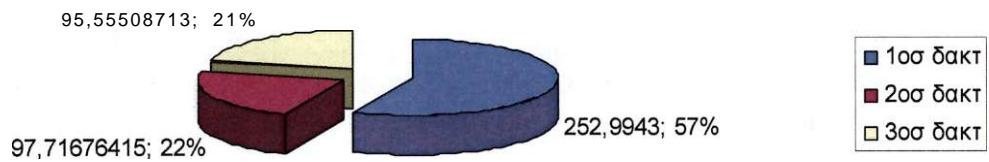
μ μ μ μ μ

μ
2000 rpm- μ 1



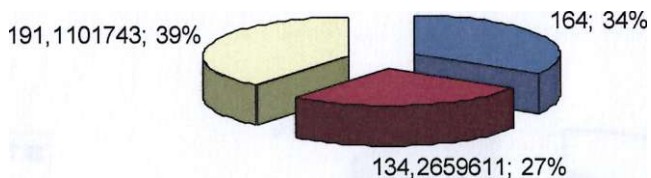
μ 3.118 μ μ
1 . 2000 rpm, μ

μ
2000 rpm- 1



μ 3.119 μ μ
1 . 2000 rpm,

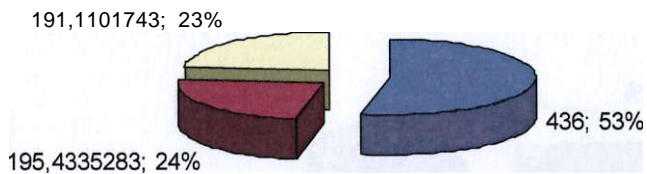
μ
4000 rpm- μ 1



- 1
- 2
- 3

μ 3.120 μ μ ,
1 . 4000 rpm, μ

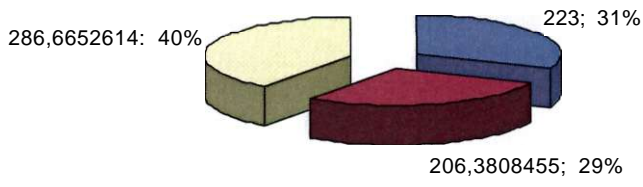
μ
4000 rpm- 1



- 1
- 2
- 3

μ 3.121 μ μ ,
 1 . 4000 rpm,

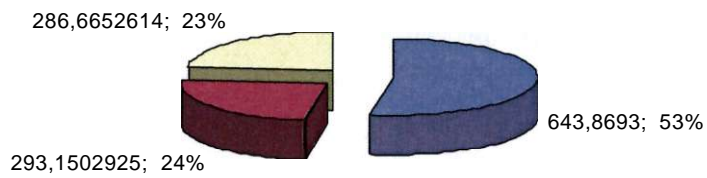
μ
 6000 rpm- μ 1



- 1
- 2
- 3

μ 3.122 μ μ ,
 1 . 6000 rpm, μ

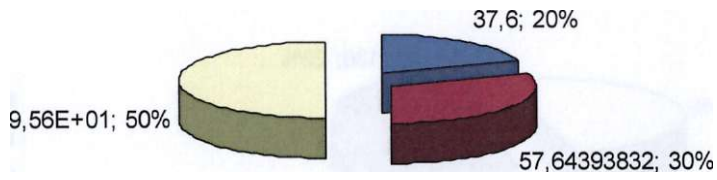
μ
 6000 rpm- 1



- 1
- 2
- 3

μ 3.121 μ μ . 4000 rpm, ,
1

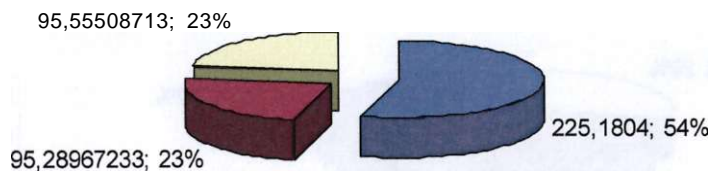
μ
2000 rpm- μ 3



- 1
- 2
- 3

μ 3.124 μ μ . 2000 rpm, μ ,
3

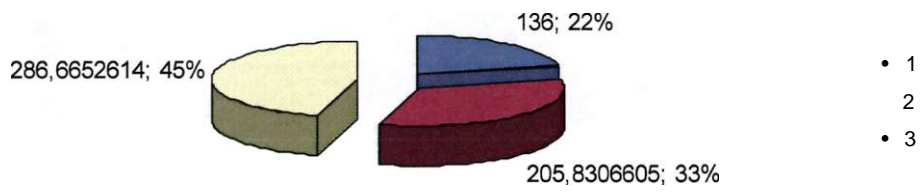
μ
2000 rpm- 3



- 1
- 2
- 3

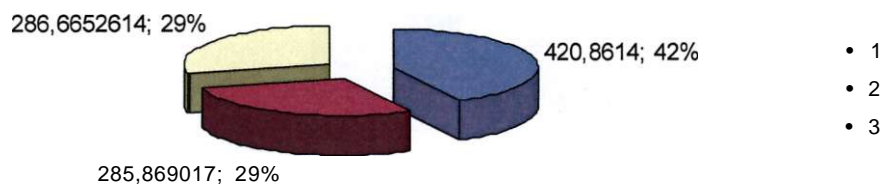
μ 3.121 μ μ , 4000 rpm, 1

μ 6000 rpm- μ 3



μ 3.126 μ μ , 6000 rpm, μ 3

μ 6000 rpm- μ 3



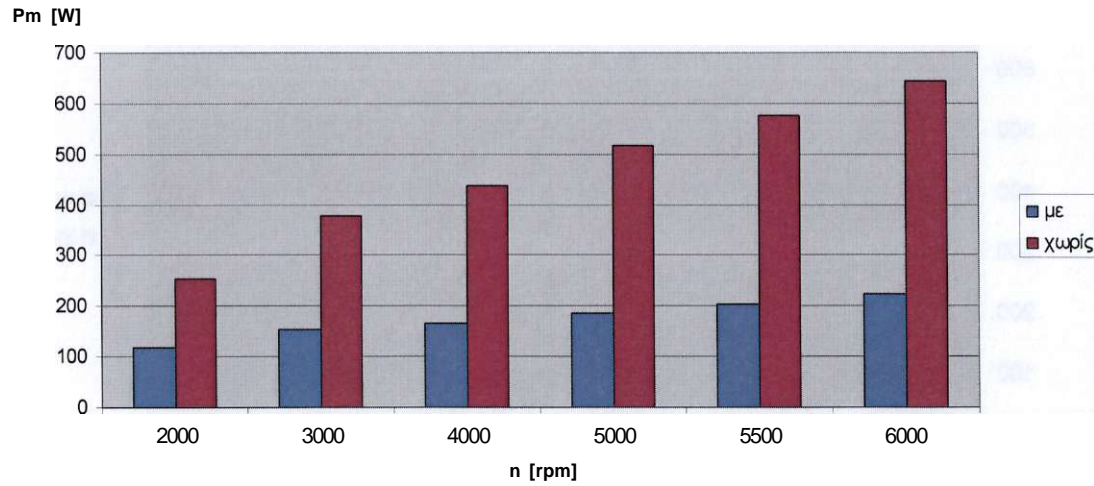
μ 3.121

μ μ

4000 rpm,

1

Pm [W], 1 , 1

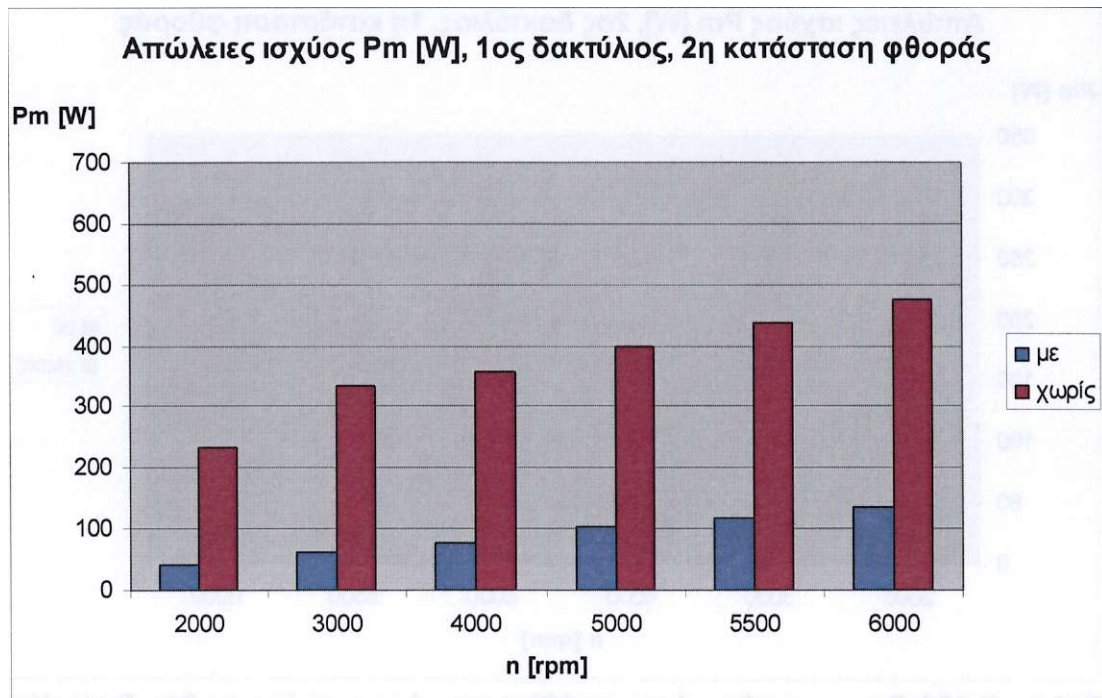


μ 3.128

μ

1⁰

- 1



μ 3.129

- 1

μ

. 1

Pm [W], 1

, 3

Pm [W]

700

600

500

400

300

200

100

J

2000

3000



n [rpm]

1 1

μ 3.130

- 1

μ

. 1⁰

Pm [W], 2

, 1

Pm [W]

350

300

250

200

150

100

50

0

2000

3000

n [rpm]



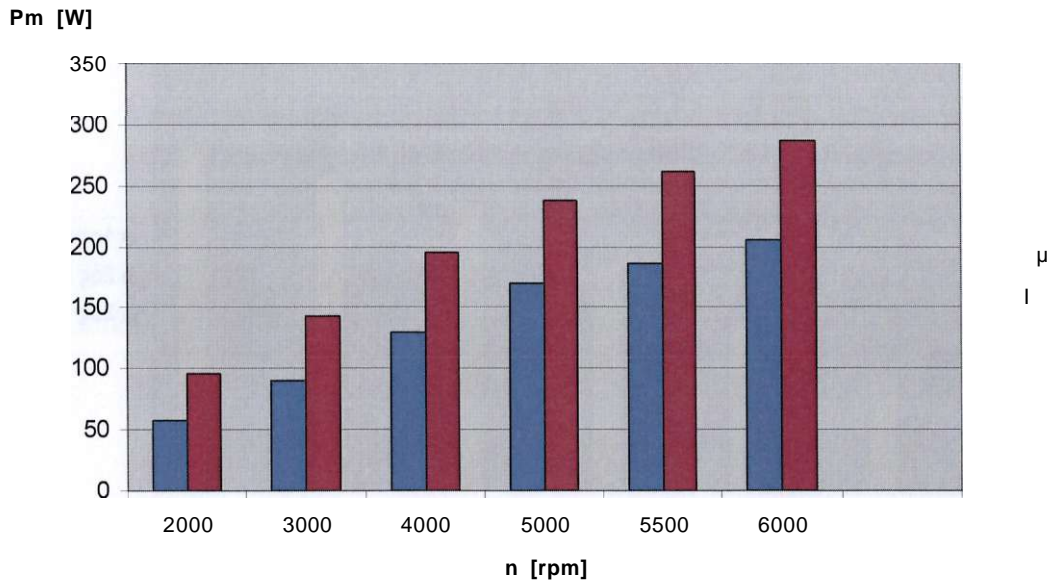
μ 3.131

- 1

μ

. 1

Pm [W], 2 , 3

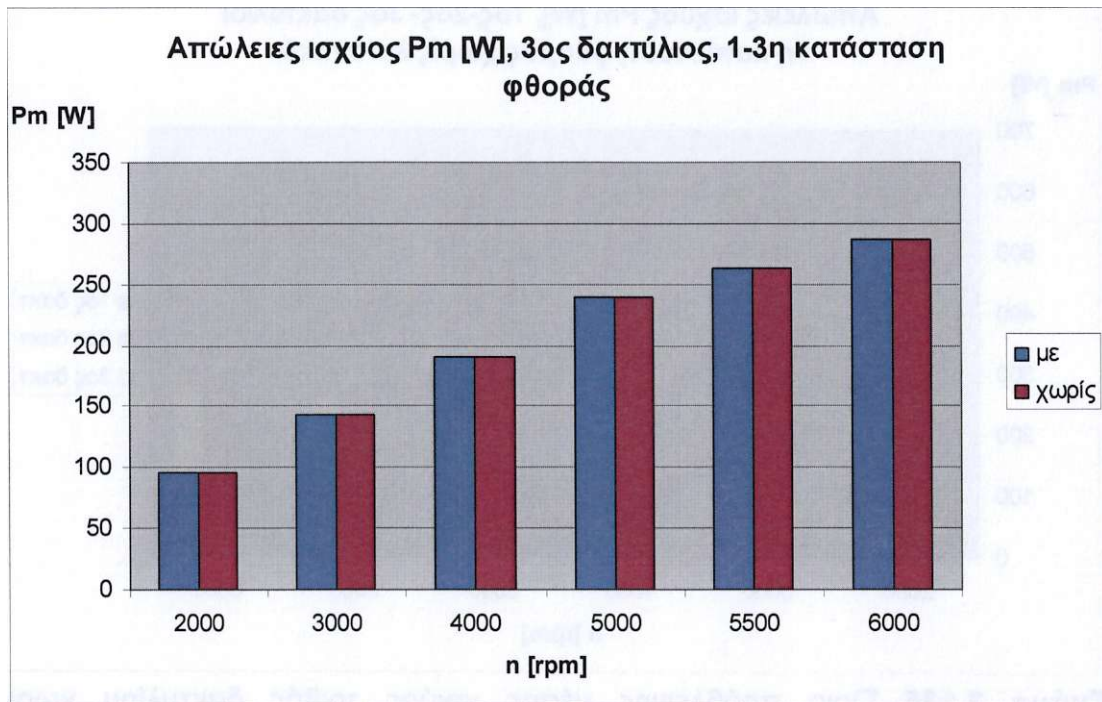


μ 3.132

μ

- 1

. 1

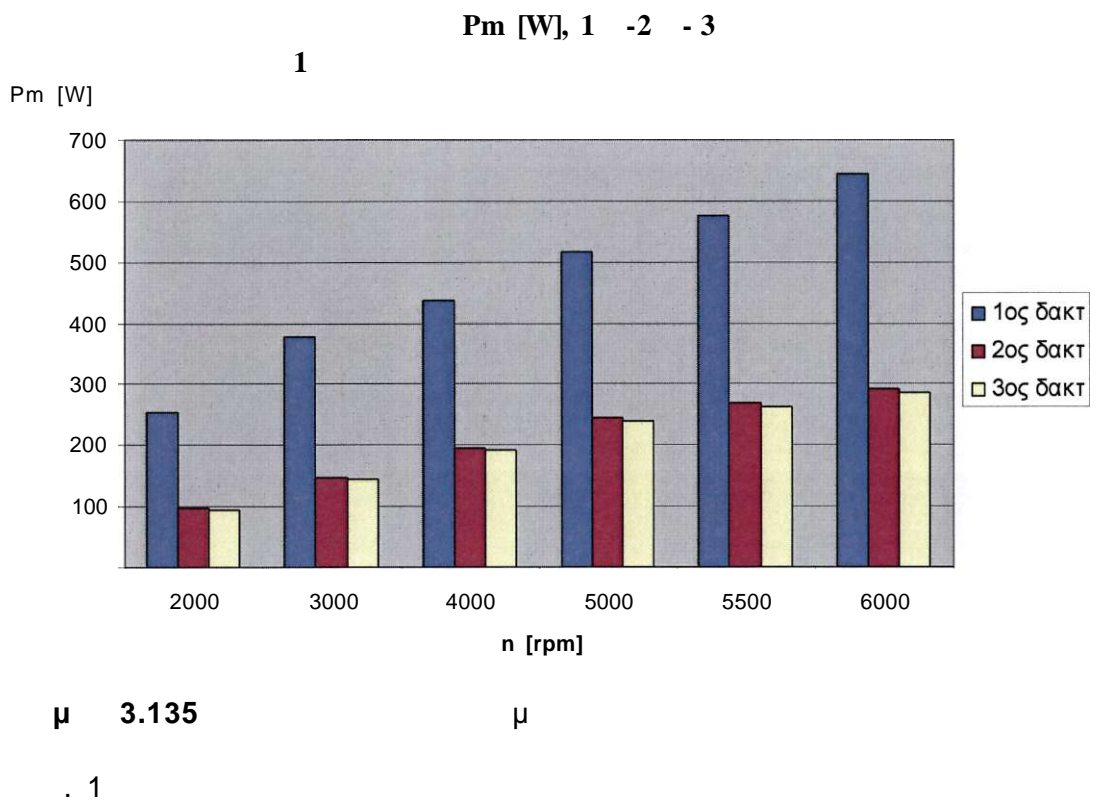
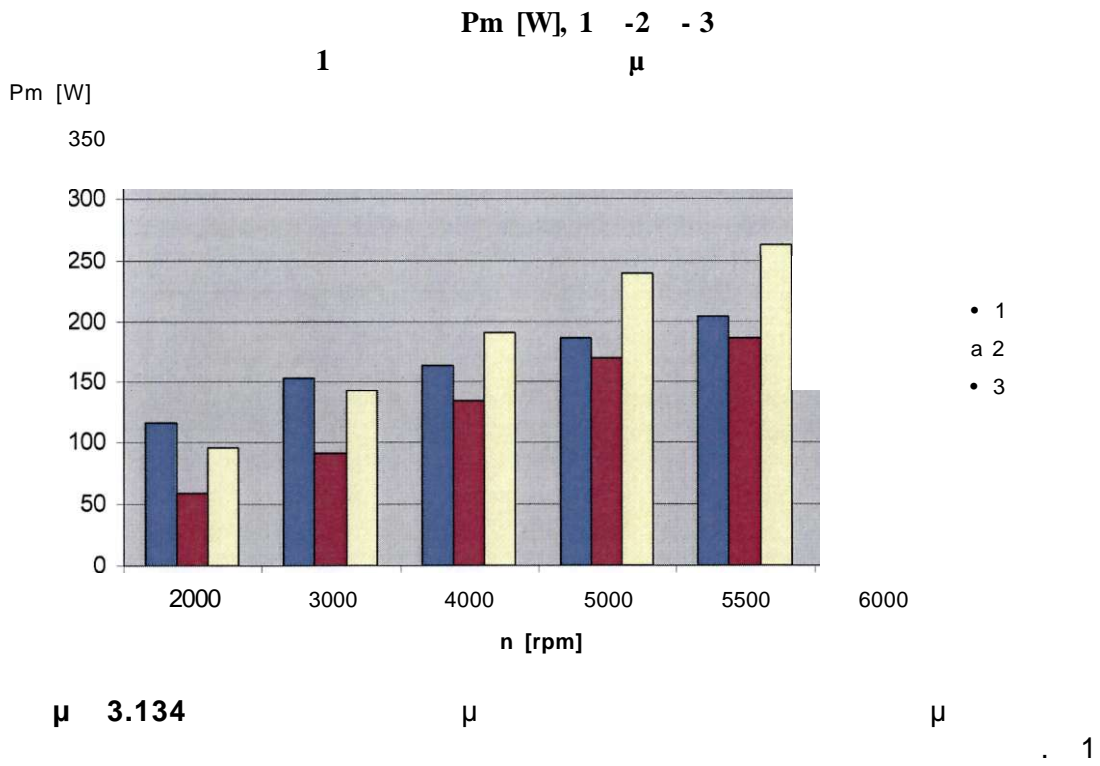


μ 3.133

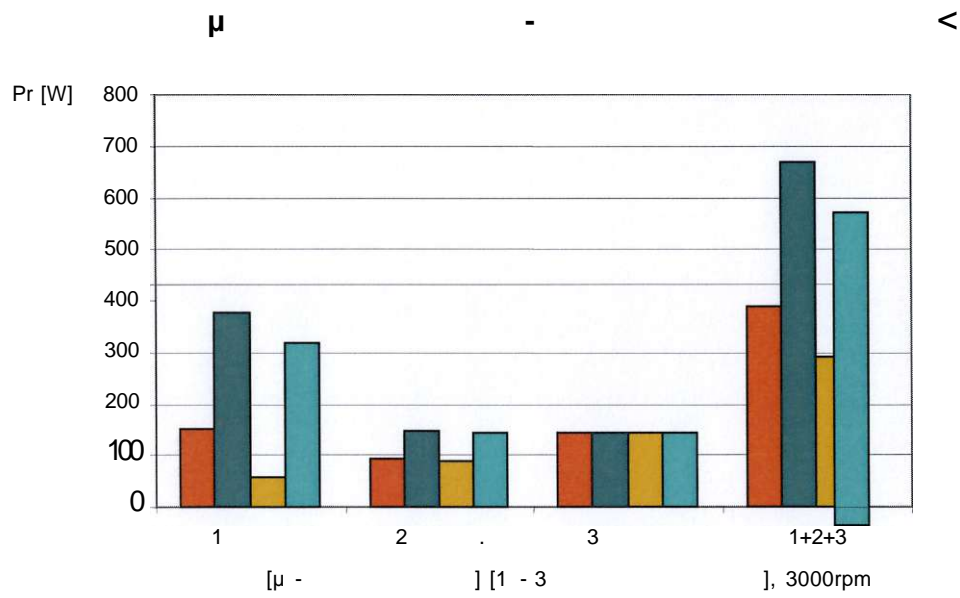
μ

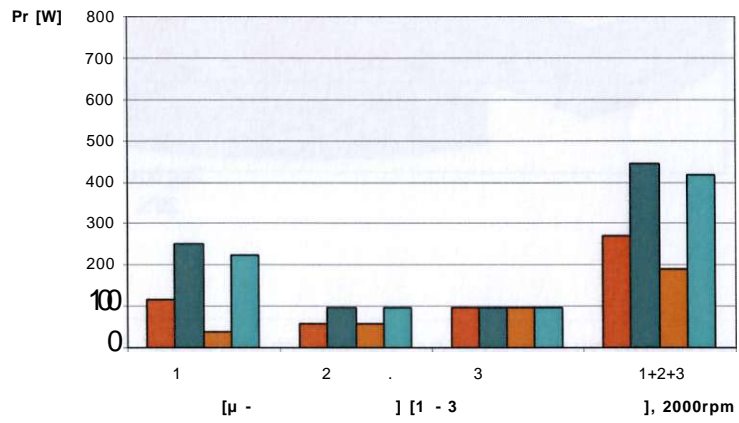
- 1

. 1



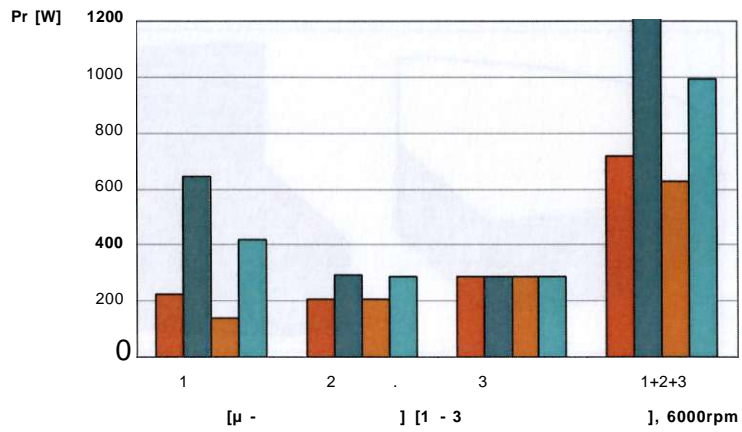
Συμπεράσματα - Προοπτικές





4.1

n=2000rpm.

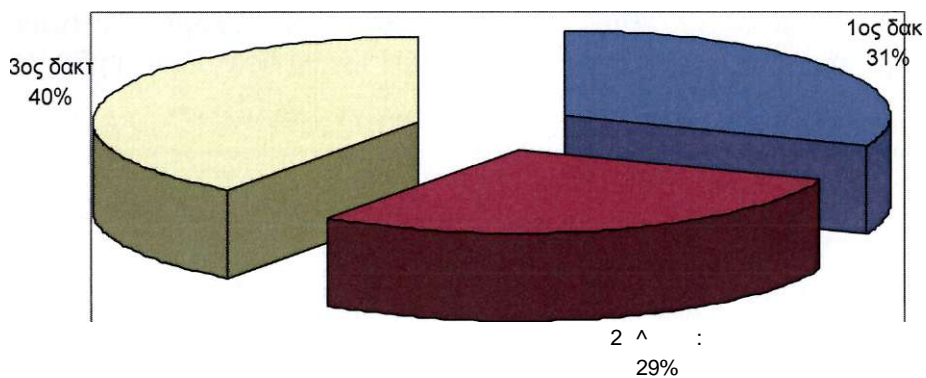


4.2

n=6000rpm.

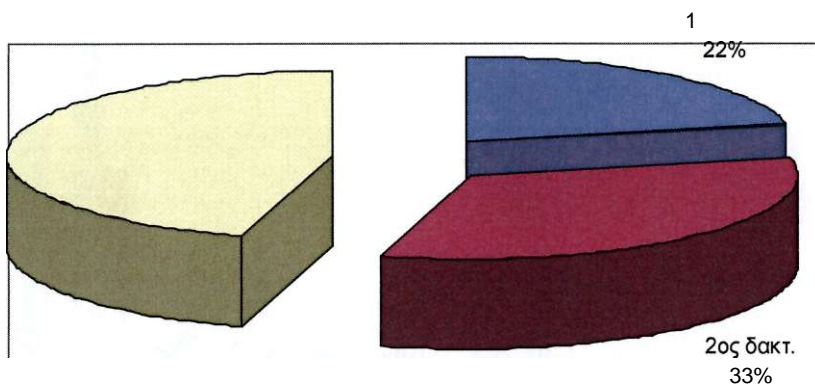
6000rpm (μ μ)

μ μ μ μ μ μ μ μ μ
 3 2 -3 , 1 2 . . . 1 3 μ 1



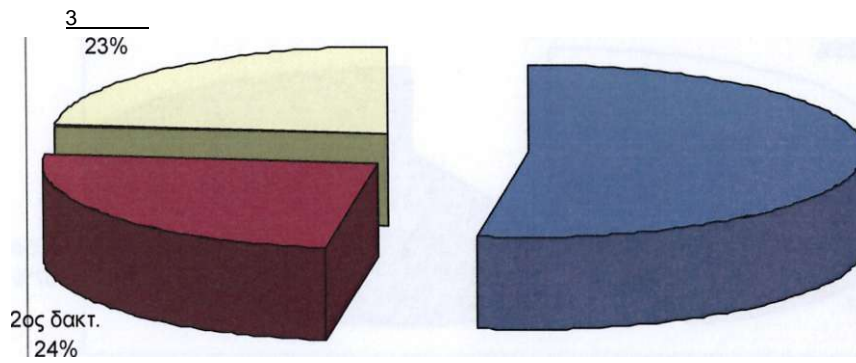
μ 4.3 μ μ . 6000 rpm, μ 1

μ -



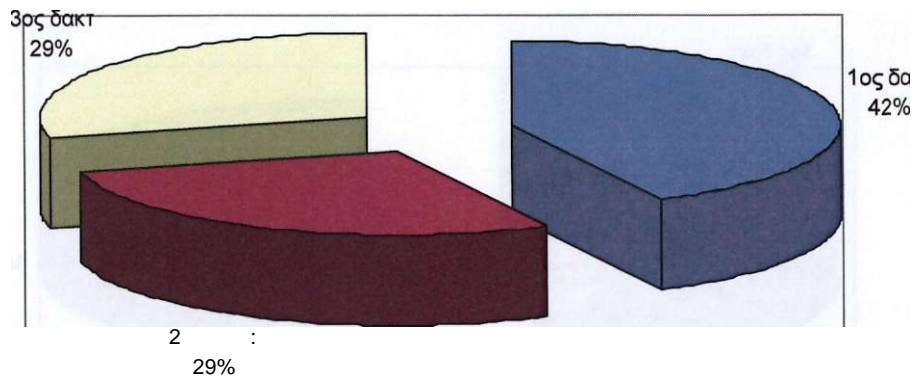
μ 4.4 μ μ . 6000 rpm, μ 3

μ -

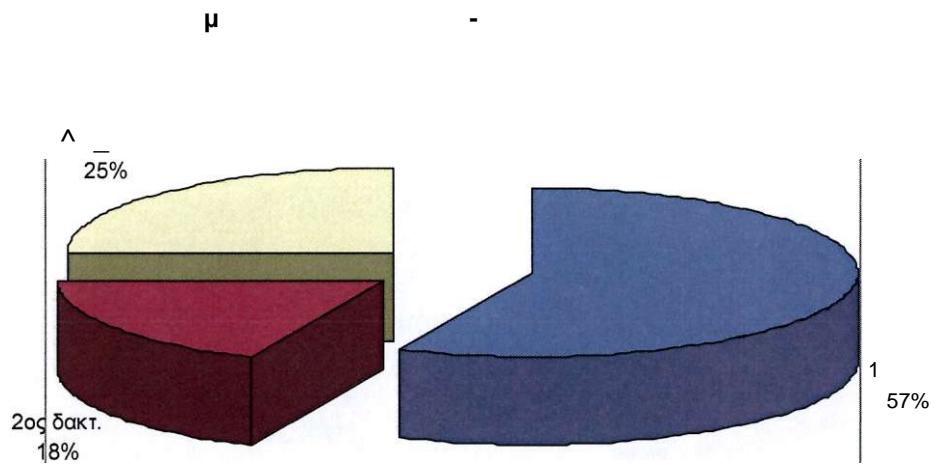


μ 4.5 μ μ , 6000rpm, 1

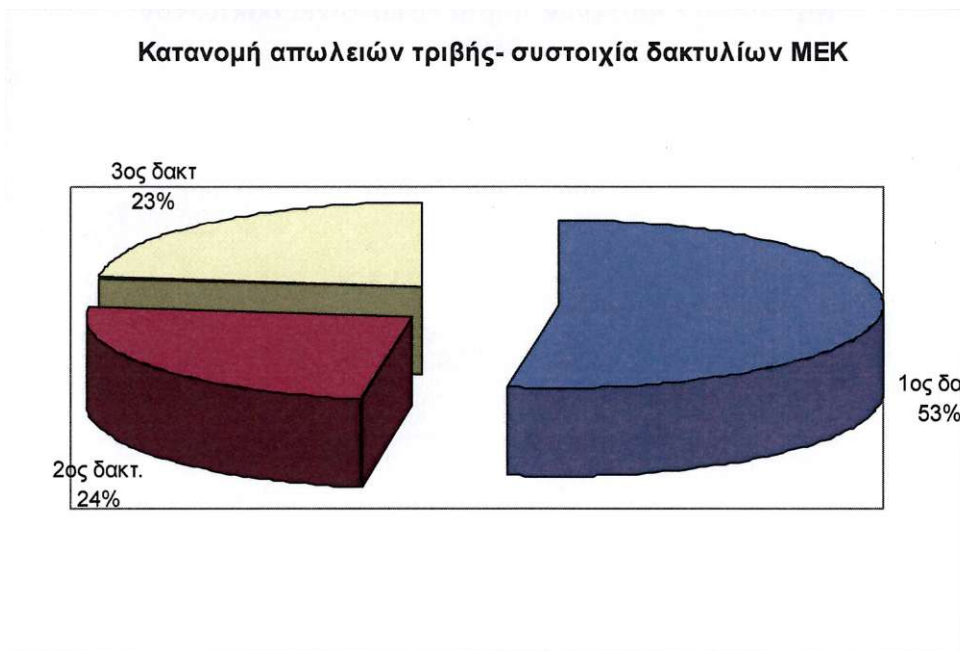
μ -



μ 4.6 μ μ , 6000rpm, 3

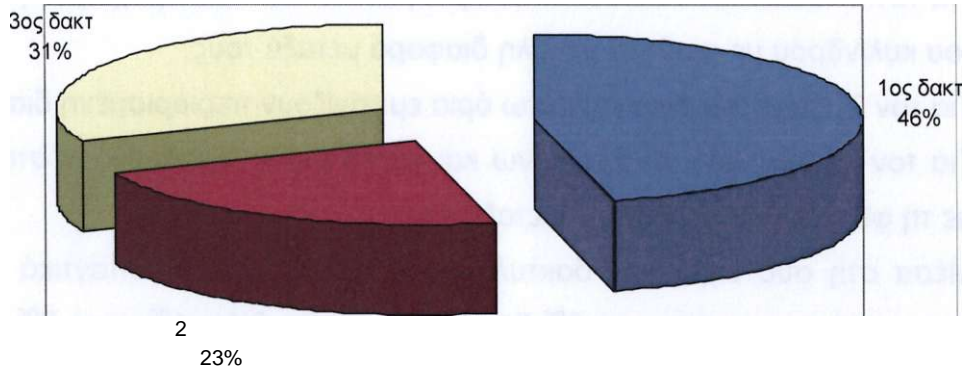


μ 4.7 μ μ , μ 2 3 6000rpm, 1 1



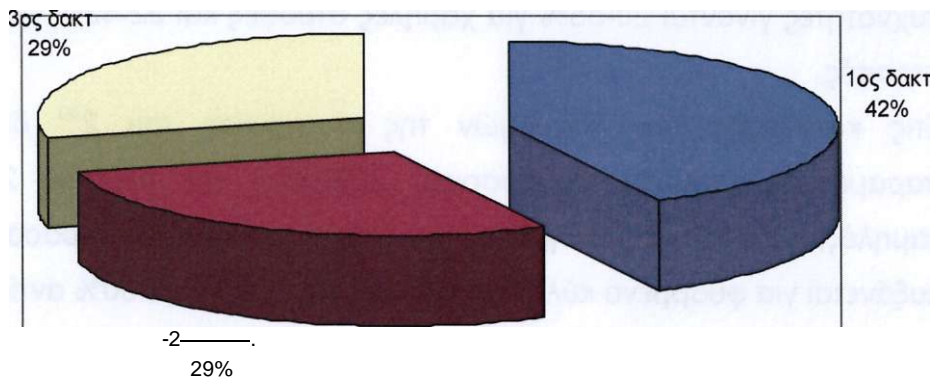
μ 4.8 μ μ , μ 3 1 6000rpm, 1 2

μ -



μ 4.9 μ μ , μ 2 3 6000rpm, 3 1

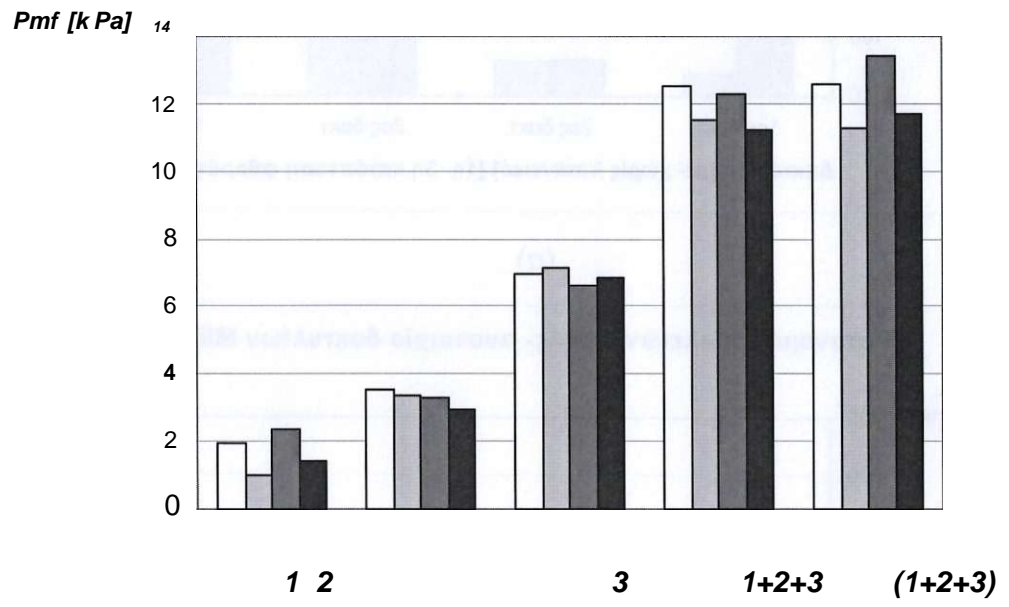
μ -



μ 4.10 μ μ , μ 3 3 6000rpm, 3 1 2

- μ μ :
- 1) 1° μ .
 - 2) 2° μ μ μ
 - 3) 3° , μ μ
 - 4) μ , μ
 - μ 3 , 1 2
μ 1
 - 5) 3 . μ
 - 6) 1 , (100%
). μ , 1
μ μ 40-50% 1
μ μ 35-55% μ 30-
50% .
 - 7) μ ,
20-55% μ 22-42%
 - 8) μ 2
μ 22%,25% 28%
μ , μ ,
 - 9) μ μ 22 30% .
3° , μ μ μ
20-50% μ μ μ , μ μ
μ μ μ μ
1 .
μ μ
μ μ 500 2000W
2000-6000 rpm

μ 1°
 $(\mu \ 4.11)$
 μ μ μ μ μ
 μ μ μ
 μ μ μ μ μ
 $(\mu \ 4.14-4.17)$



$\mu \ 4.11$ $\rho_{mf} [kPa]$ μ
 μ *
 1. ()
 2: ()
 3: ()
1+2+3 : , μ μ μ
(1+2+3) \ , μ μ
 μ

*

:

/

500 rpm/70 mPa.s, 500 rpm/11 mPa.s, 955 rpm/70 mPa.s, 955 rpm/11 mPa.s

μ

,

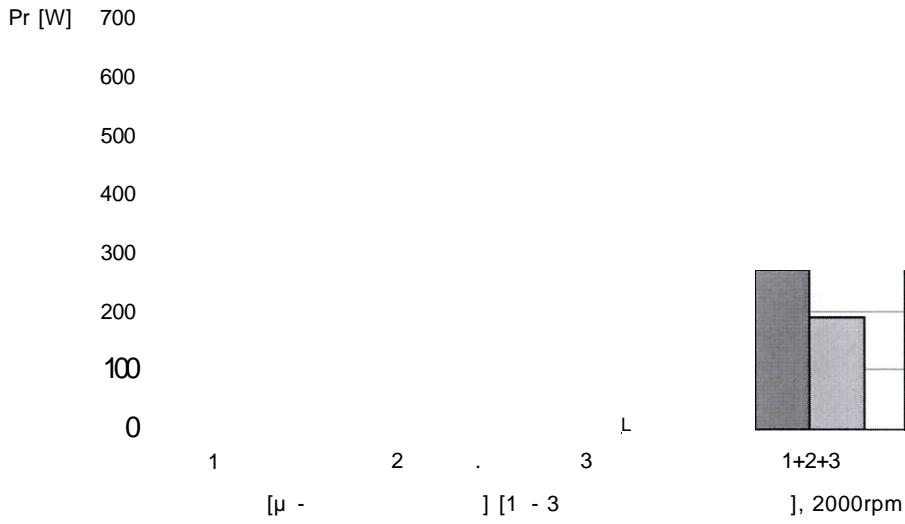
μ

Renault 851-

541 ³/

μ

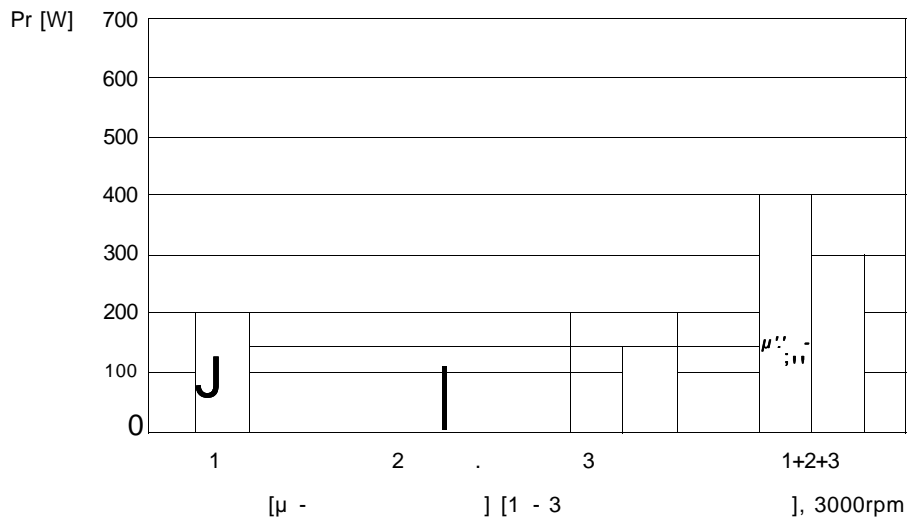
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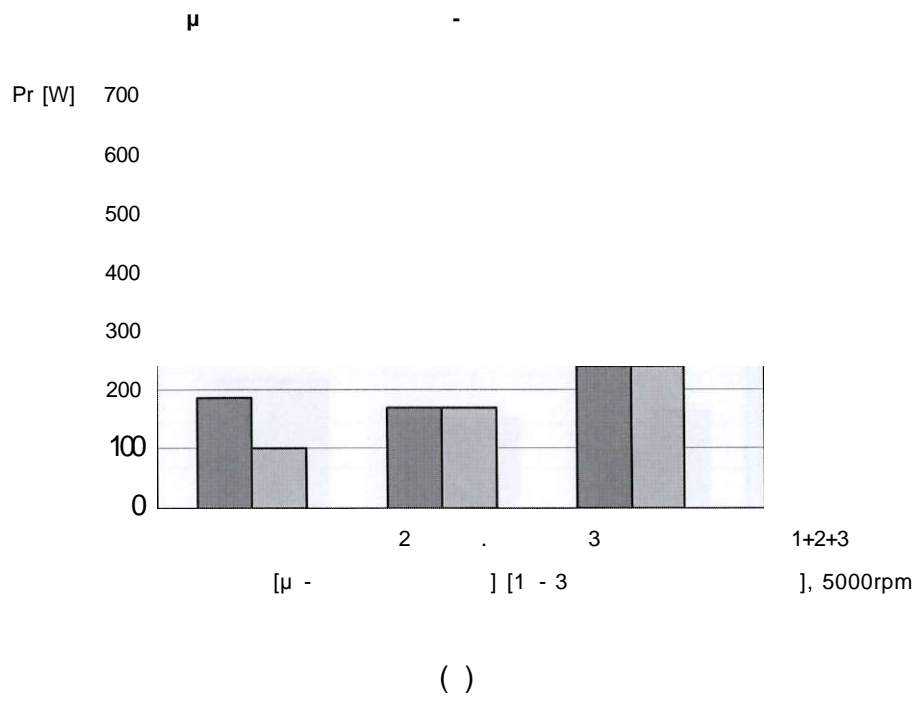
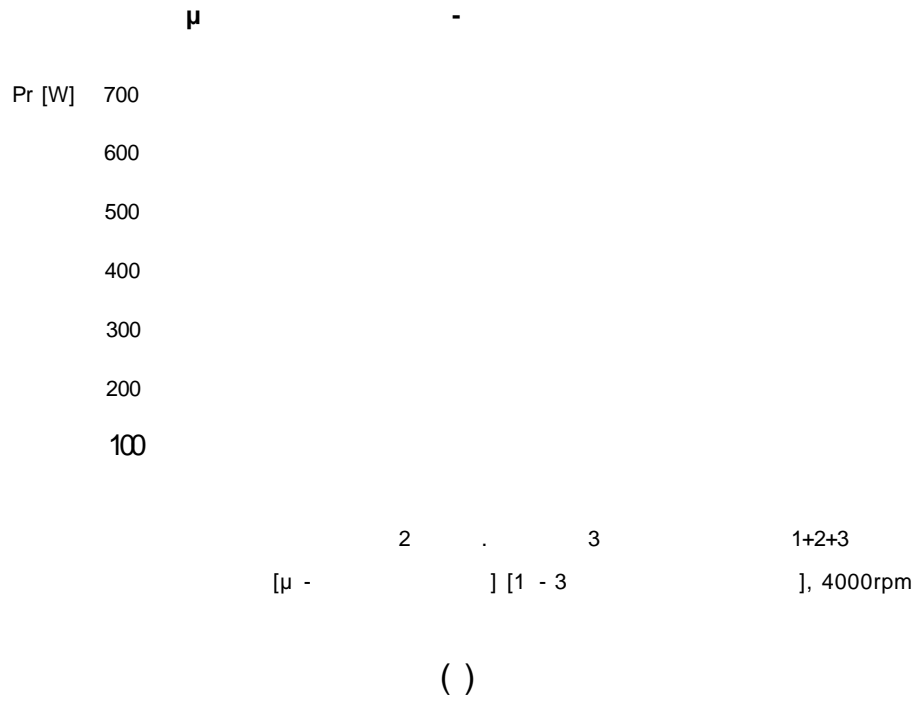
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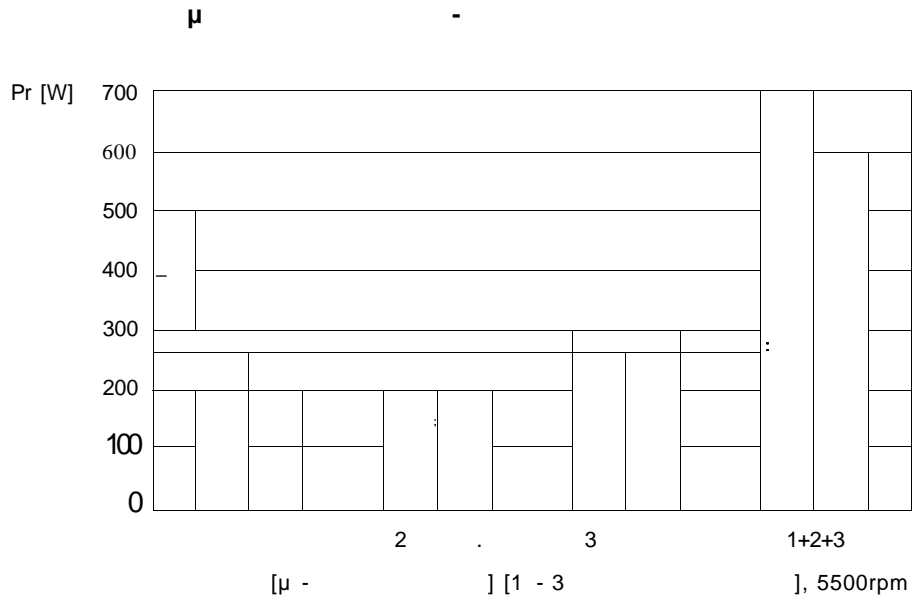
μ

-

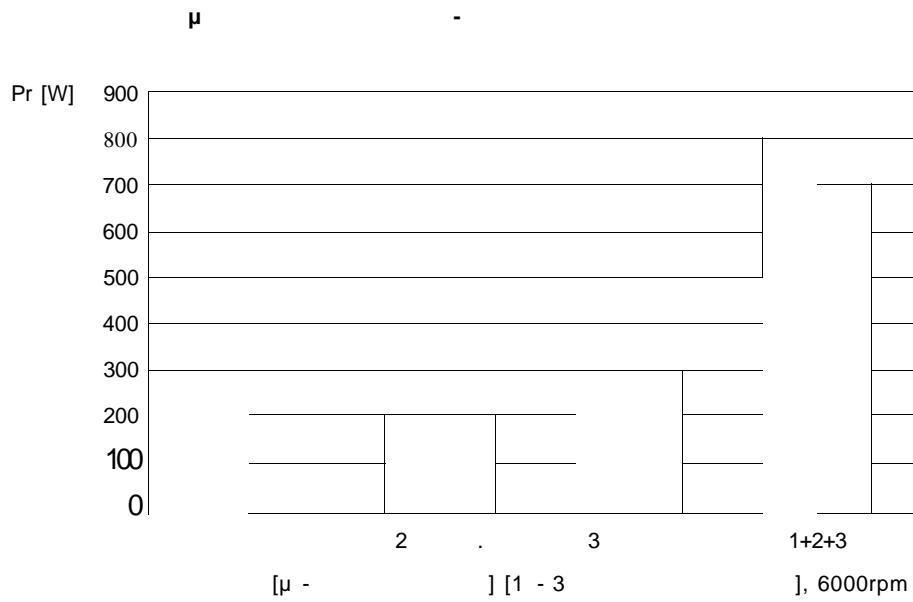


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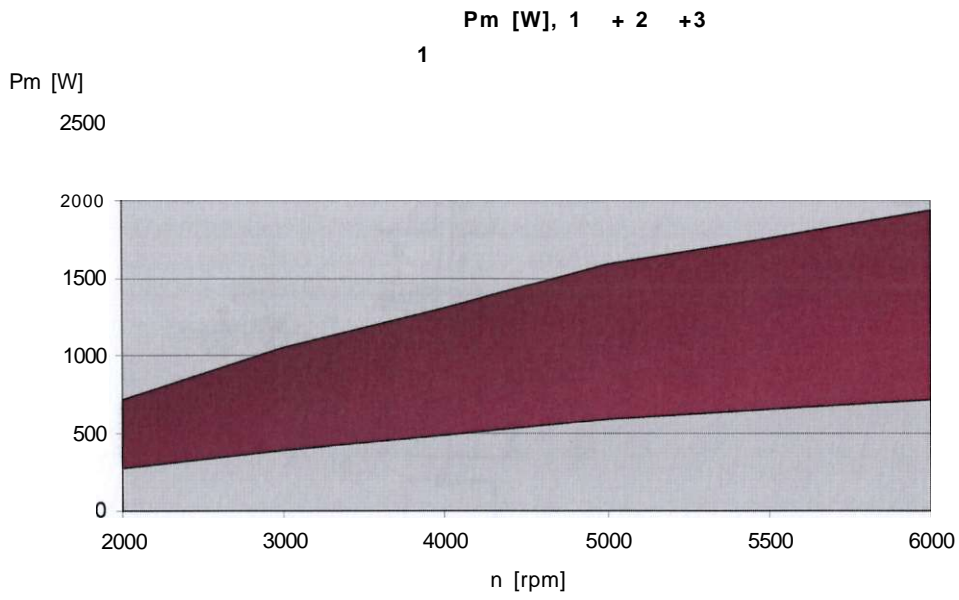
()



()

μ 4.12
(2000-6000 rpm)

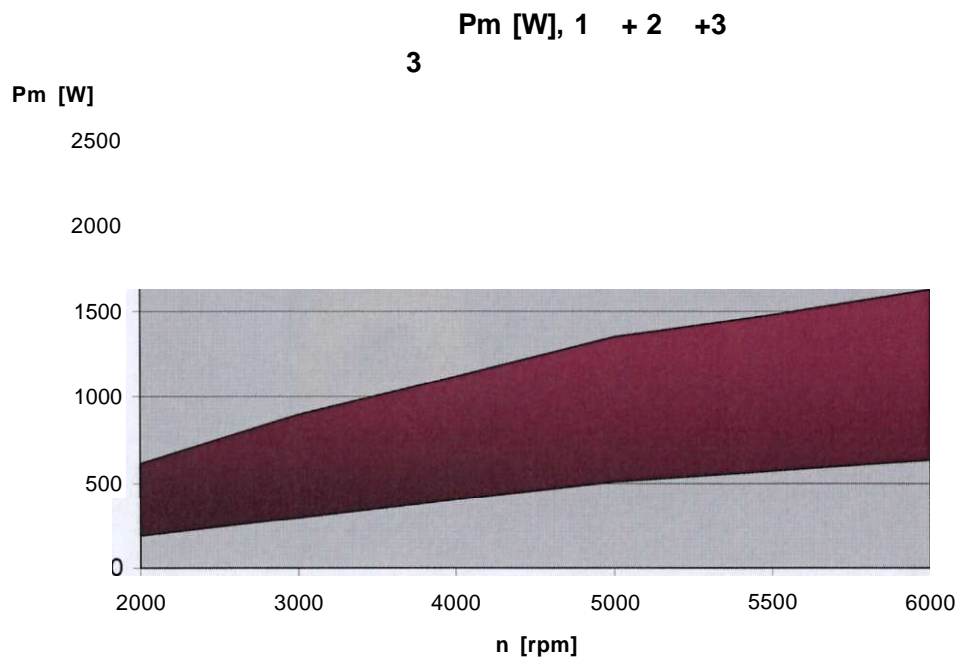
. 1



μ 4.13

μ

1

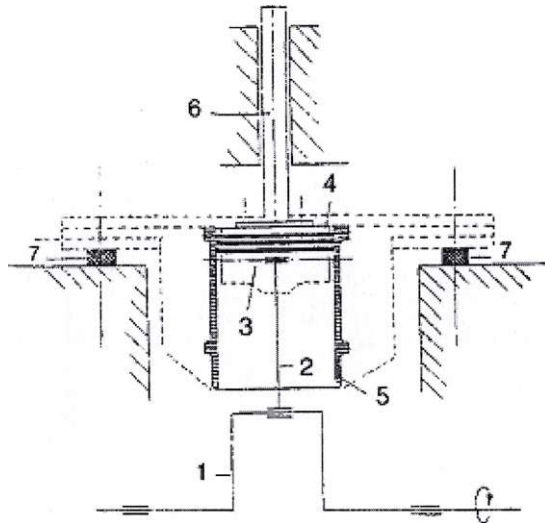


μ 4.14

μ

3

- 1 crank shaft
- 2 connecting rod
- 3 piston
- 4 piston rings
- 5 floating liner
- 6 piston guide
- 7 quartz friction force measurement elements

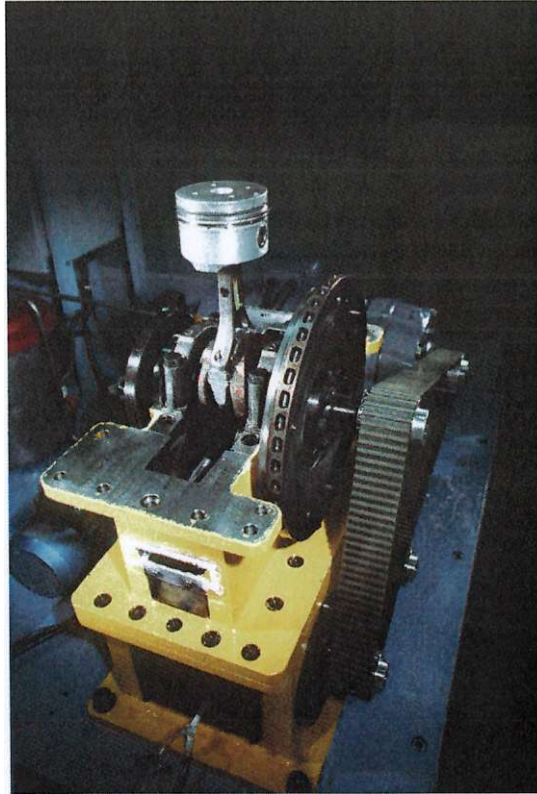


μ 4.15 μ μ μ (μ - Renault) μ



μ 4.16 μ μ - μ

(- Renault)



μ 4.17
(

μ - Renault)

μ

-

μ



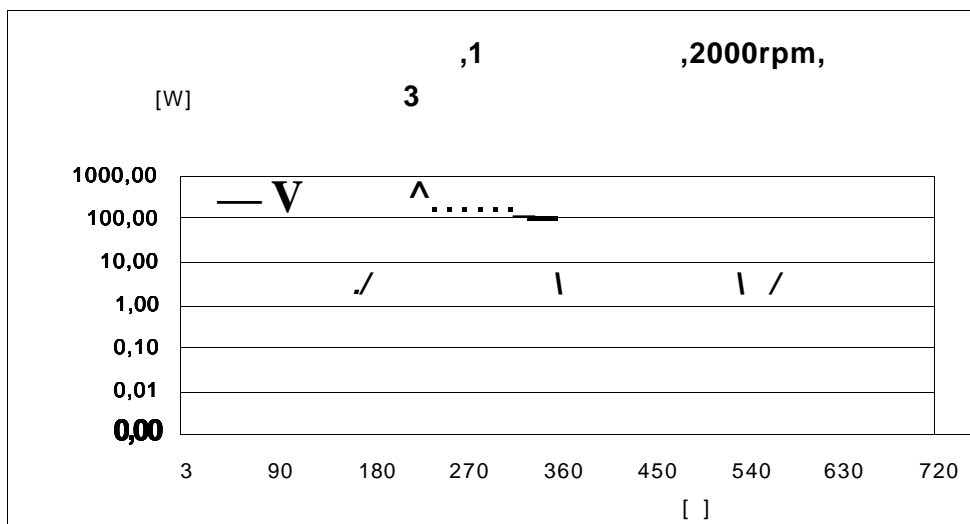
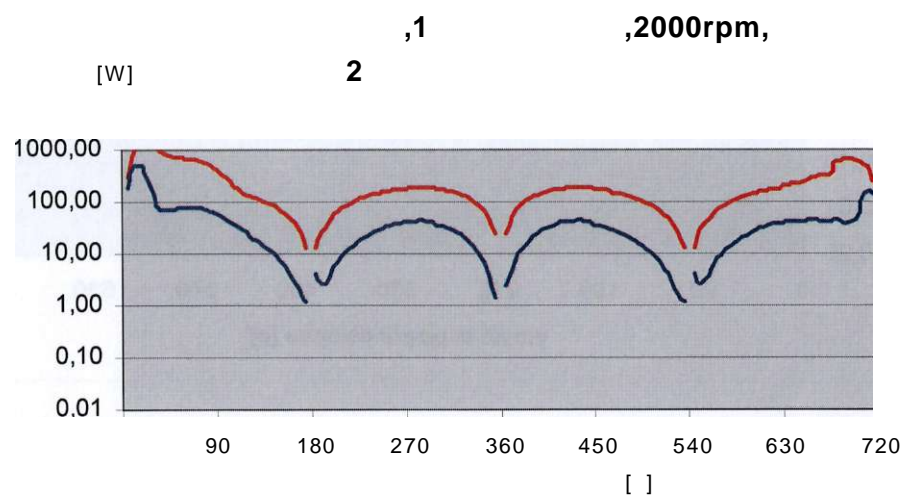
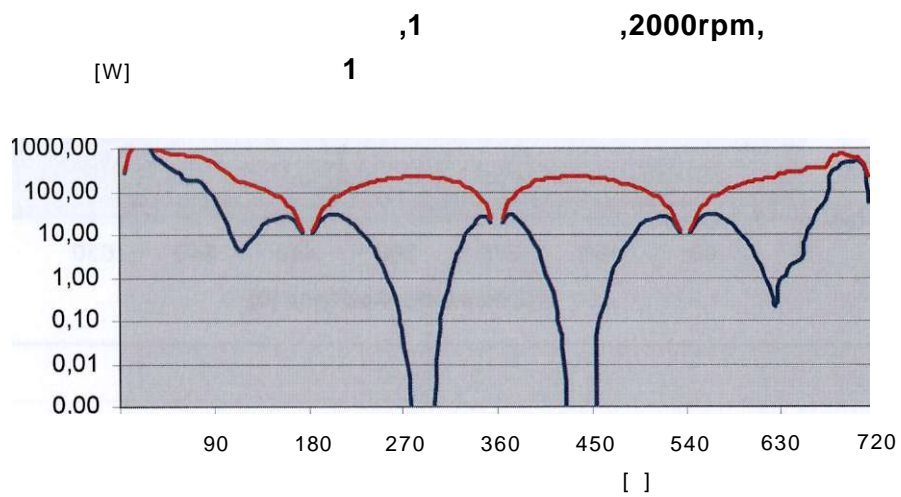
μ 4.18
(

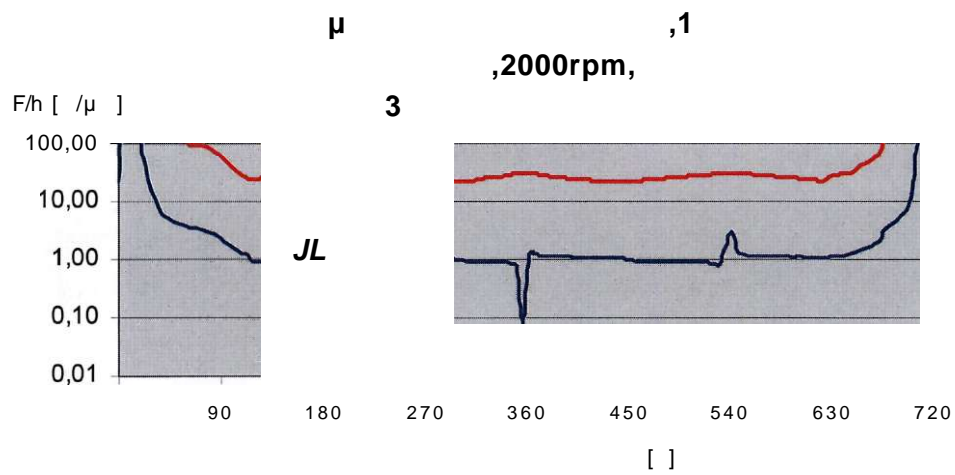
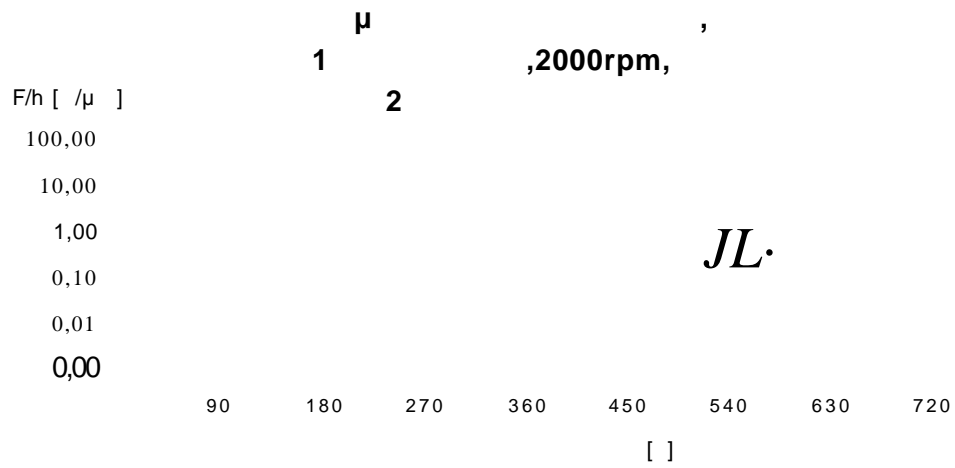
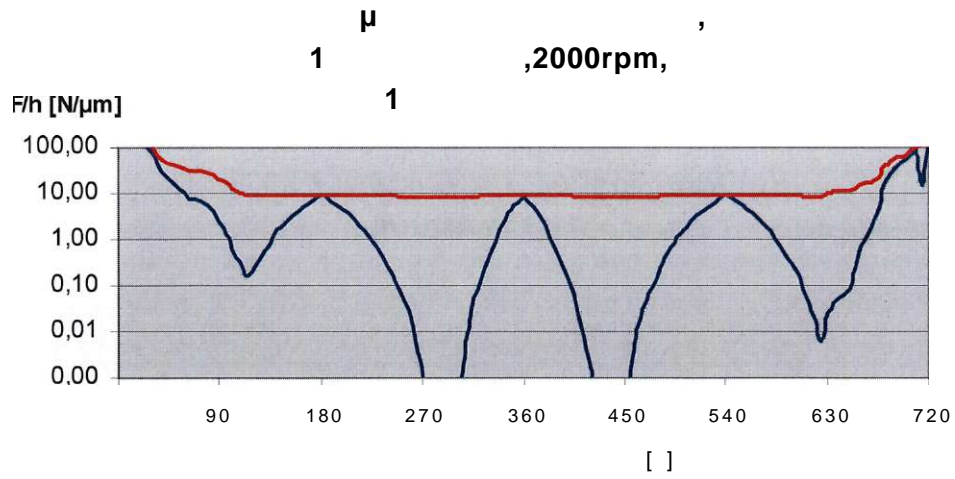
μ - Renault)

μ

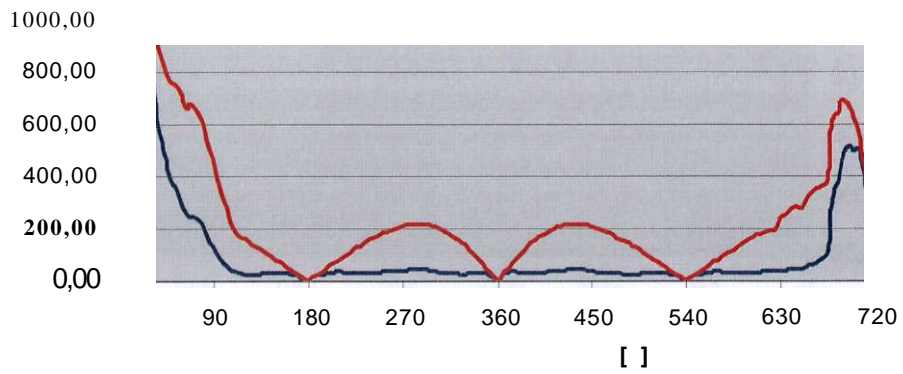
-

μ

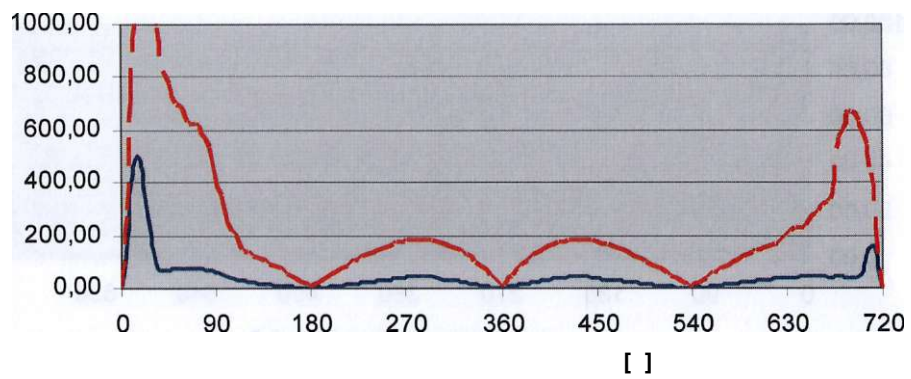




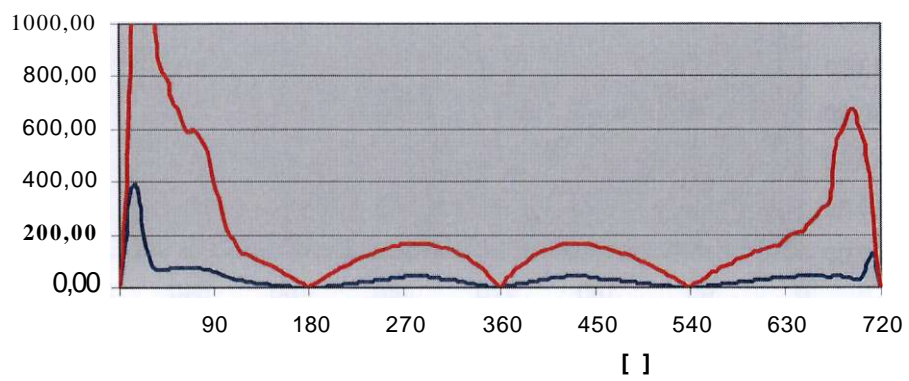
1,1 **,2000rpm,**
[W]

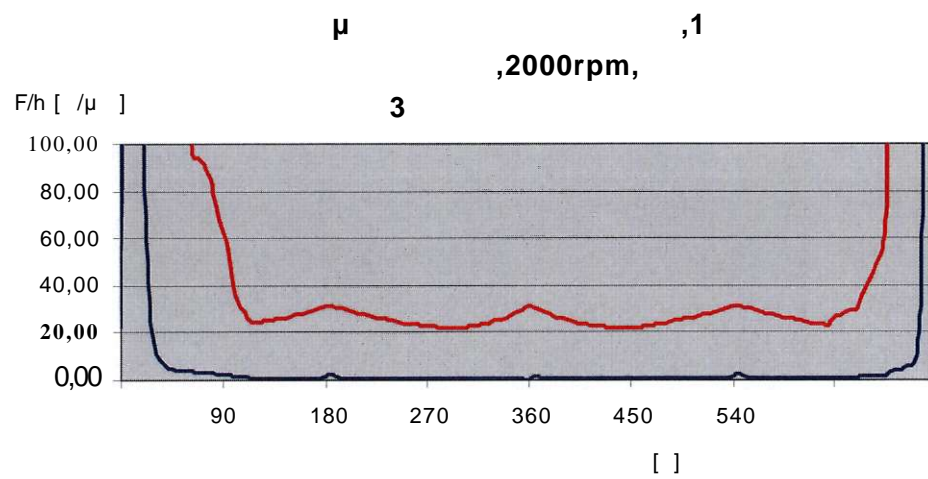
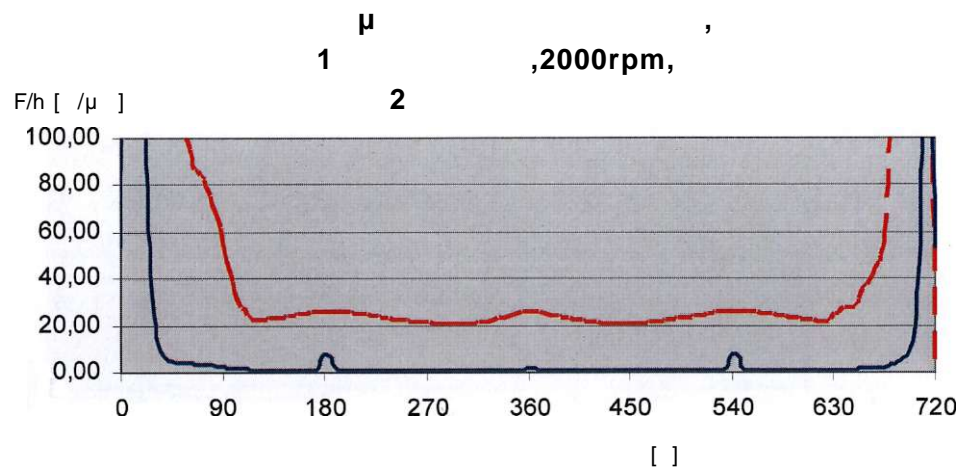
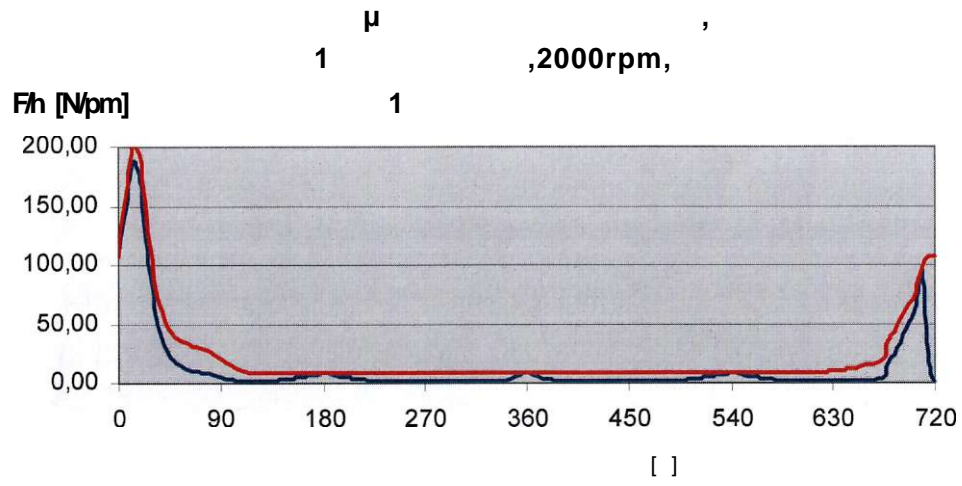


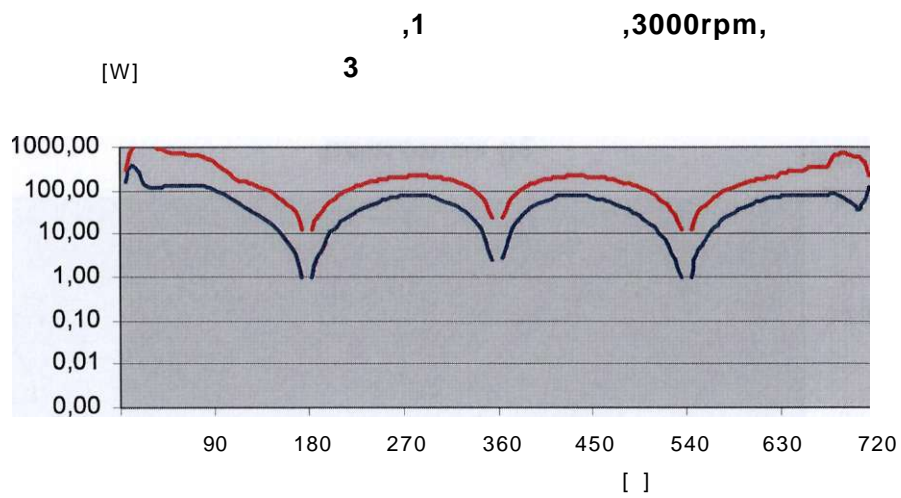
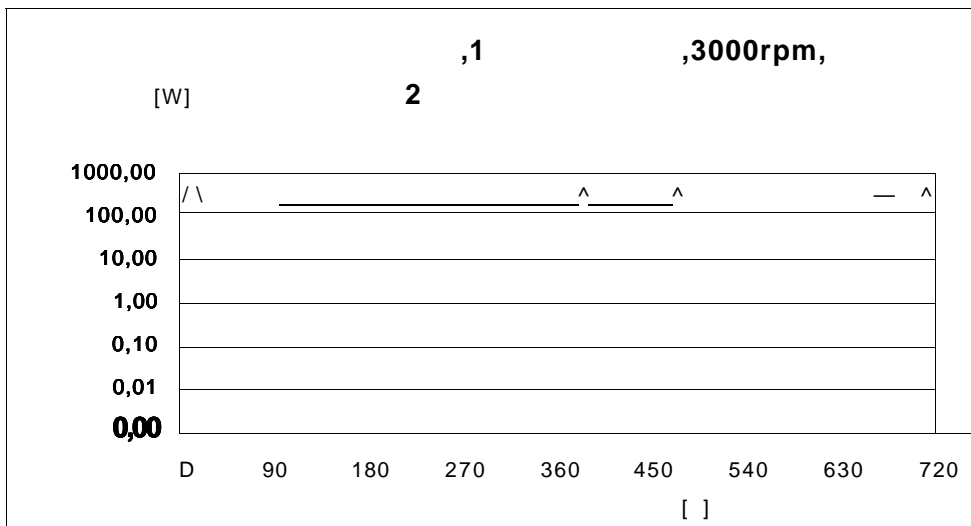
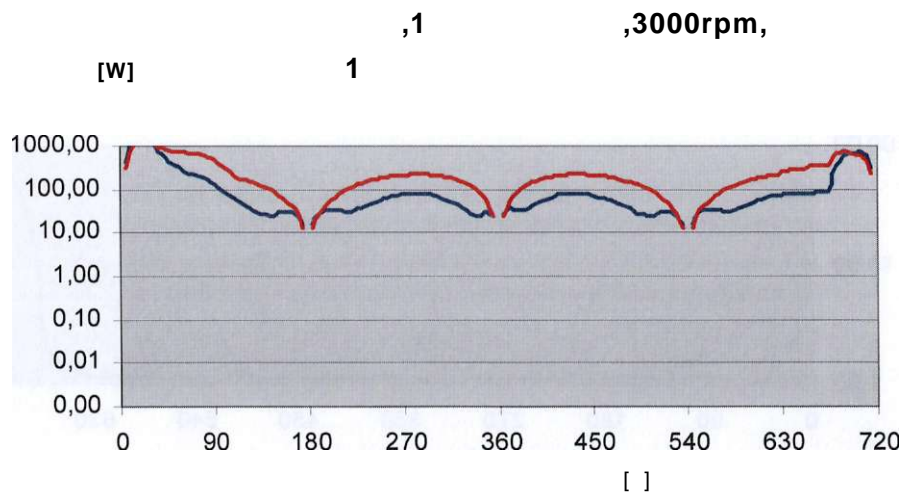
2,1 **,2000rpm,**
[W]

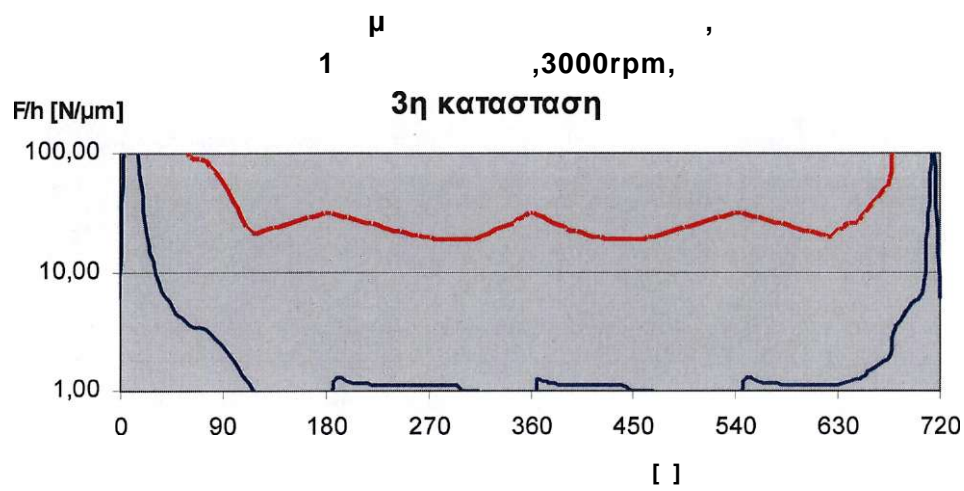
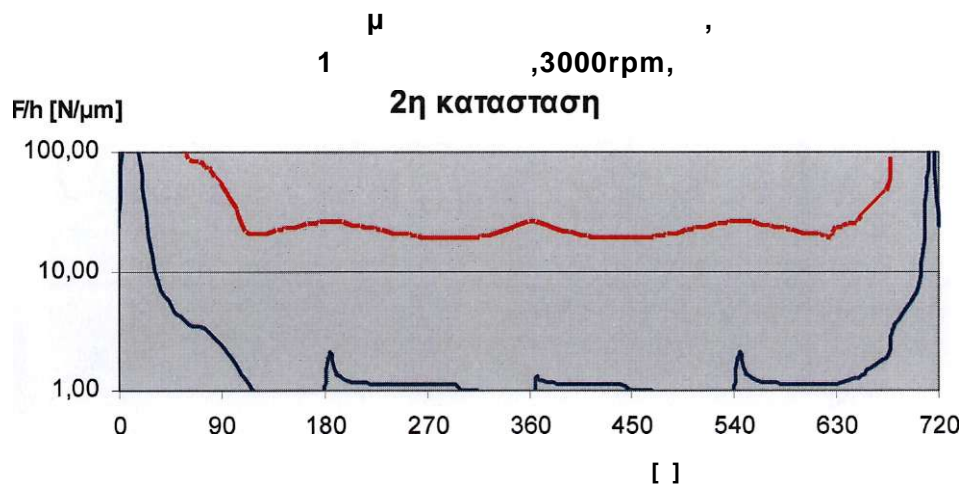
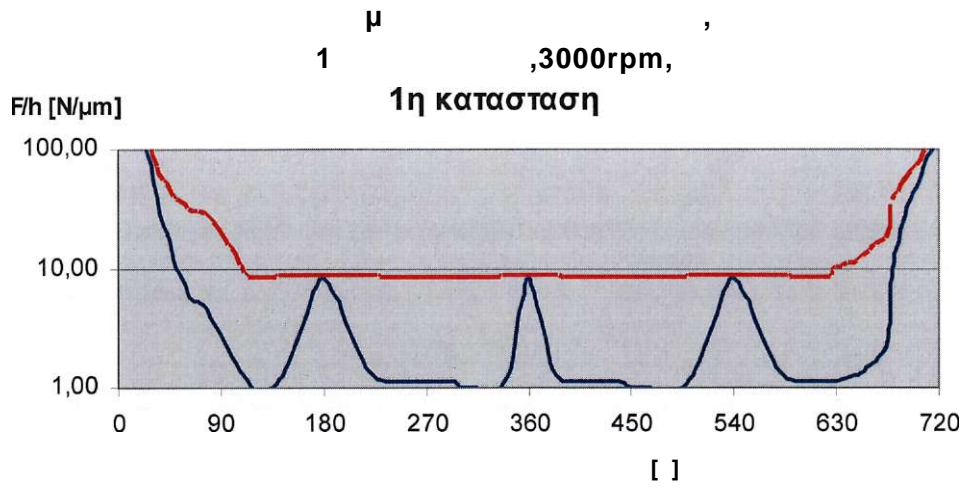


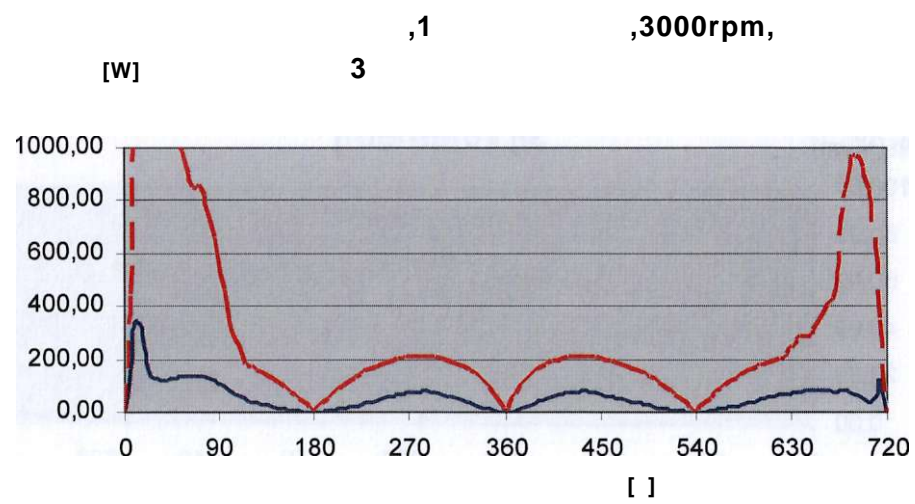
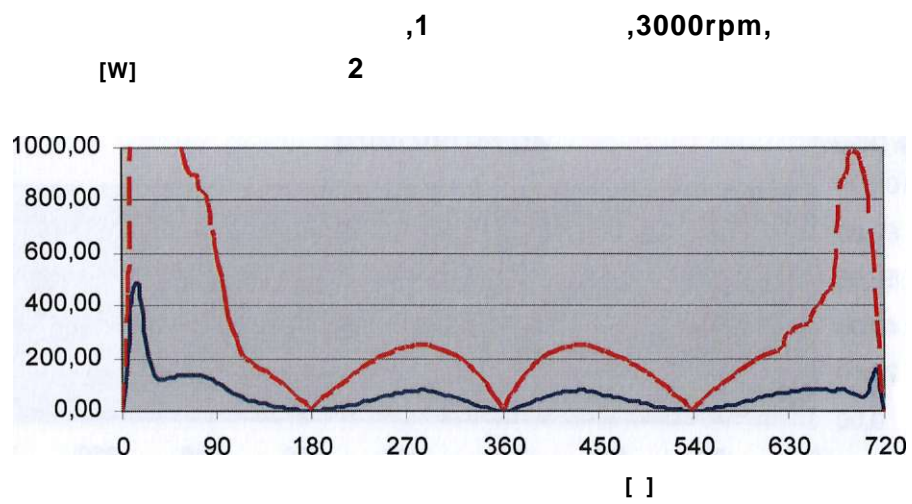
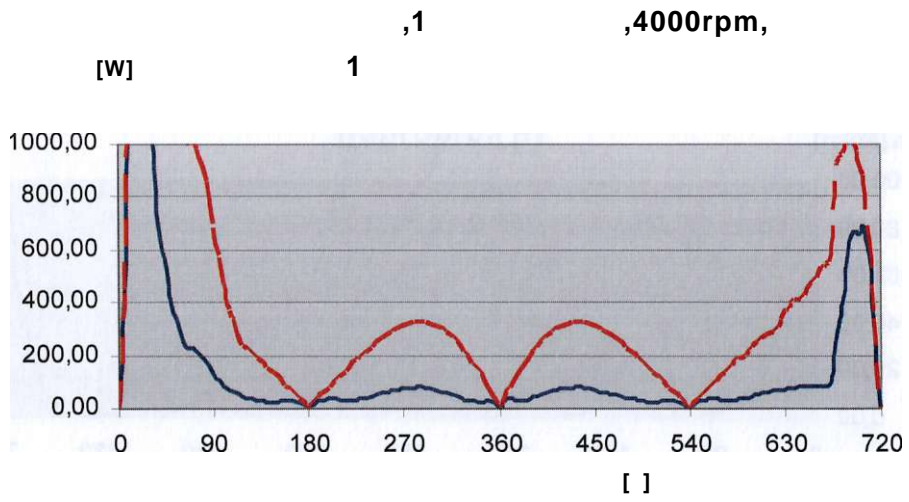
3,1 **,2000rpm,**
[W]

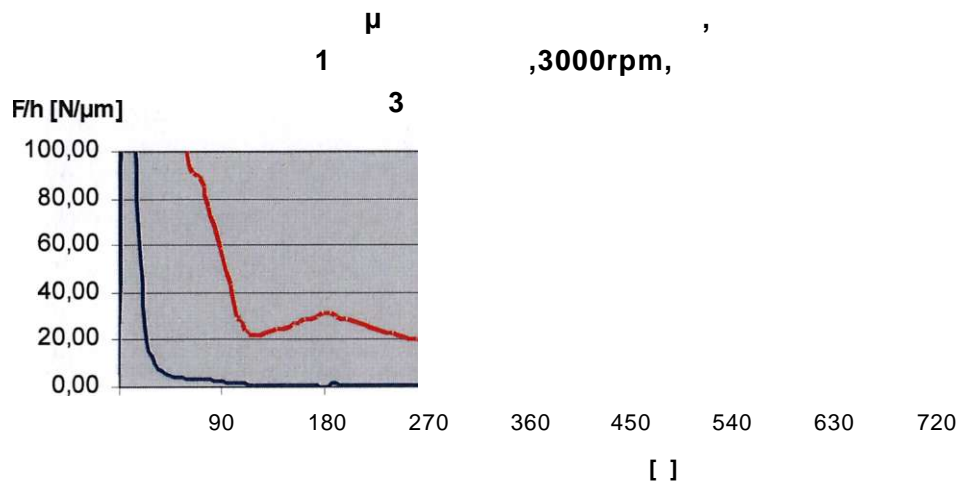
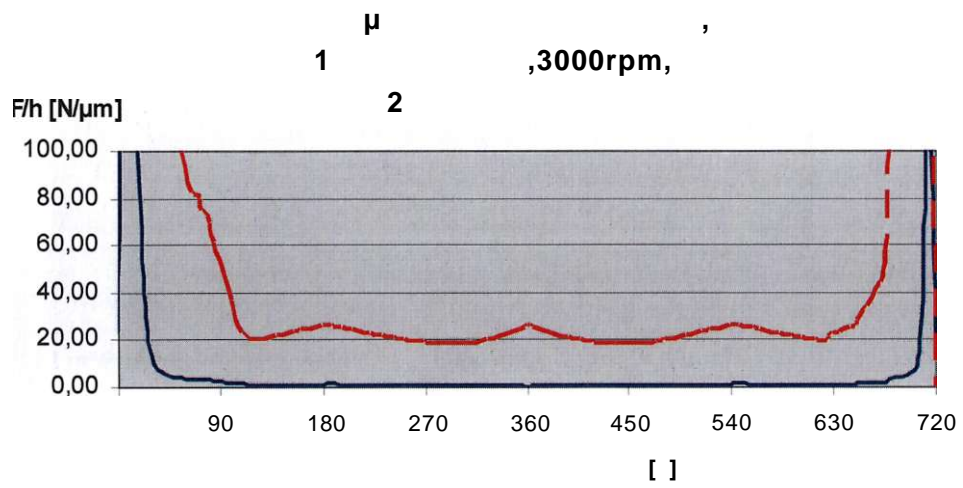
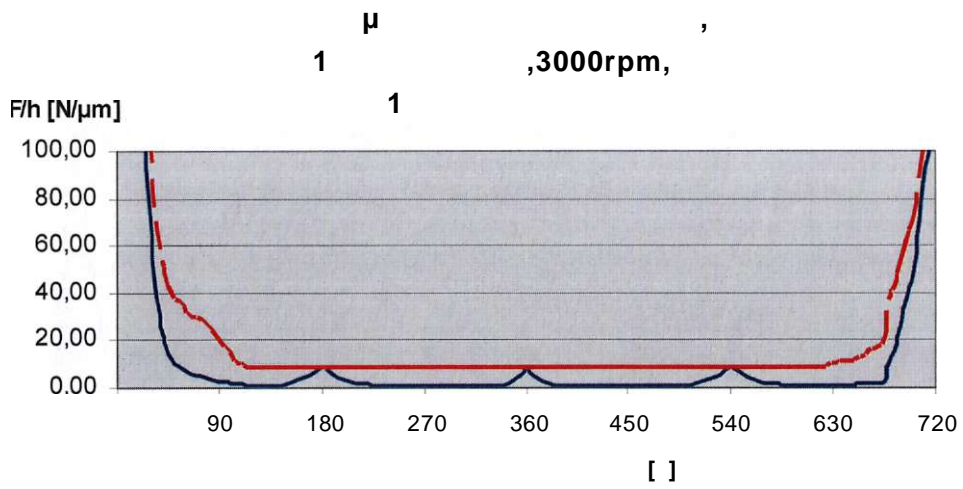


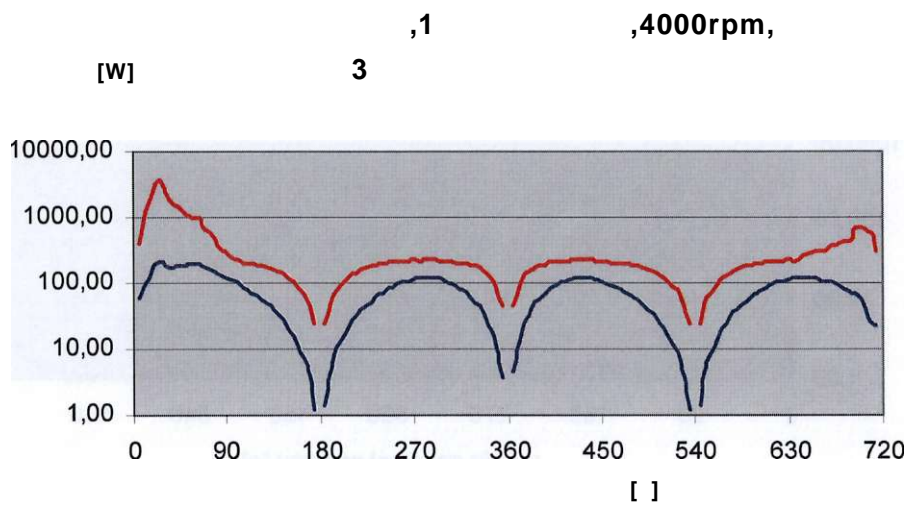
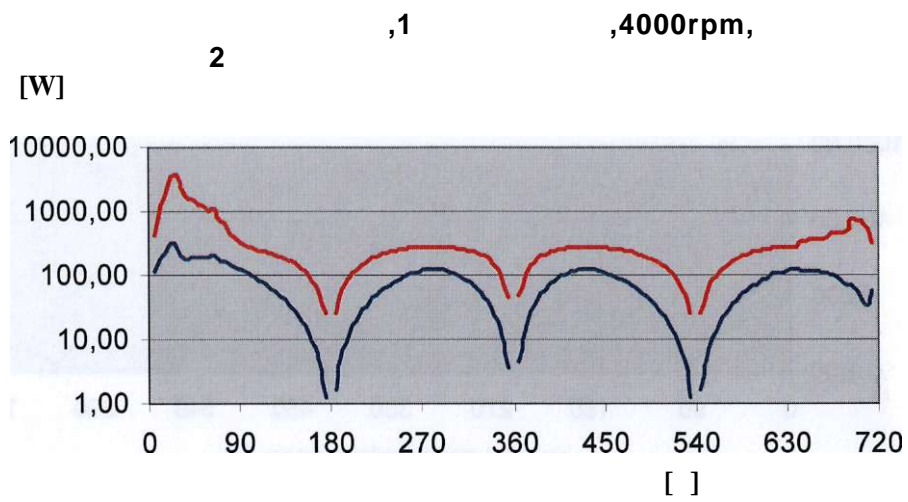
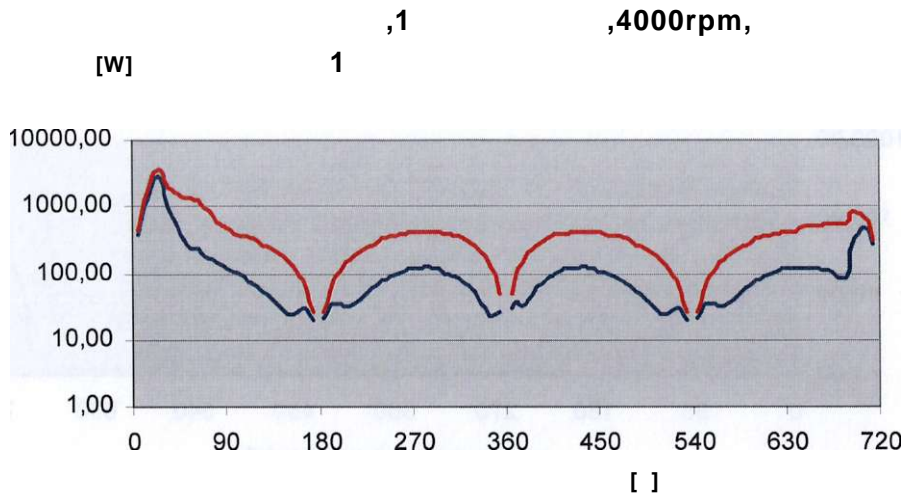


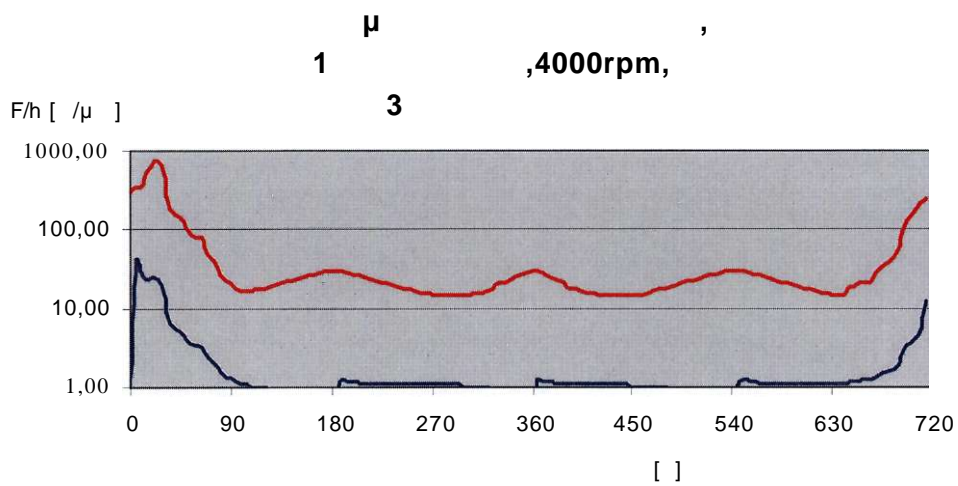
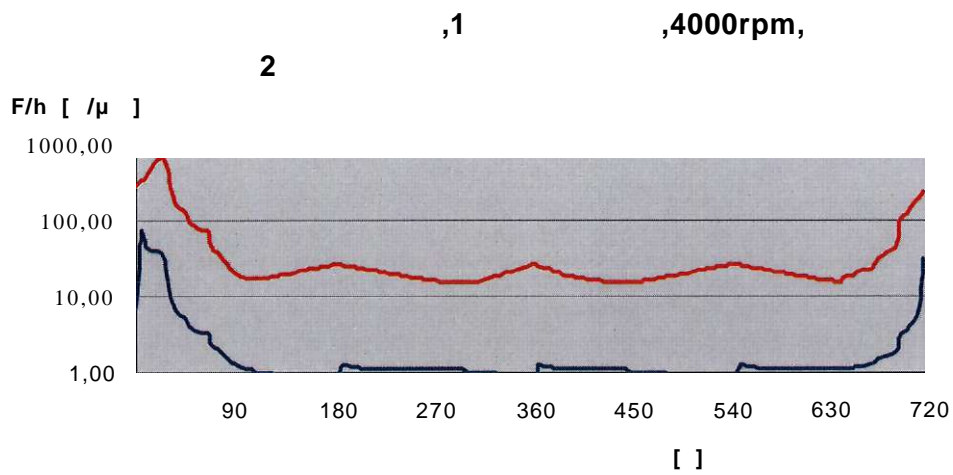
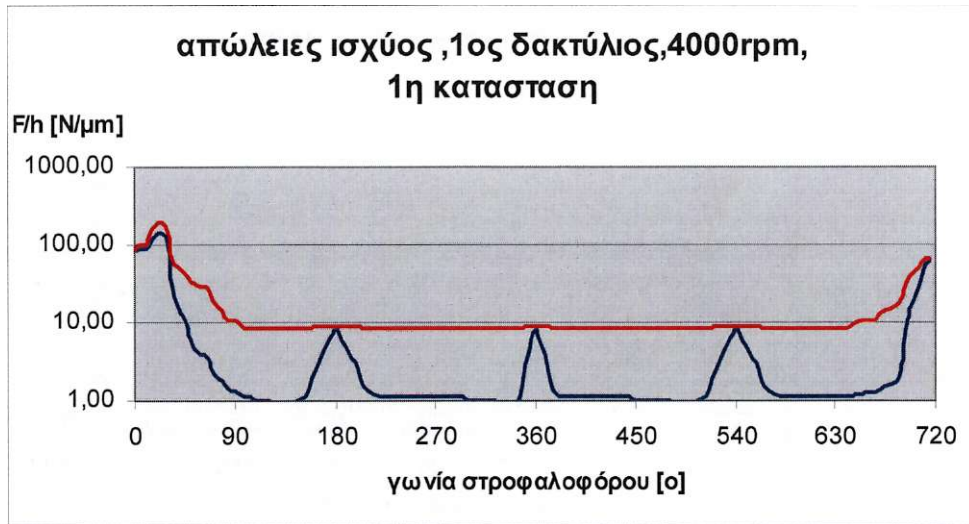




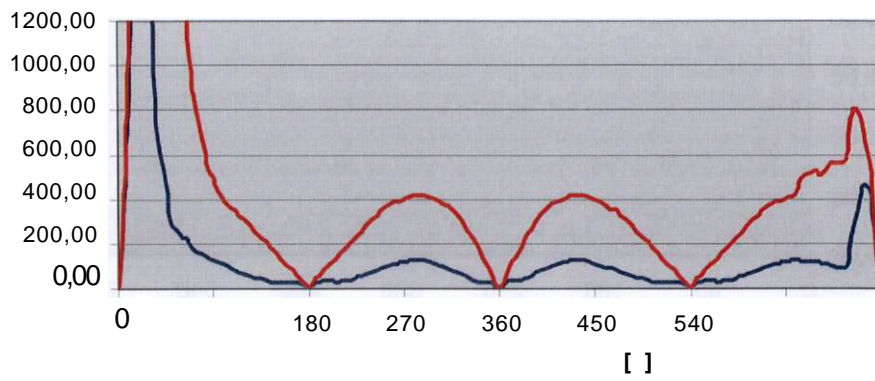




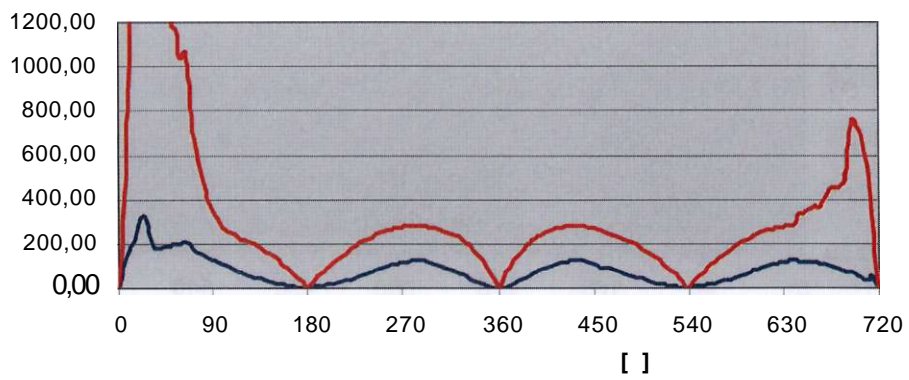




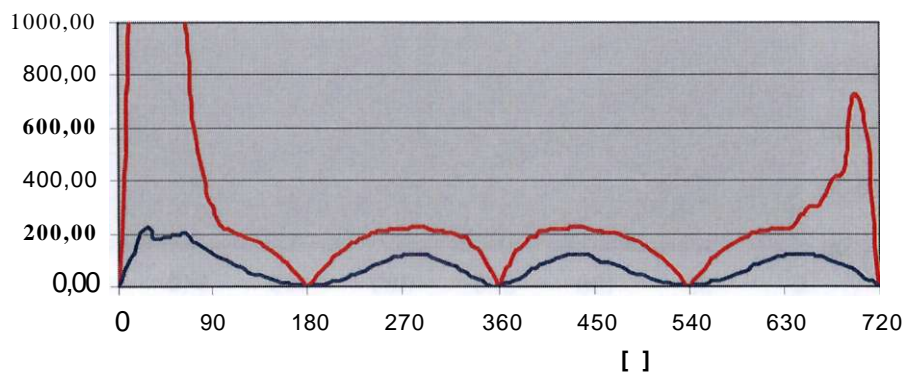
1,1 **,3000rpm,**
[W]



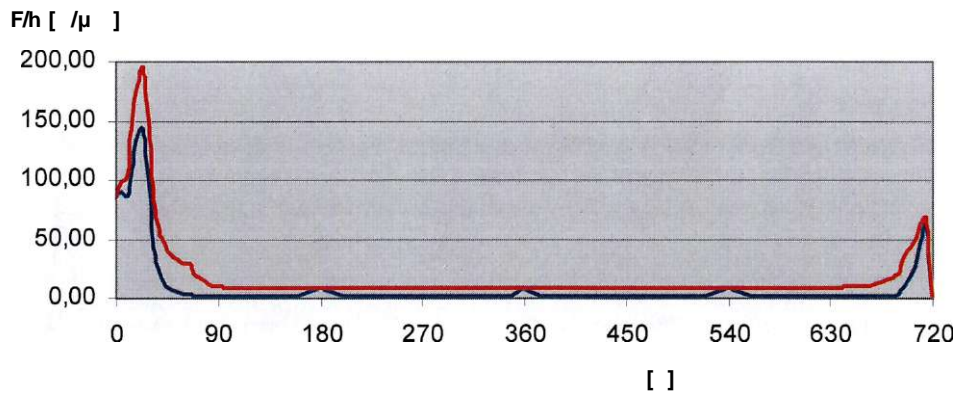
2,1 **,4000rpm,**
[W]



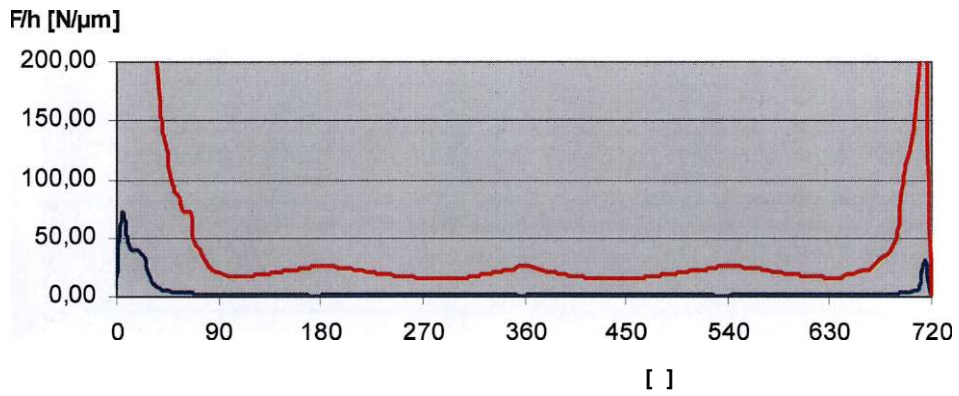
3,1 **,4000rpm,**
[W]



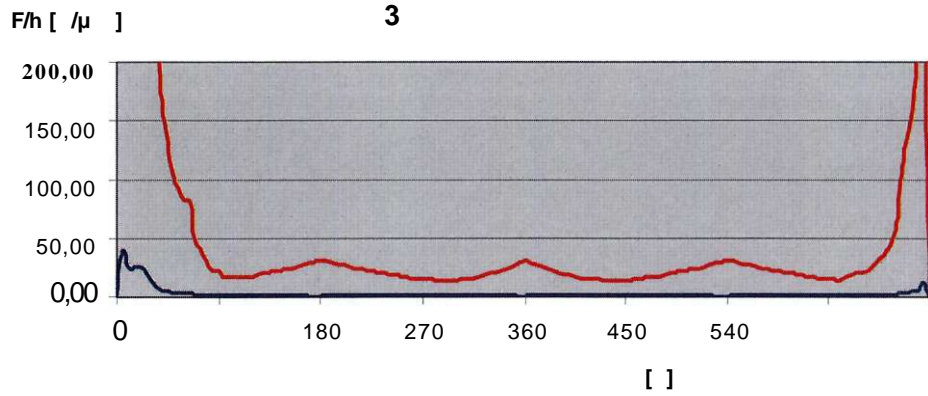
1,1 ,4000rpm,
1



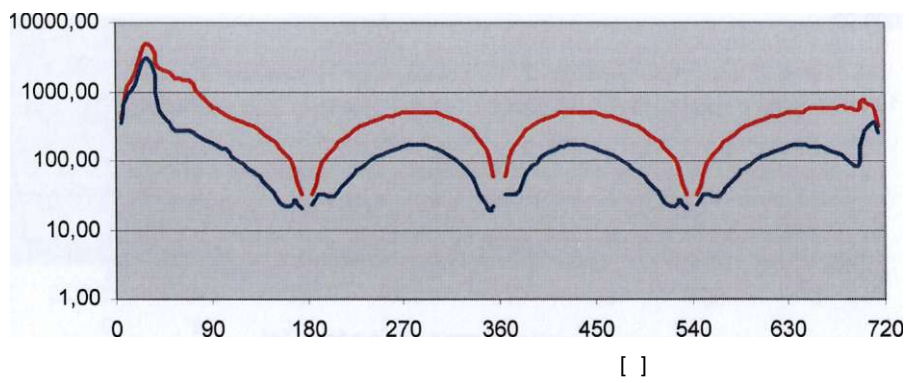
2,1 ,4000rpm,
2



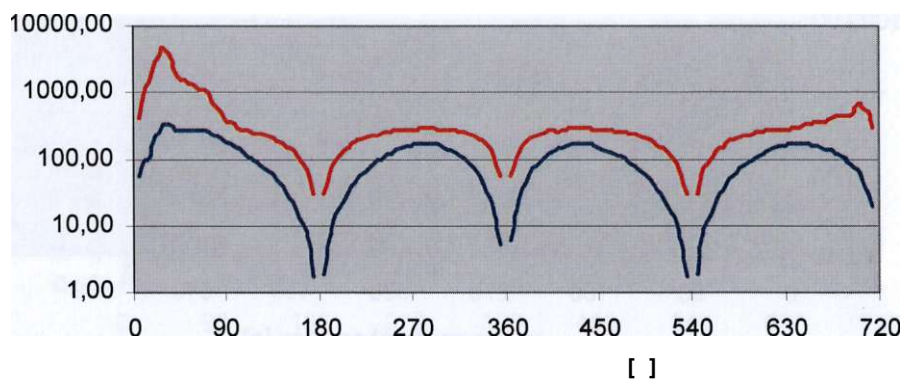
1 μ ,
3 ,4000rpm,
3



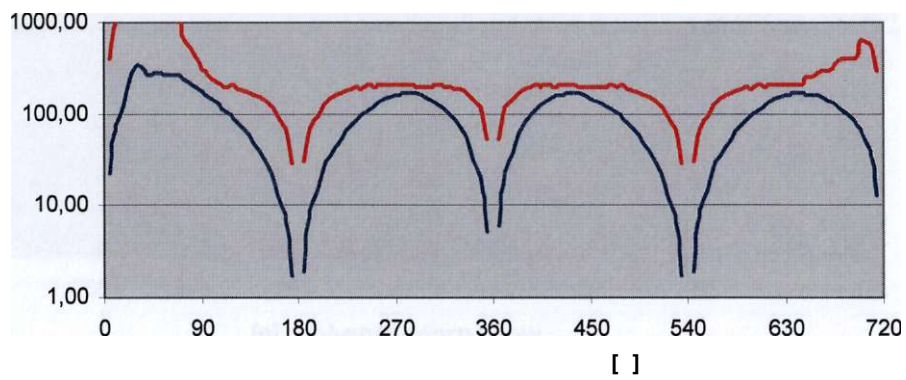
[W] 1 ,1 ,4000rpm,

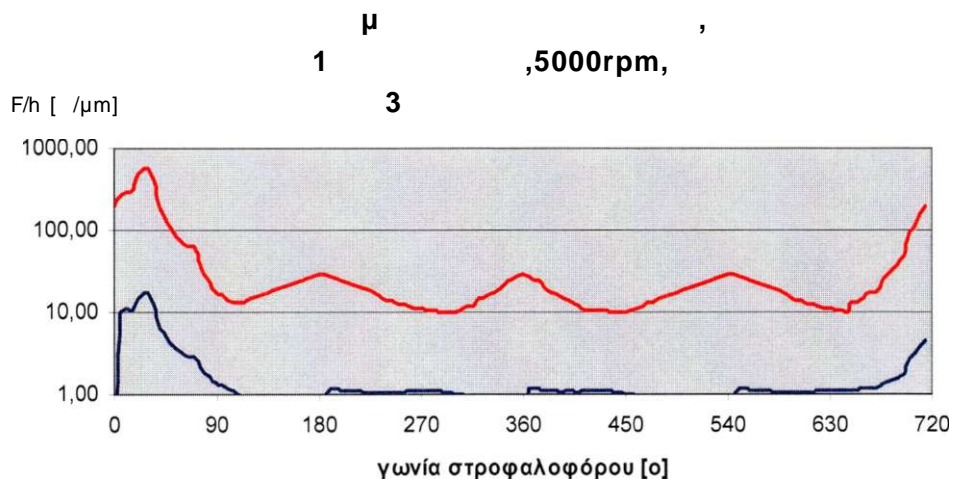
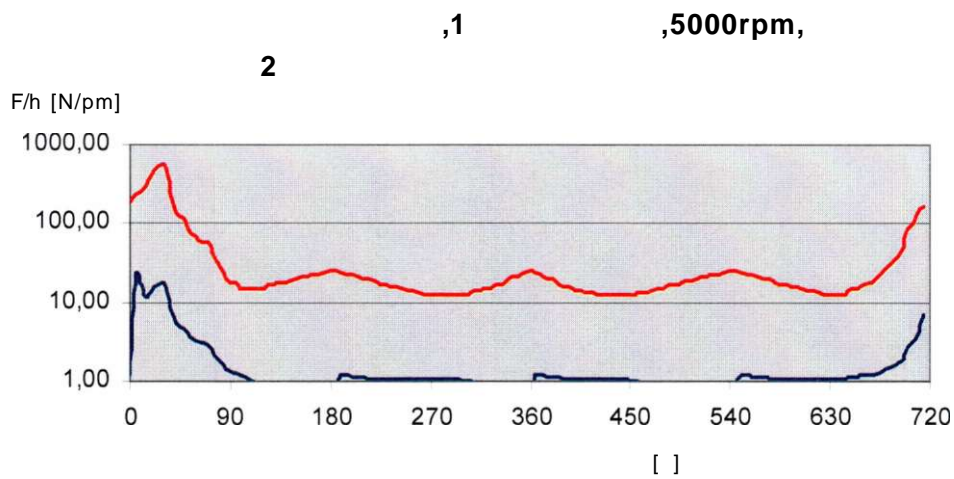
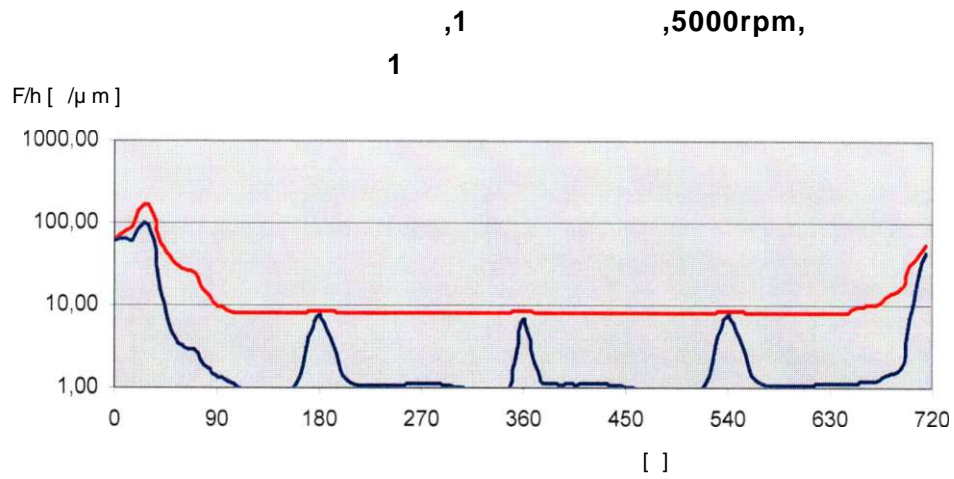


[W] 2 ,1 ,5000rpm,

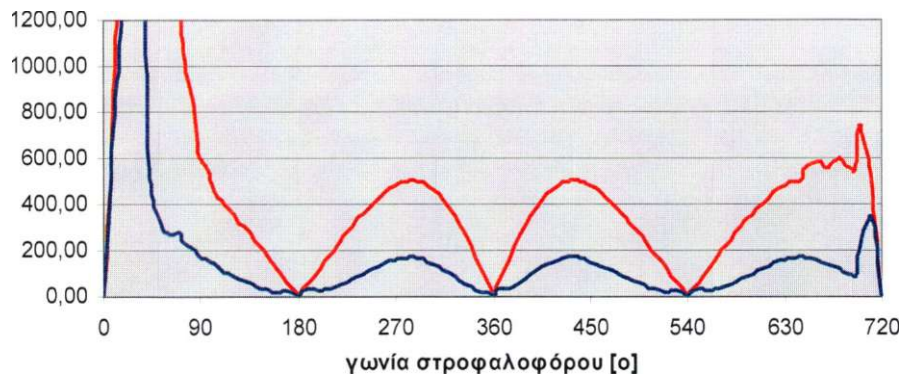


[W] 3 ,1 ,5000rpm,

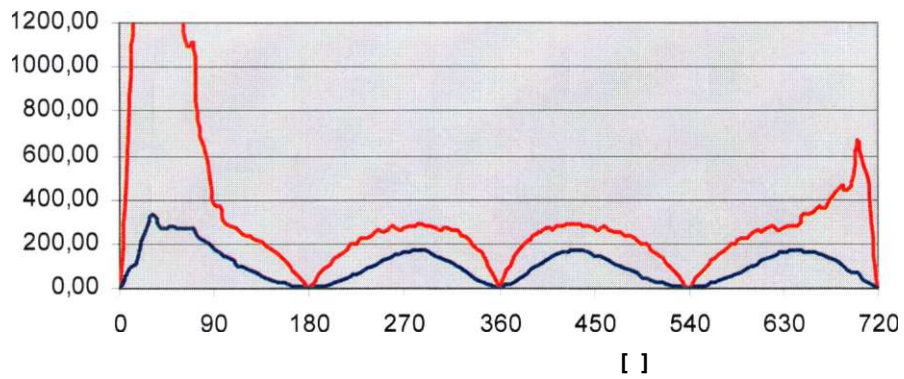




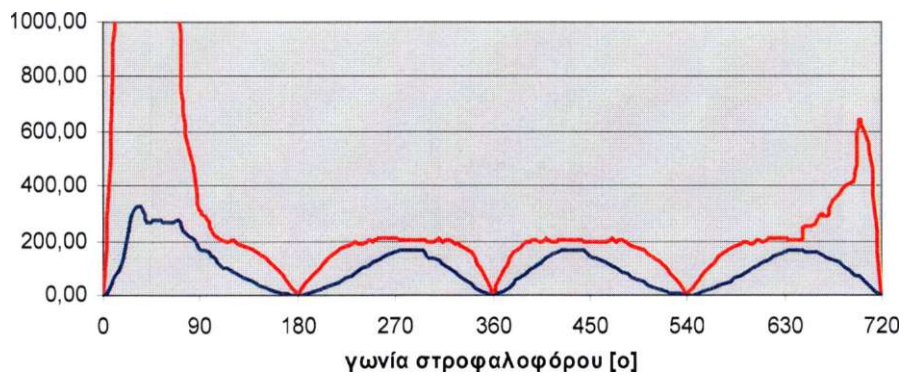
1,1 ,3000rpm,
[W] 1



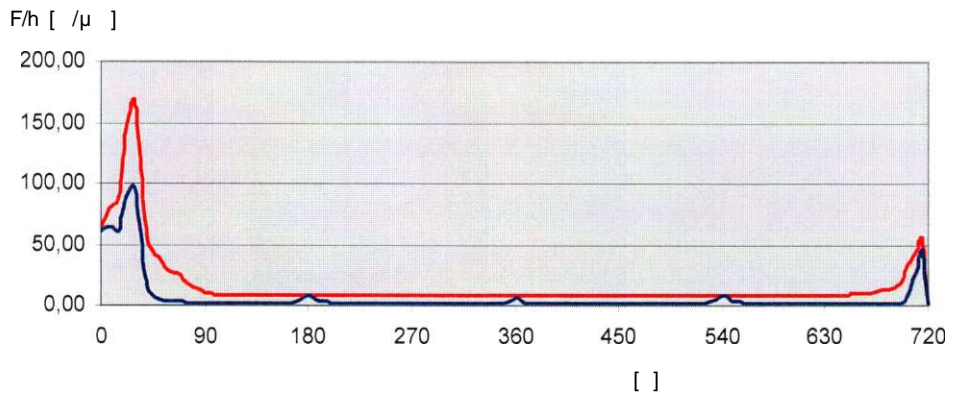
2,1 ,5000rpm,
[W] 2



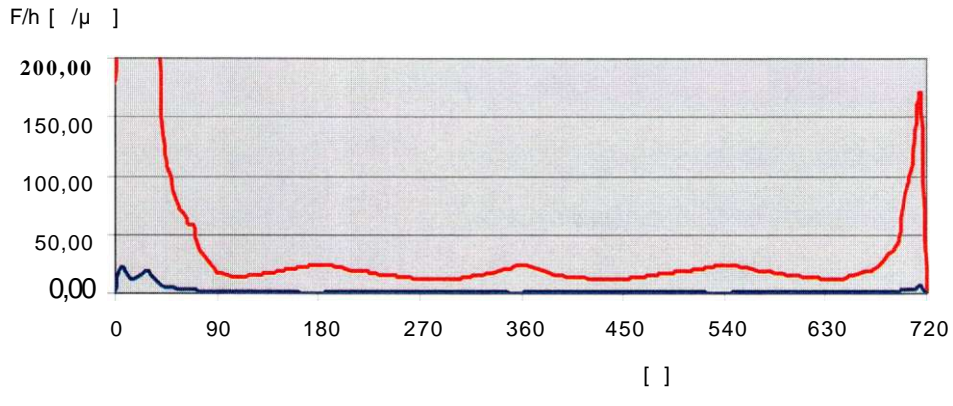
3,1 ,5000rpm,
[W] 3



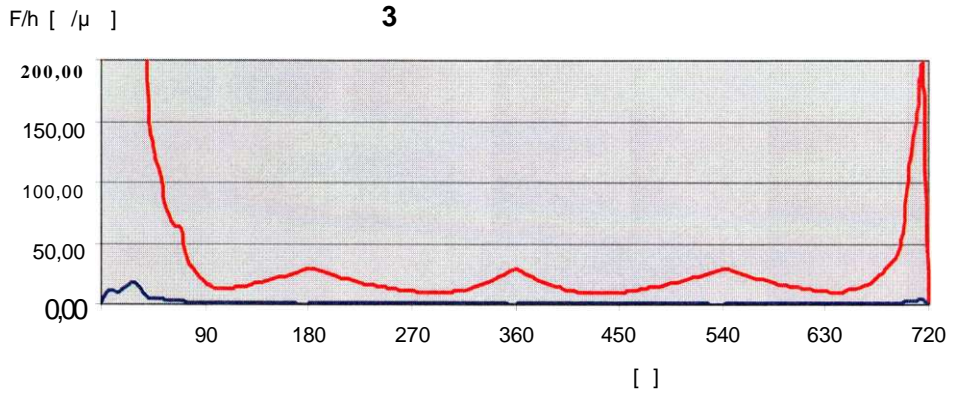
1,1 ,5000rpm,

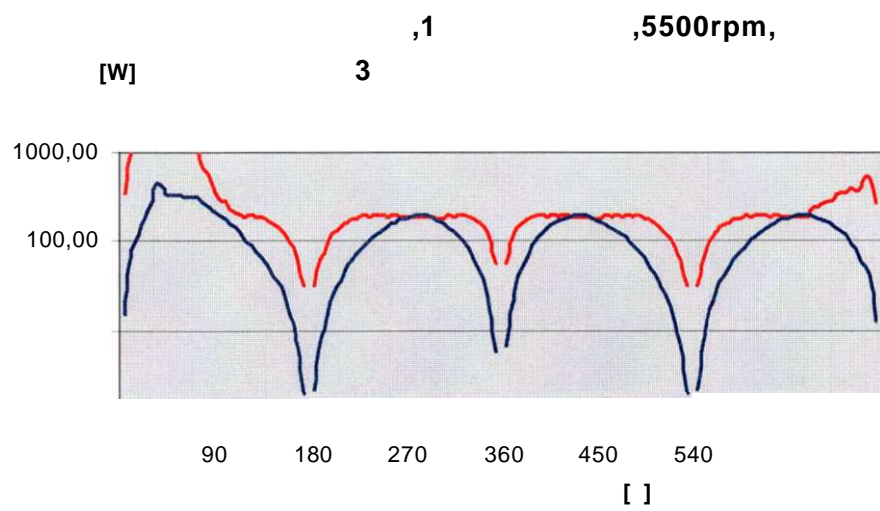
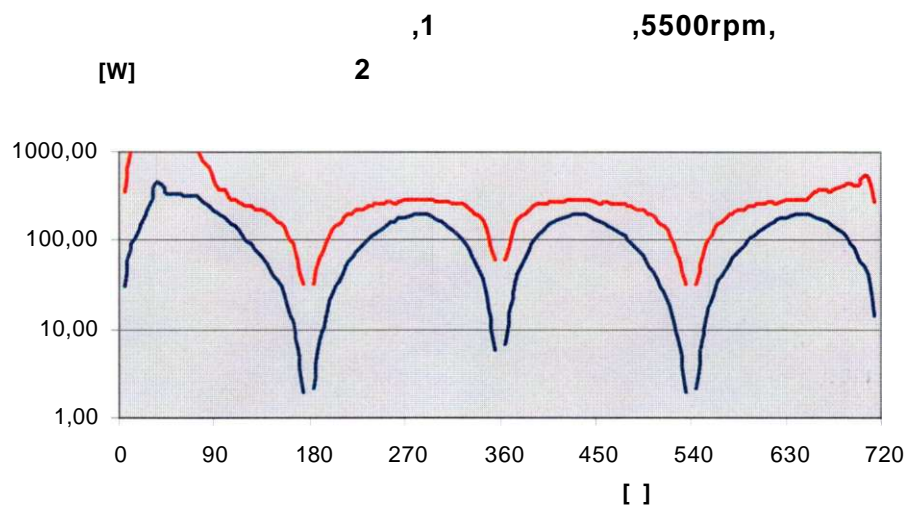
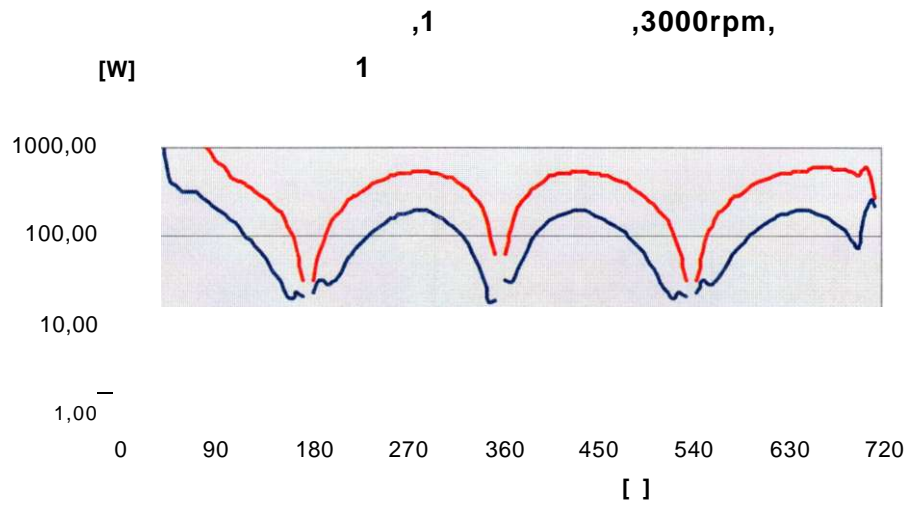


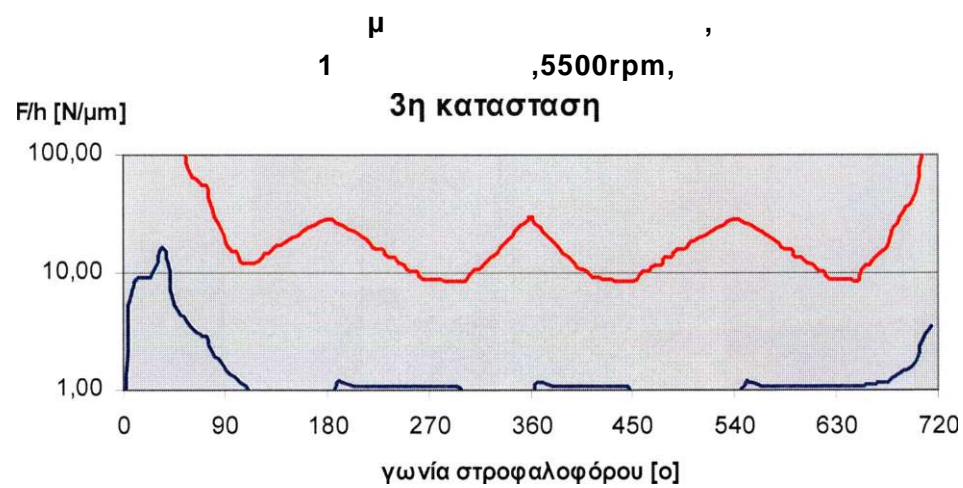
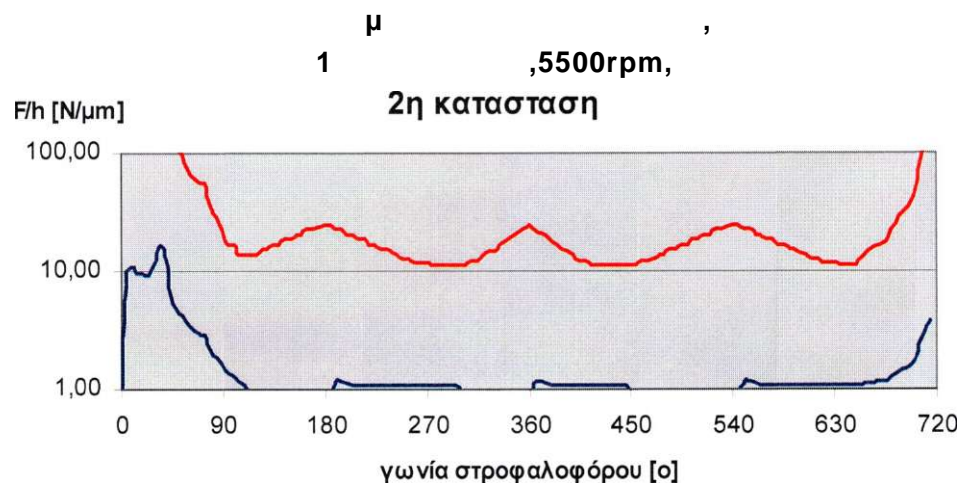
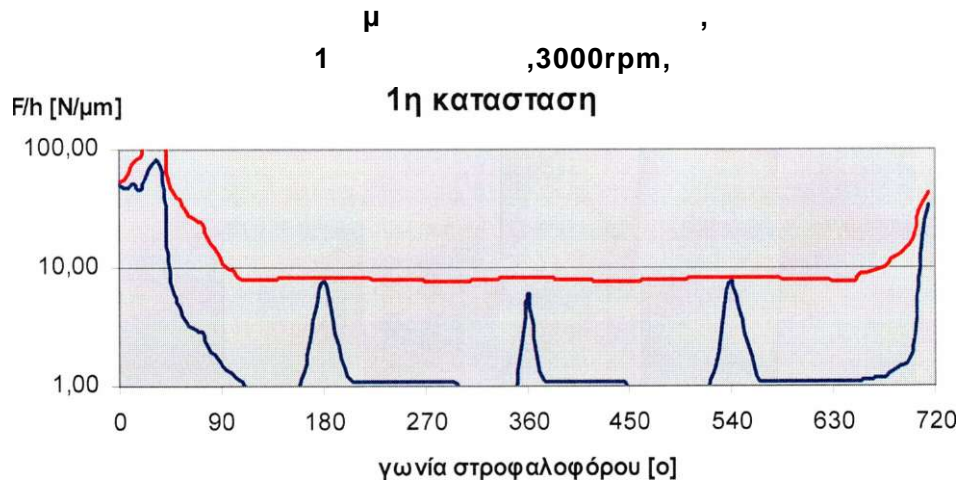
2,1 ,5000rpm,

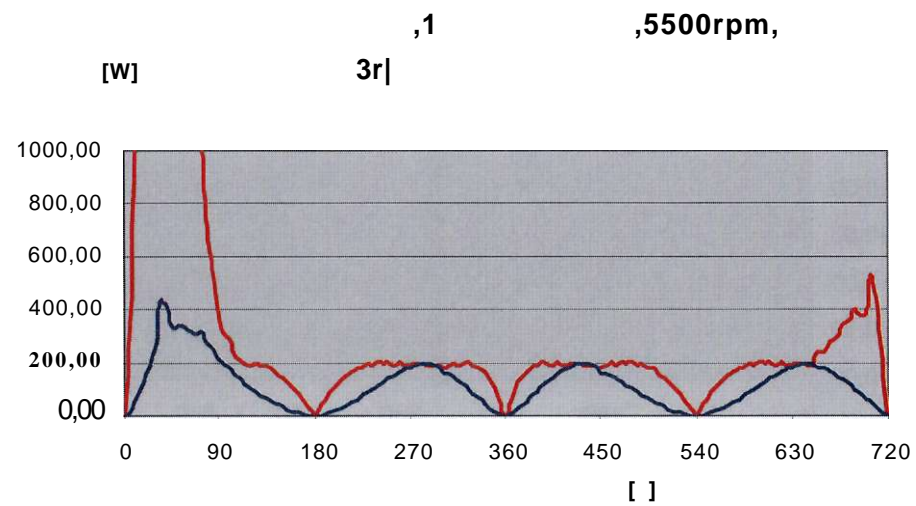
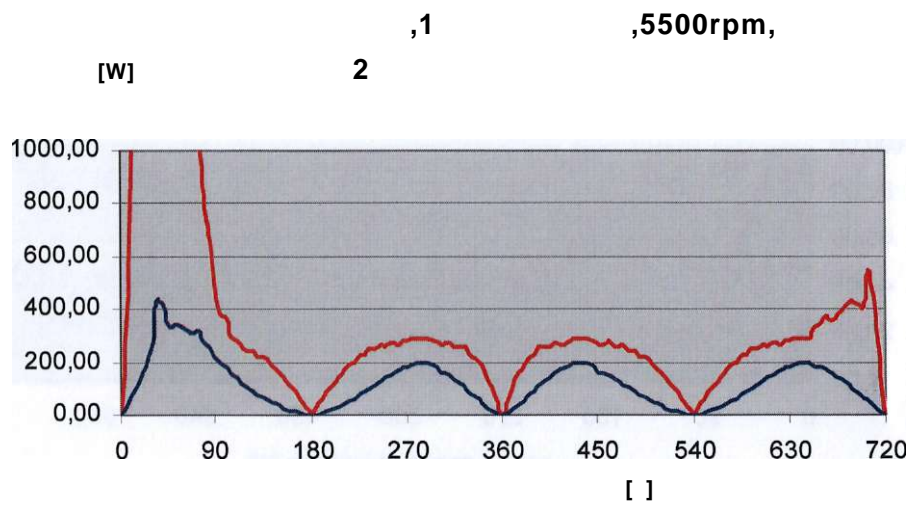
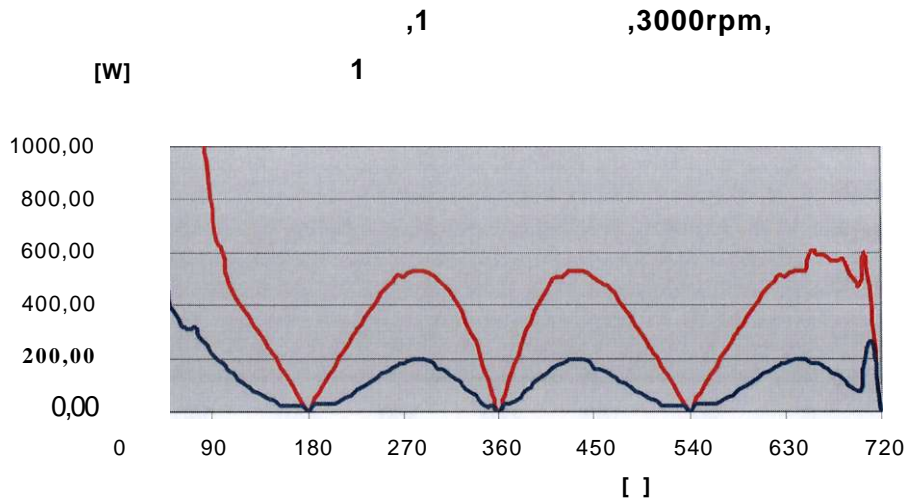


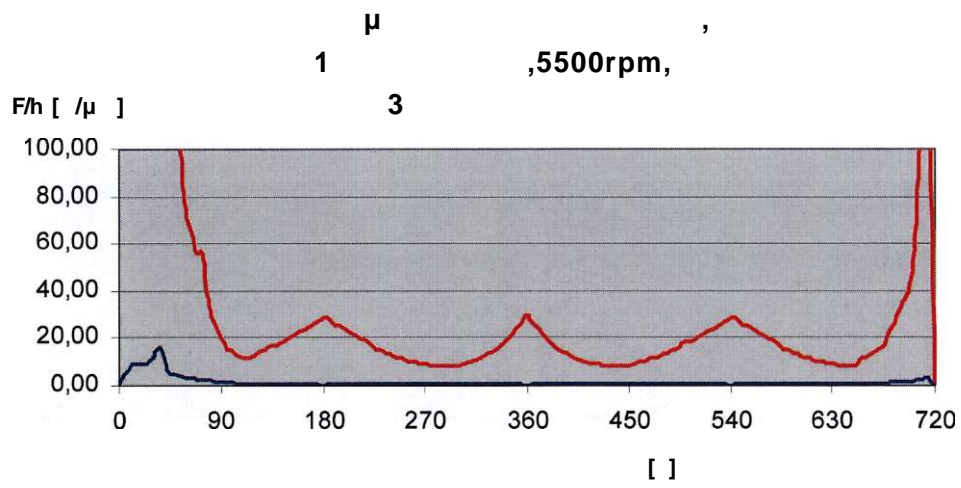
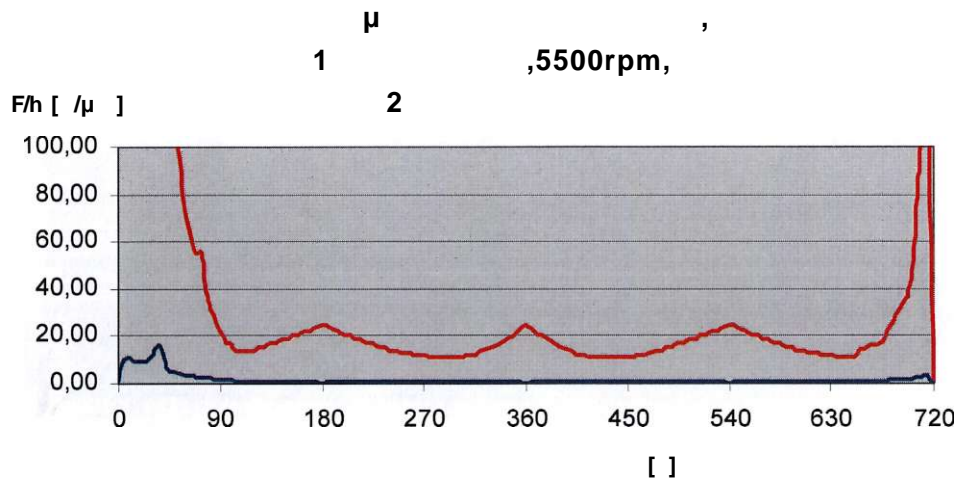
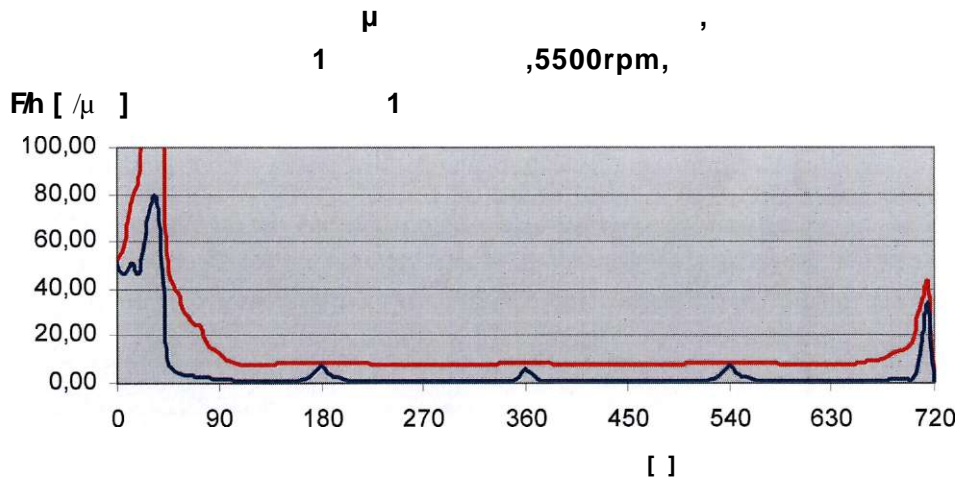
1 μ ,
3 ,5000rpm,

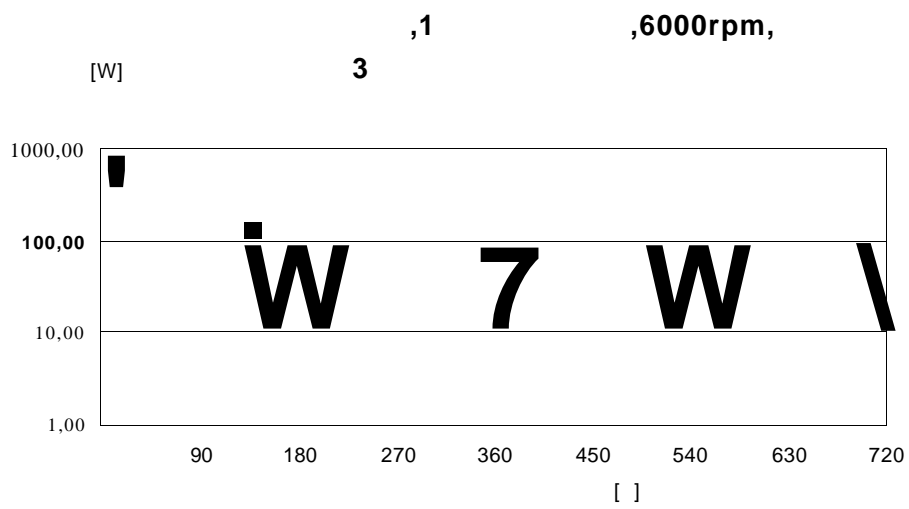
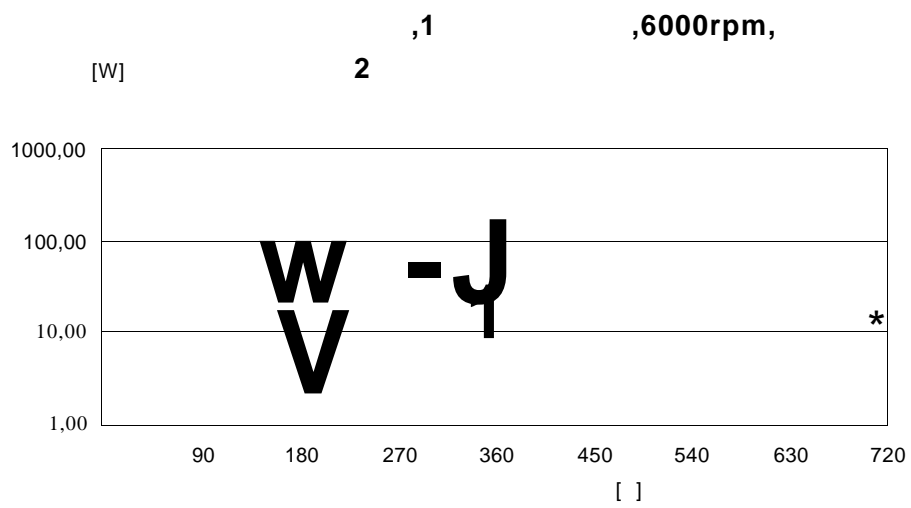
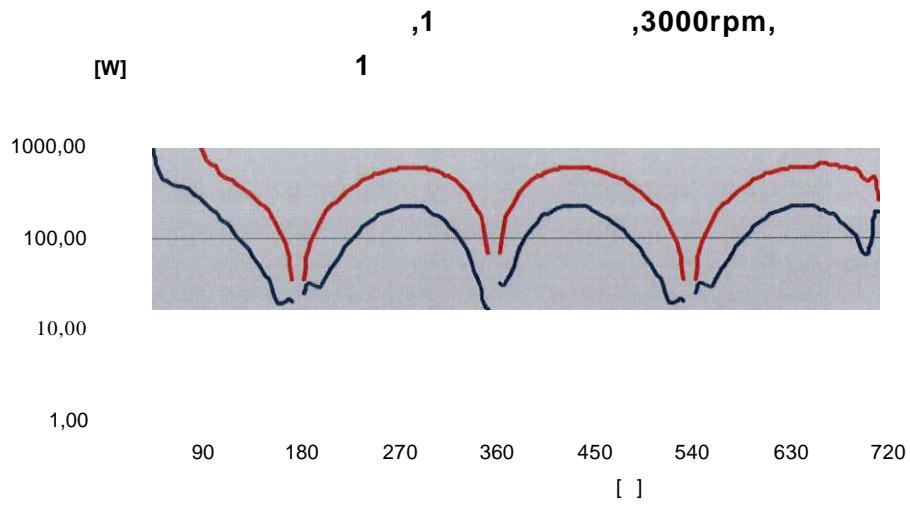


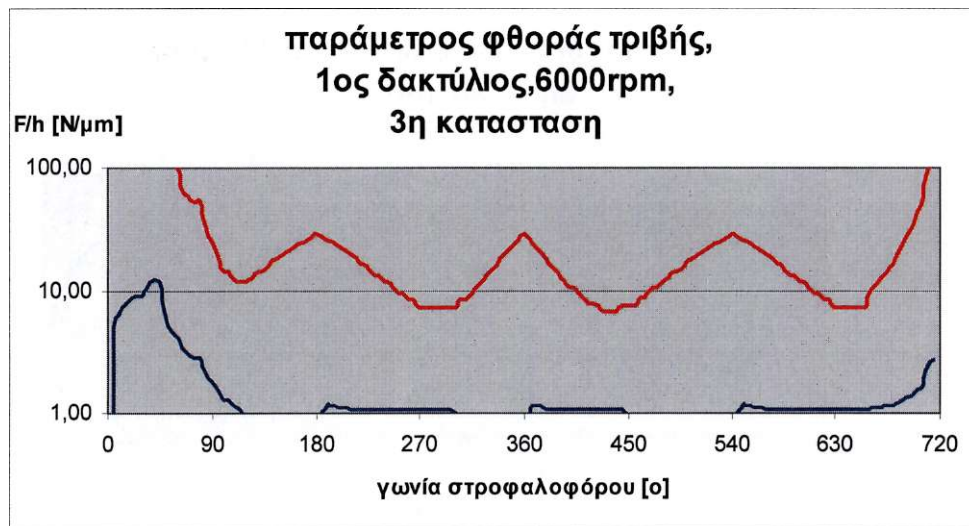
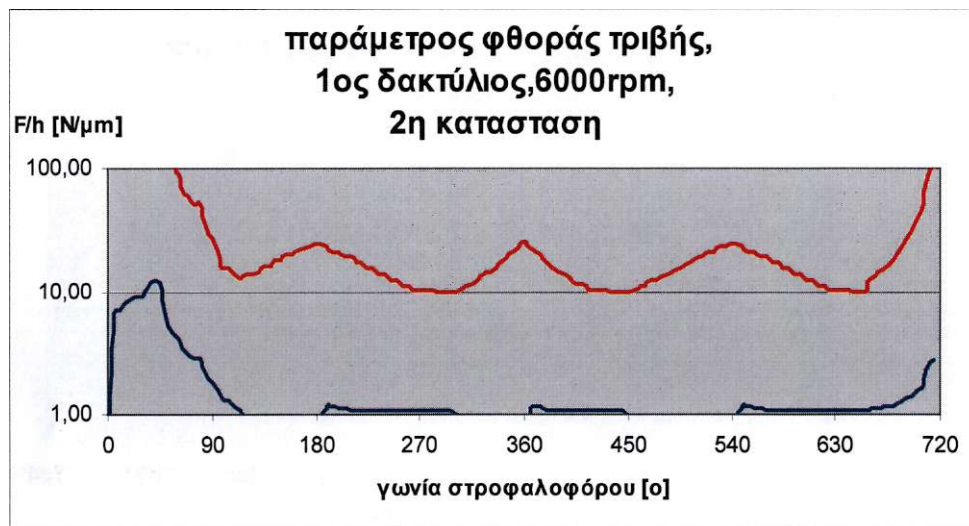
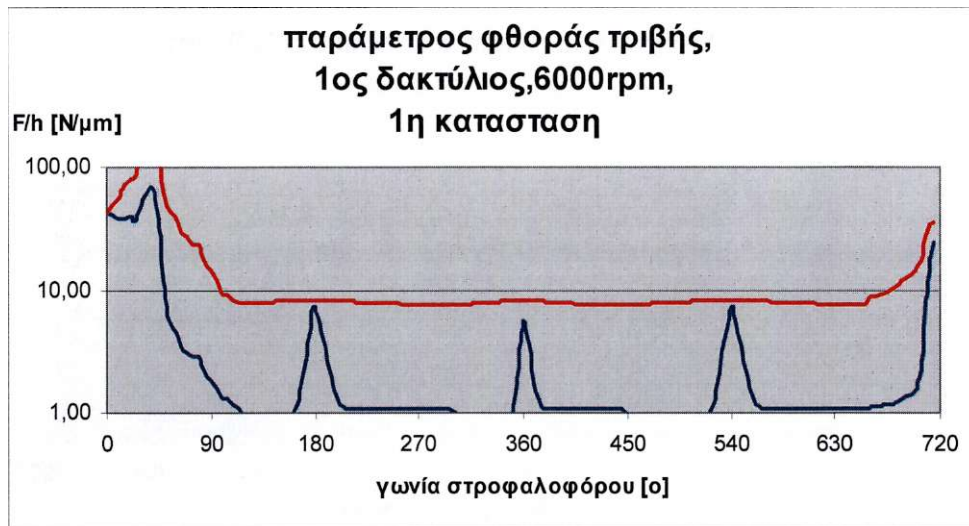




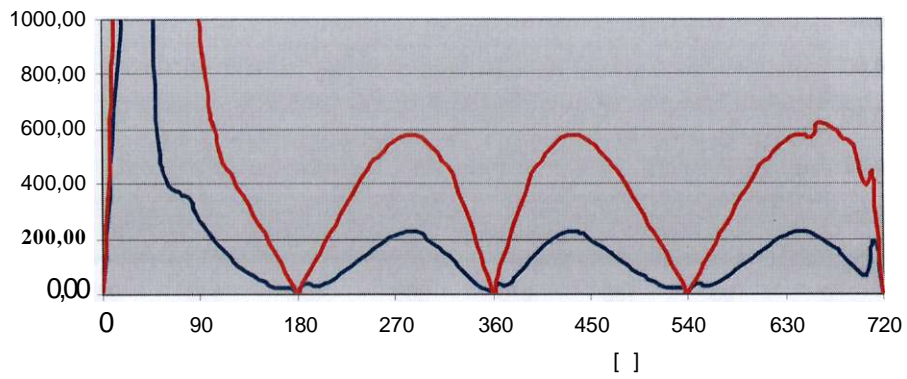




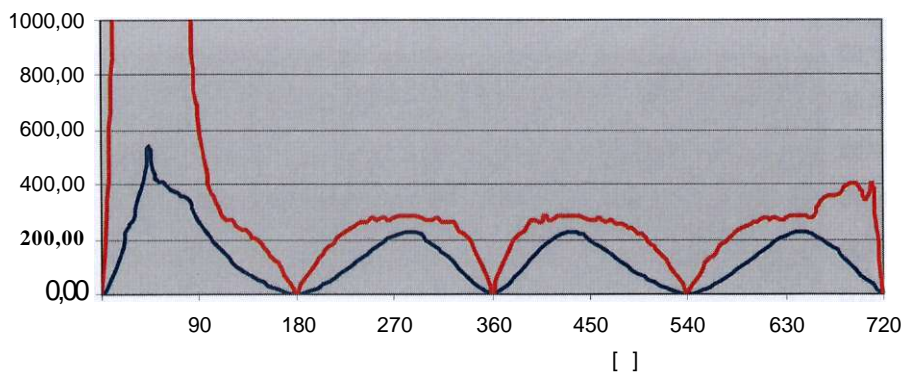




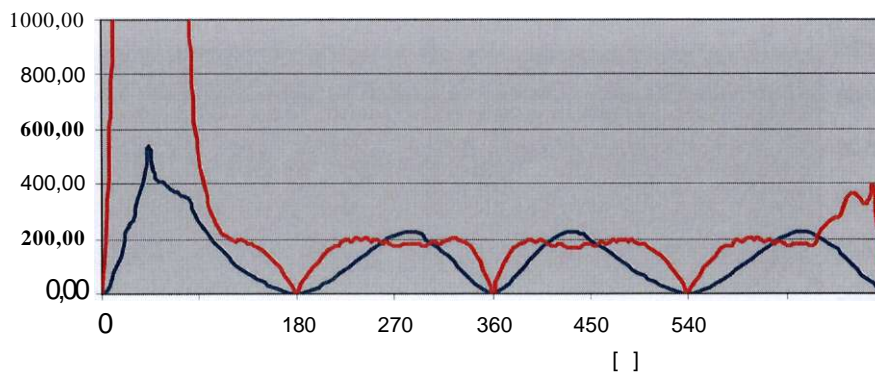
[W] **1** **,1** **,3000rpm,**

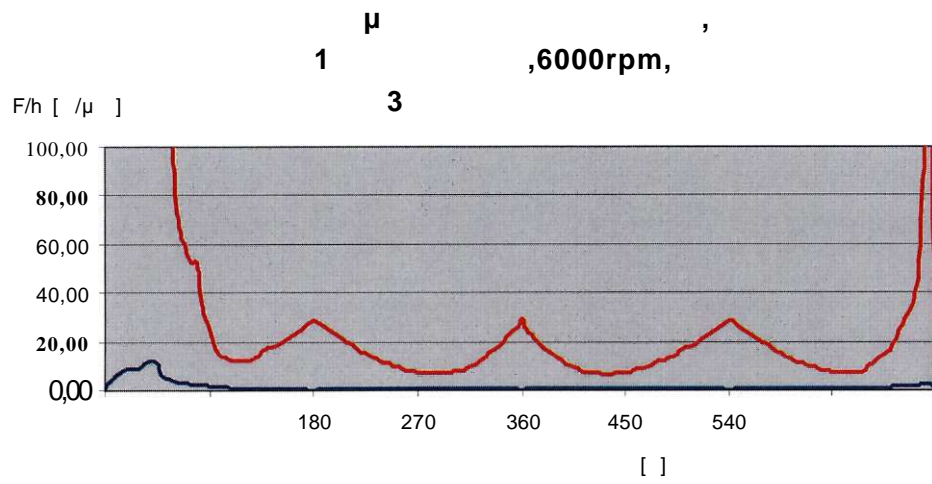
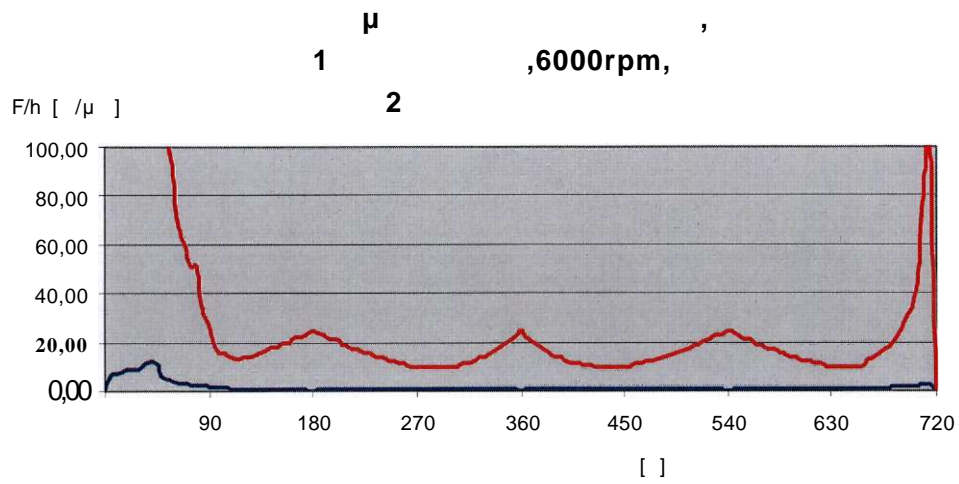
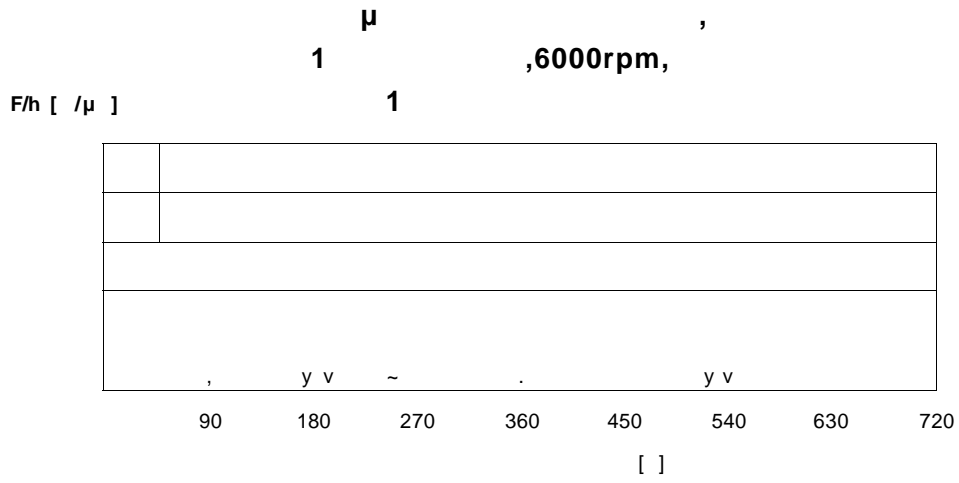


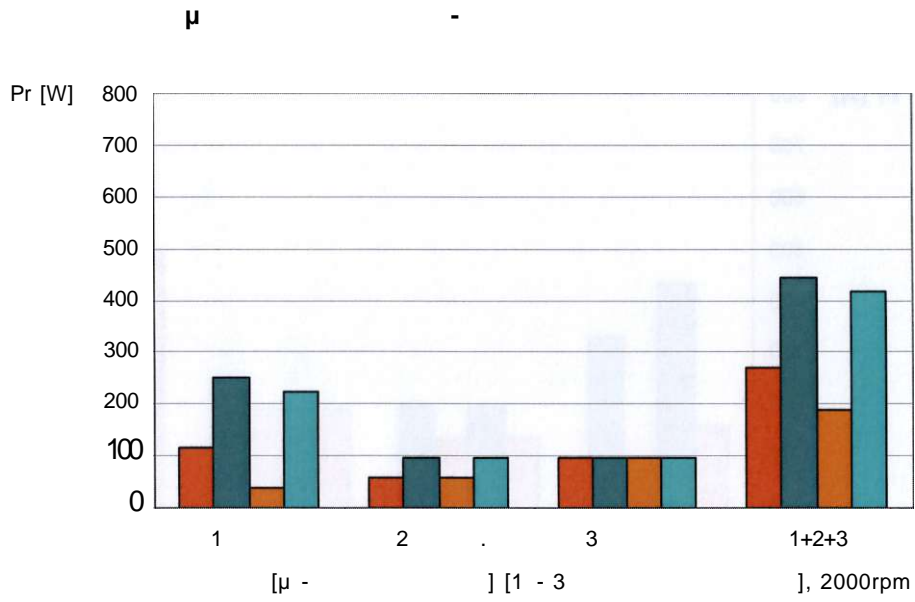
[W] **2** **,1** **,6000rpm,**



[W] **3** **,1** **,6000rpm,**

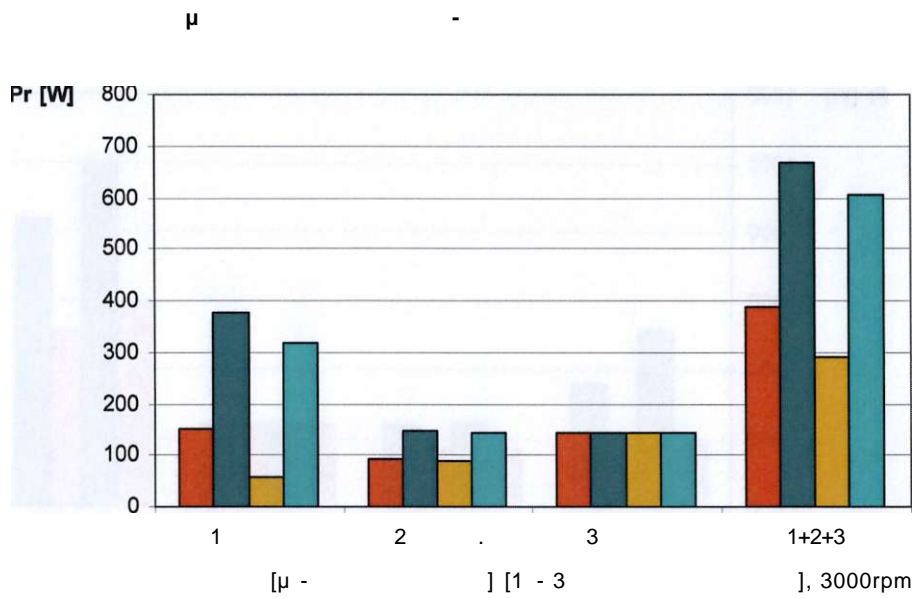






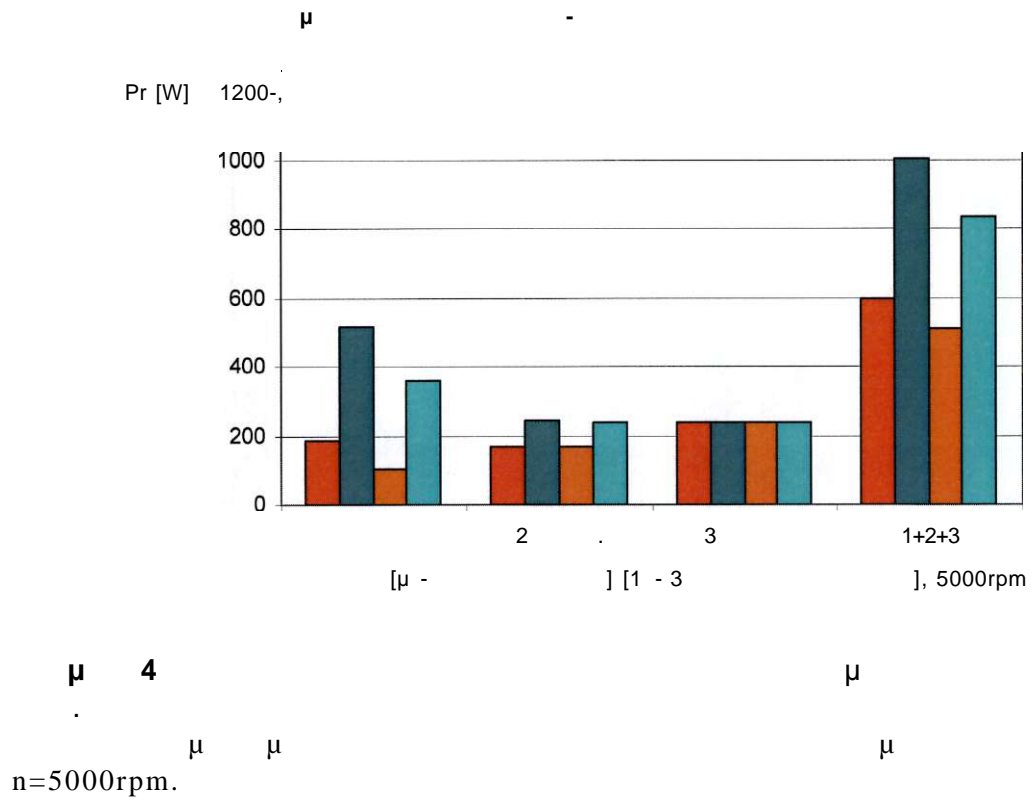
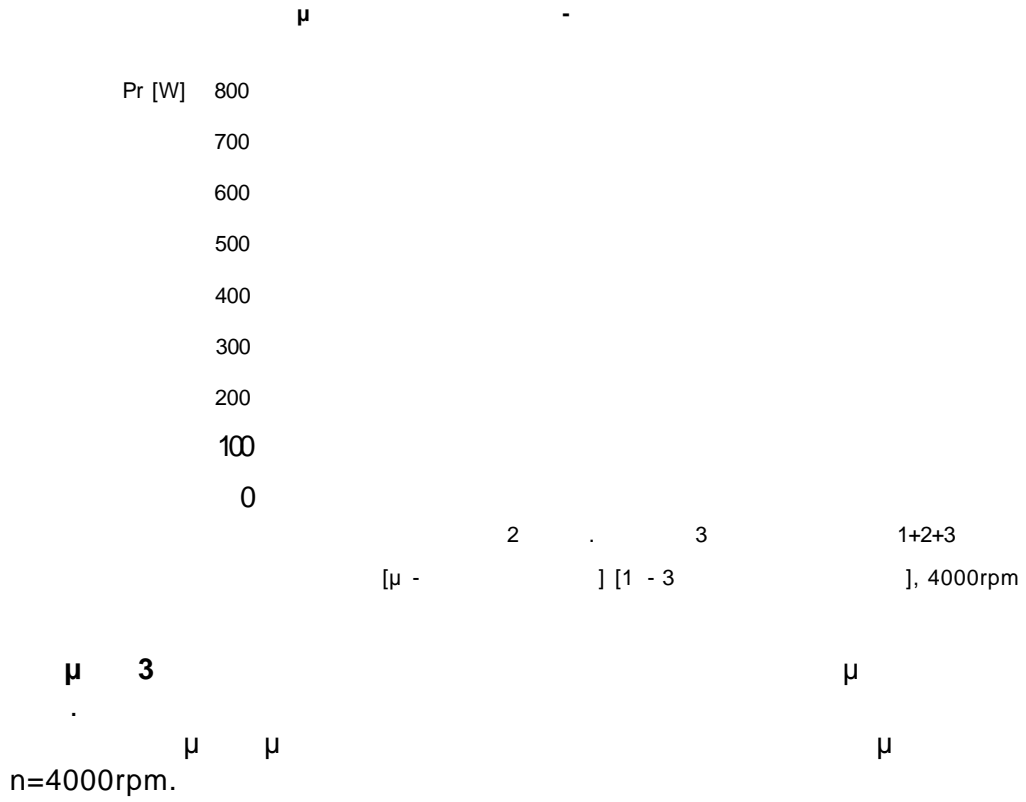
μ 1
n=2000rpm.

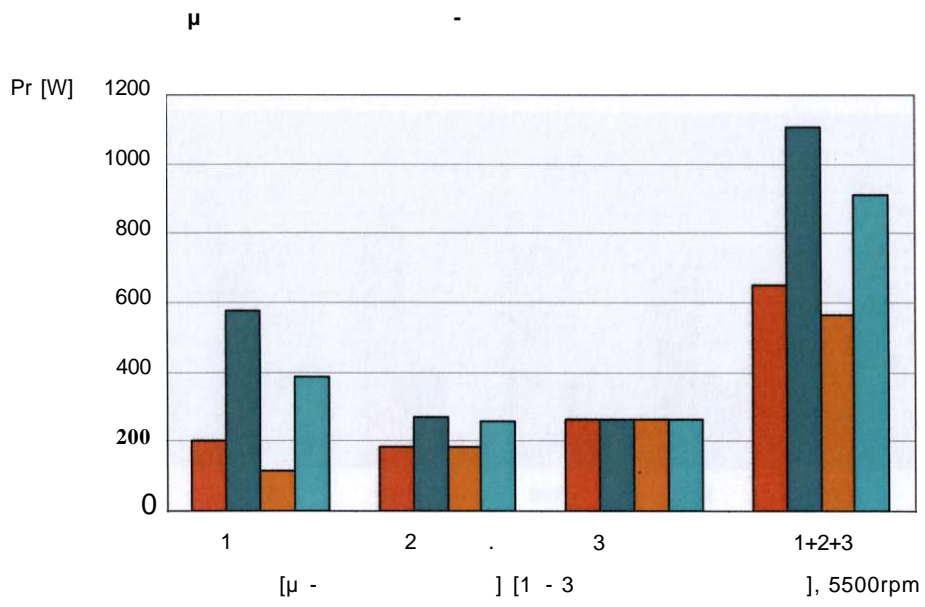
μ
 μ



μ 2
n=5000rpm.

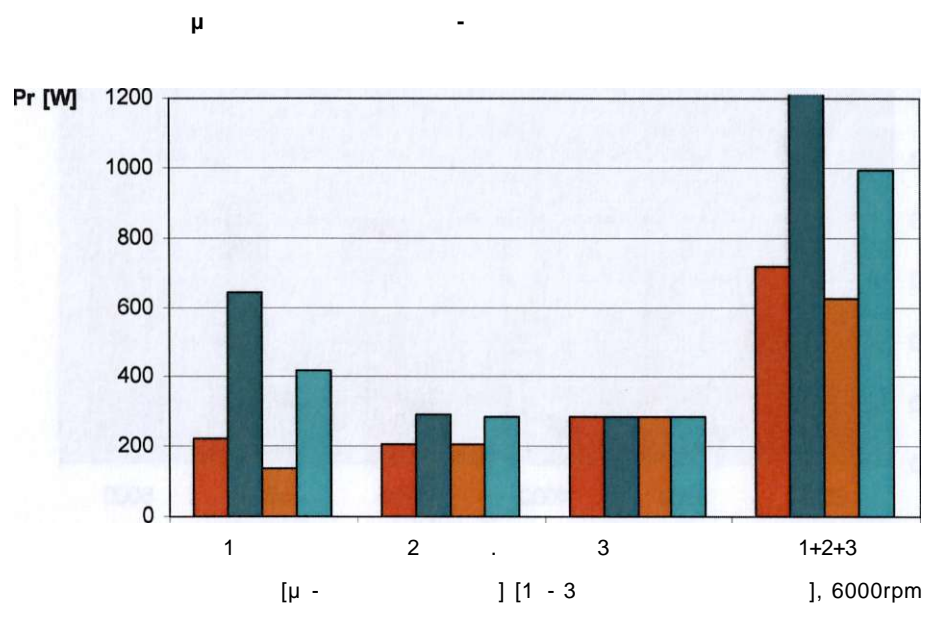
μ
 μ





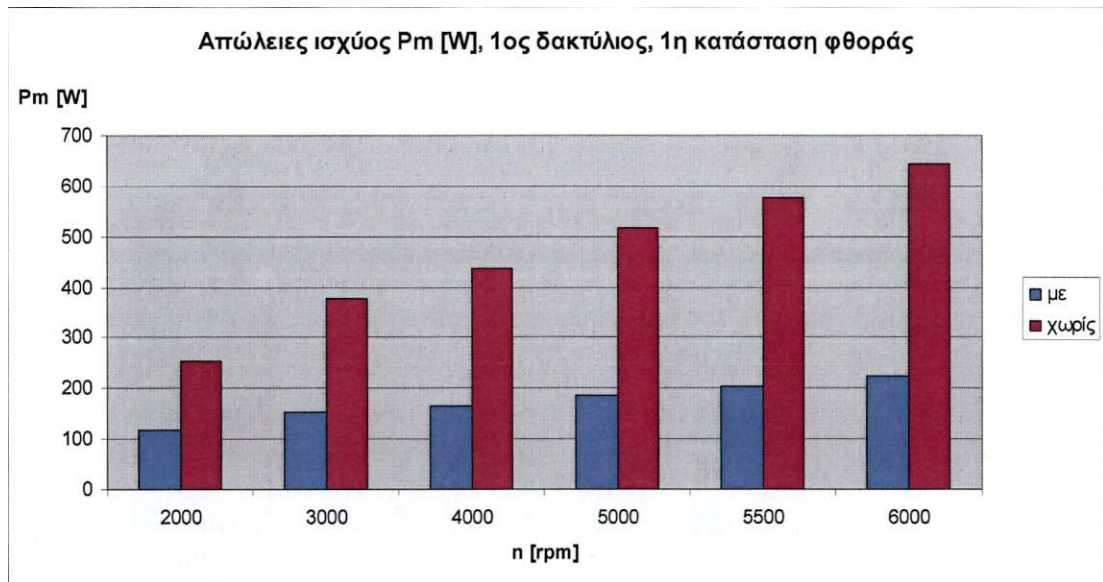
μ 5
n=5500rpm.

μ
 μ



μ 6
n=6000rpm.

μ
 μ



μ 7

μ

. 1

- 1

P_m [W], 1

, 2

P_m [W]

700

600

500

400

300

200

100

mm

2000

3000

4000

5000

5500

6000

n [rpm]

μ

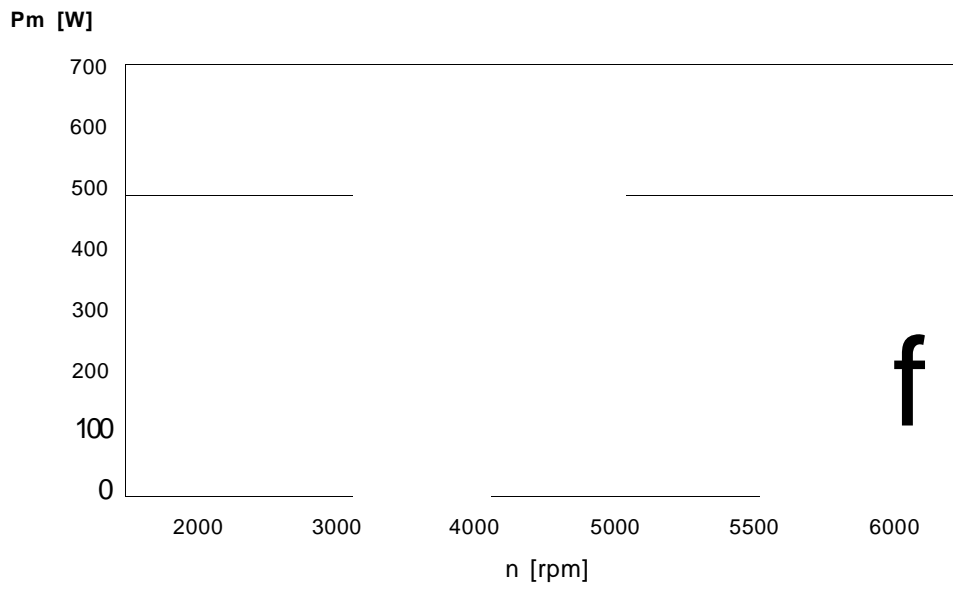
μ 8

μ

. 1

- 1

Pm [W], 1 , 3



μ

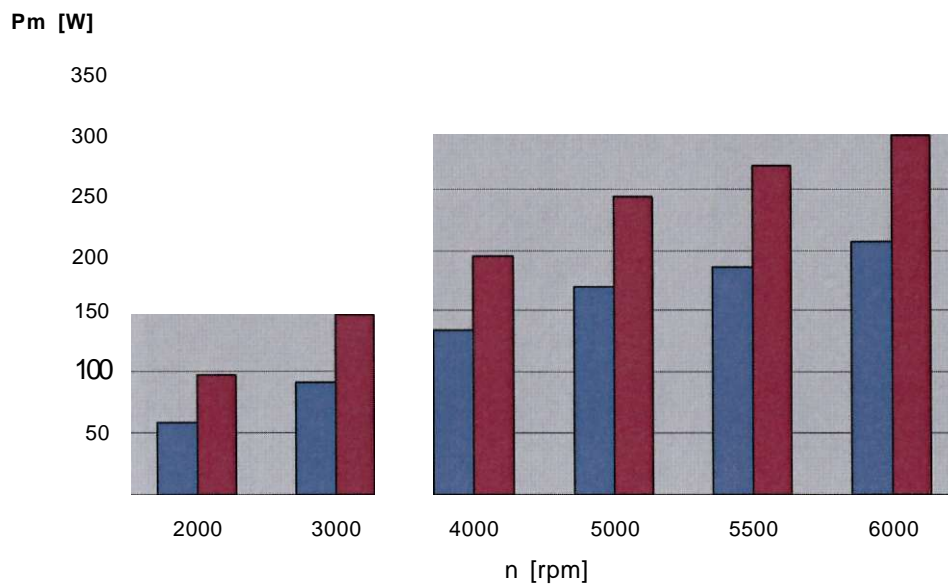
μ 9

μ

. 1

- 1

Pm [W], 2 , 1



$l\mu$

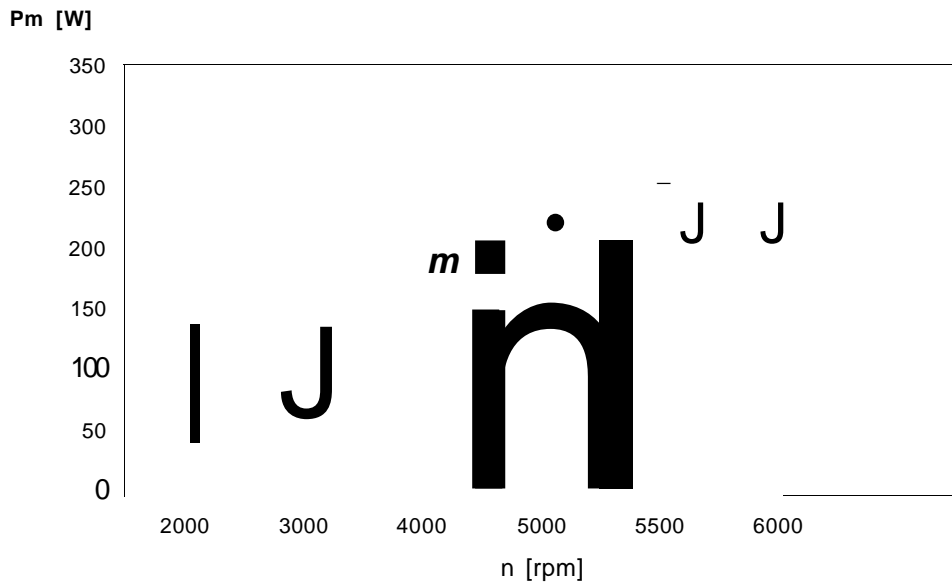
μ 10

μ

. 1

- 1

Pm [W], 2 , 3



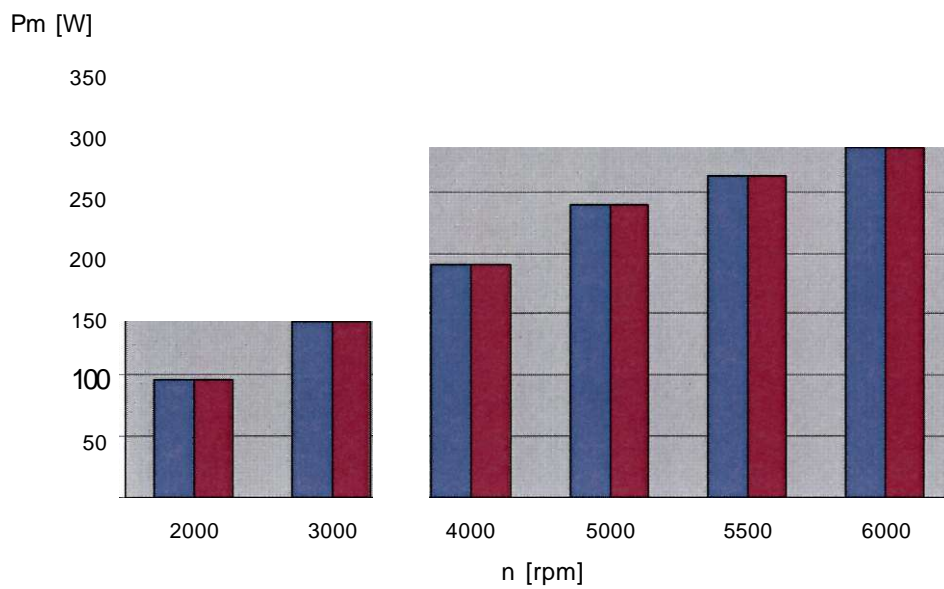
μ 11

μ

- 1

. 1

Pm [W], 3 , 1-3

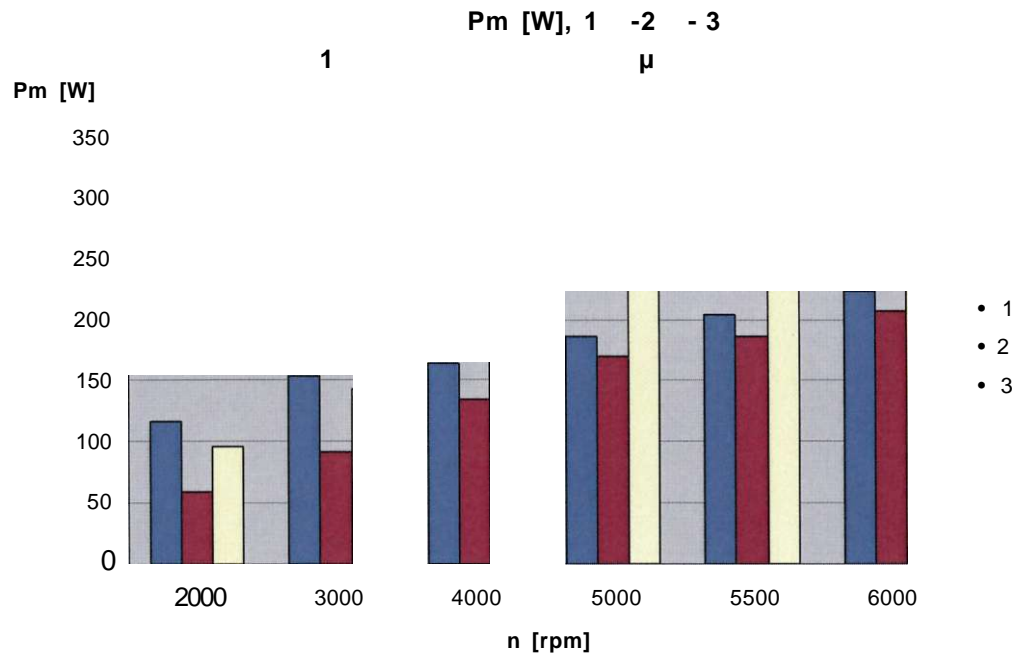


μ 12

μ

- 1

. 1

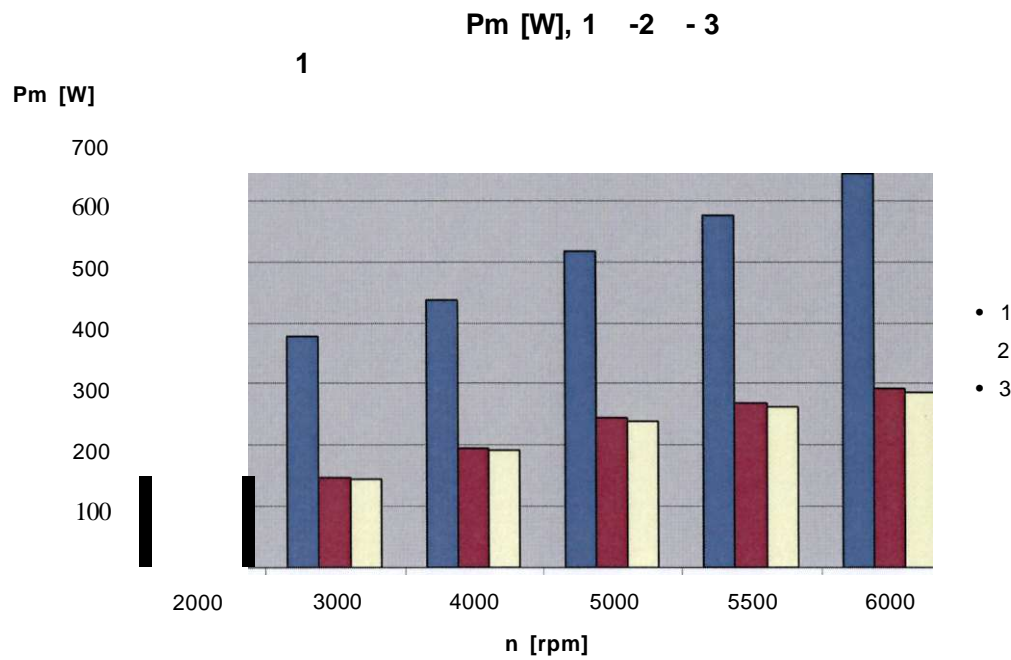


μ 13

μ

μ

. 1



μ 14

μ

. 1

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