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**National Society of the Internal Combustion Engines Specialists**

**National Scientific-Technical Club of the Automobile, Tractor and Industrial Truck Specialists**

*TECHNICAL UNIVERSITY - SOFIA*

**Faculty of Transport**

*SCIENTIFIC-TECHNICAL UNION OF TRANSPORT*

**National Section for Automobile Transport**

*HIGHER SCHOOL OF TRANSPORT "TODOR KABLESHKOV"*

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*ДЕСЕТАТА МЕЖДУНАРОДНА НАУЧНО - ТЕХНИЧЕСКА КОНФЕРЕНЦИЯ* ***MOTAUTO'03*** *СЕ ПОСВЕЩАВА НА 40-ГОДИШНИНАТА ОТ СЪЗДАВАНЕТО НА ФАКУЛТЕТ ПО ТРАНСПОРТА ПРИ ТУ - СОФИЯ.*

*Със създаването на Държавната политехника през 1946г. в България се слага началото на висшето образование в областта на транспорта и транспортното машиностроене. През 1963г. в рамките на ВМЕИ - София от Факултета по транспорт и съобщения се създава самостоятелен Факултет по транспорт, изграден на базата на 5 катедри - ДВГ, ПЖПС, ЕЖПТ, Механика и Съпротивление на материалите. Факултетът е имал около 30 преподаватели и е обучавал над 300 студента.*

*Понастоящем Факултетът по транспорт обучава студенти - бакалаври и магистри по три специалности - "Транспортна техника и технологии", "Технология и управление на транспорта" и "Авиационна техника и технологии". Във факултета работят 64 преподаватели, от които 37 хабилитирани и обучава ежегодно над 1000 студента и докторанта. Важна роля за подготовката на кадри за транспорта имат и двете висши школи за следдипломно обучение към Факултета - по автомобилен транспорт и по железопътен транспорт. Факултетът по транспорт е и важно средище за научно-изследователска работа.*

*През настоящата 2003г. Факултетът по транспорт чества 40 години от създаването си.*

*Благодарим на всички, които взеха участие в Международната конференция* ***MOTAUTO'03*** *и в честването на нашия юбилей.*

*доц. д-р инж. Борислав Трайков*
*Декан на Факултета по транспорт и*
*Председател на Организационния комитет*

# *CONTENTS*

## *SECTION II*

## *"AUTOMOBILE TECHNICS AND TRANSPORT"*

# THE INFLUENCE OF THE GEOMETRY OF THE TORQUE CONVERTERS ON THEIR PROPERTIES

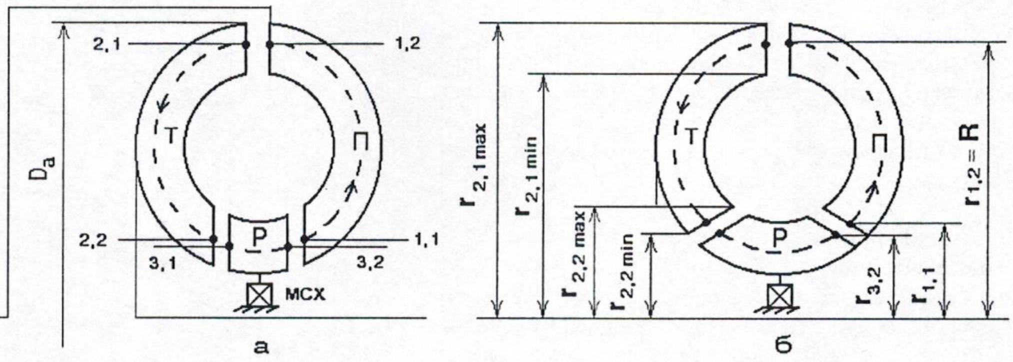
GIGOV B.I. Bulgaria M.Sc, Ph.D, Technical Univercity of Sofia

The parameters of a normal torque converter which is utilized in cars and industrial trucks have been investigated in a computer experiment as a function of the input and exit blade angles and reported in the present paper.

In the process of design and calculation of torque converters one has to use simplified theoretical approaches in which only he major factors which define the conditions of interaction between the current of the unutilized liquid and the blades of the working wheels and the less important factors are ignored. Such a simplification is essential since otherwise it is extremely difficult to investigate even the most simple torque converter phenomena. Therefore the theoretical results are approximate and can be used only for preliminary estimation of the torque converter properties and are subject to corrections based on experimental results.

The dependence between the geometry of the working wheels of the torque converter and its characteristics are based on the Euler jet theory, which is considered as adequate enough for analysis and approximate calculations of torque converters and for the deduction of the balance equations of the moments and energy if the geometrical and the velocity parameters of the current of the working liquid are correctly averaged. For the determination of the hydraulic losses and generalization of experimental data the similarity theory is used [1].

For most of the contemporary two phase torque converters it is assumed that the radii of the middle line of the current at the input and the exit of corresponding wheels and the radii of the of the live cross section of the inter-blade channels are equal. That is a special case which allows the considerable simplification of the dependencies. (In that case the relative areas and the radii are equal to one and only the relative radius r is deployed).




$$\frac{r_{ij}}{R} = \overline{r}_{ij} \; ; \; \overline{r}_{11} = \overline{r}_{22} = \overline{r}_{31} = \overline{r}_{32} = r \; ; \; \overline{r}_{12} = \overline{r}_{21} = 1$$

Fig.1 Simplified scheme of a regular torque converter

Following the approach, for the parameters which characterize the torque converter properties and their relation to the geometrical parameters of the blade wheels the following dependencies are obtained:

- for the transfer mode:

(1) $$K = \frac{\mu - i.r^2 + k_q.q}{\mu + k_{q,1}.q}$$

(2) $$\lambda = (\mu + k_{q,1}.q).q$$

(3) $$\eta = K.i$$

(4) $$k_q = \mu.ctg\beta'_{12} - r.ctg\beta_{22}$$

(5) $$k_{q,1} = \mu.ctg\beta'_{12} - r.ctg\beta_{32}$$

(6) $$q = \frac{-B + \sqrt{B^2 - A.C}}{A}$$

(7) $$A = \zeta_1(2 + ctg^2\beta'_{11} + ctg^2\beta'_{12}) + \zeta_2(2 + ctg^2\beta'_{21} + ctg^2\beta'_{22}) + \zeta_3(2 + ctg^2\beta'_{31} + ctg^2\beta'_{32}) + \xi_1(ctg\beta_{32} - ctg\beta'_{11})^2 + \xi_2(\mu.ctg\beta'_{12} - ctg\beta'_{21})^2 + \xi_3(ctg\beta_{22} - ctg\beta'_{31})^2$$

(8) $$B = B_0 + B_1.i \; ; \; C = C_0 + C_1.i + C_2.i^2$$

(9) $$B_0 = r.\xi_1(ctg\beta'_{11} - ctg\beta_{32}) + (r.ctg\beta_{32} - \mu.ctg\beta'_{12}) + \mu.\xi_2(\mu.ctg\beta'_{12} - ctg\beta'_{21})$$

(10) $$B_1 = \xi_2(ctg\beta'_{21} - \mu.ctg\beta'_{12}) + (\mu.ctg\beta'_{12} - r.ctg\beta_{22}) + r.\xi_3(ctg\beta_{22} - ctg\beta'_{31})$$

(11) $C_0 = \xi_1 . r^2 + \xi_2 . \mu^2 - 2.\mu$

(12) $C_1 = 2.\mu(1 - \xi_2)$

(13) $C_2 = \xi_2 + \xi_3 . r^2 - 2.r^2$

- for clutch mode the following equations are valid:

(14) $A = \zeta_1(2 + ctg^2\beta'_{11} + ctg^2\beta'_{12}) + \zeta_2(2 + ctg^2\beta'_{21} + ctg^2\beta'_{22}) + \zeta_3(2 + ctg^2\beta'_{31} + ctg^2\beta'_{32}) + \xi_1(ctg\beta_{22} - ctg\beta'_{11})^2 + \xi_2(\mu.ctg\beta'_{12} - ctg\beta'_{21})^2 + \xi_3(ctg\beta'_{31} - ctg\beta_{32})^2$

(15) $B_0 = r.\xi_1( ctg\beta'_{11} - ctg\beta_{22}) + ( r.ctg\beta_{22} - \mu.ctg\beta'_{12}) + \mu.\xi_2( \mu.ctg\beta'_{12} - ctg\beta'_{21})$

(16) $B_1 = \xi_2( ctg\beta'_{21} - \mu.ctg\beta'_{12}) + ( \mu.ctg\beta'_{12} - r.ctg\beta_{22}) + r.\xi_1( ctg\beta_{22} - ctg\beta'_{11})$

(17) $C_1 = 2.\mu(1 - \xi_2) + 2.r^2(1 - \xi_1)$

(18) $C_2 = \xi_2 + \xi_1 . r^2 - 2.r^2$

(19) $\lambda = (\mu - r^2 i + k_q q)q$

(20) $K = 1 ; \eta = i$

Here:

K – transformation coefficient which characterizes the transformation properties of the torque converter;

$\lambda$ - coefficient of the rotating moment of the pump wheel, which characterizes the energy capacity of the torque converter;

$\eta$ - efficiency coefficient of the torque converter which characterizes the energy losses during energy transfer;

i – speed ratio;

q – relative flow;

$\mu$ - coefficient of the current deviation at the exit of the pump wheel, which accounts for the finite blade number. The experimentally confirmed recommended values are between 0.85 and 0.97 [2]

$\xi_1,\xi_2,\xi_3$ – coefficients which account for the losses due to the collision of the liquid and the blades at the input of the corresponding wheel. For cast wheels they are assumed to be 0.8, and for stamped and welded – 0.65 [3]

$\zeta_1,\zeta_2,\zeta_3$ – coefficients which account for the friction losses between the liquid and the walls of the interblade channels.

$\beta'_{n1}$ , $\beta'_{n2}$ – angle of the blades at the input and the exit at the corresponding wheel;

$\beta_{22}$ , $\beta_{32}$ – angles of the current at the middle current line at the exit of the turbine and the reactor wheel.

A torque converter type Brockhaus 1334 with cast wheels and blade system BBA, a Bulgarian license production has been investigated with computer numerical methods. The torque converter is a complex two phase one with a centripetal turbine and reactor fixed to a socket for idle movement. The geometrical parameters and the assumed loss coefficients are listed in Table 1.

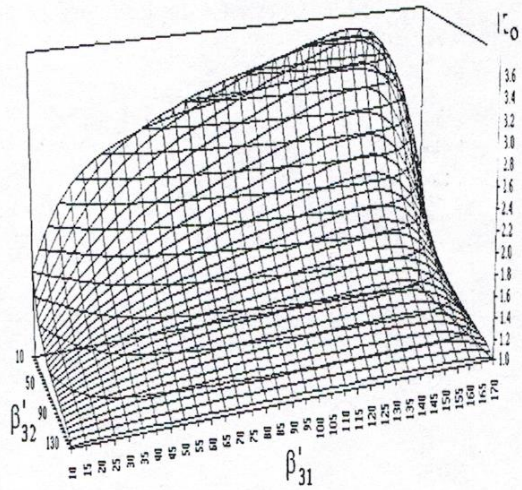
Table 1.

| Parameters of the torque converter Brockhaus 1334 BBA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $\beta'_{11}$ | $\beta'_{12}$ | $\mu$ | $\beta'_{21}$ | $\beta'_{22}$ | $\beta_{22}$ | $\beta'_{31}$ | $\beta'_{32}$ | $\beta_{32}$ |
| $90^o$ | $147^o$ | 0.9 | $53^o$ | $143^o$ | $141^o$ | $60^o$ | $25^o$ | $27^o$ |
| R | $\zeta_1$ | $\zeta_2$ | $\zeta_3$ | $\xi_1$ | $\xi_2$ | $\xi_3$ | i* | $i_c$ |
| 0.505 | 0.308 | 0.291 | 0.125 | 0.65 | 0.65 | 0.65 | 0.8 | 0.855 |

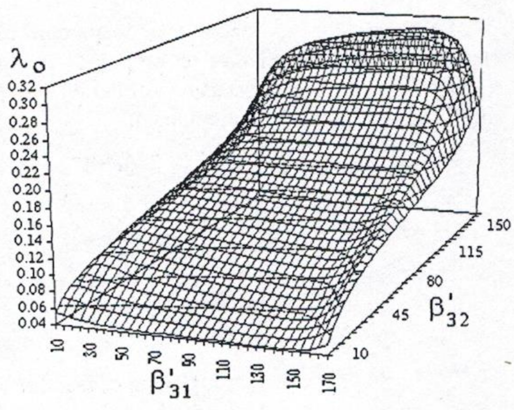
The coefficients $K_0$ and $\lambda_0$ for stop mode have been investigated, $\eta^*$ for transformer mode, $\lambda_C$ for clutch mode and the transparency coefficient $\Pi=\lambda_0/\lambda_C$.

The influence of the magnitude of the input and the exit angles of the blades and the relative radius of the work wheels on the torque converter properties can be evaluated separately, for the rest of them the original values can be assumed or an optimization can be performed for a given torque converter parameter over all geometrical parameters simultaneously. In the last case the limits for the angles are from $10^0$ to $170^0$, for the radii from 0.4 to 0.6.

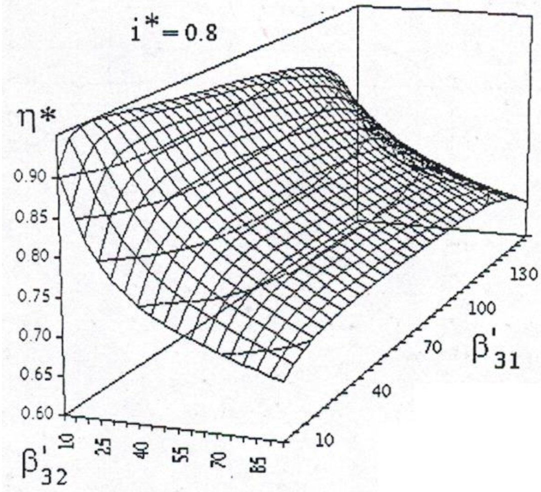
The obtained results in 3D which have as an argument the input and the out put angle of the blades of each of the working wheels of the torque converter are presented on Fig.2 to Fig.5.



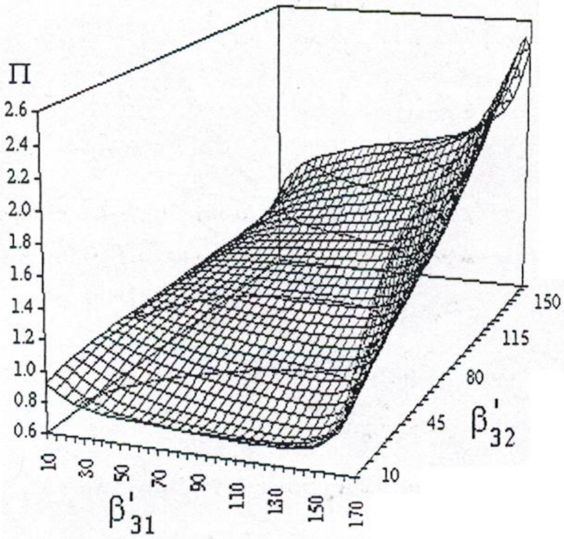

2a) Stop mode coefficient of transformation;



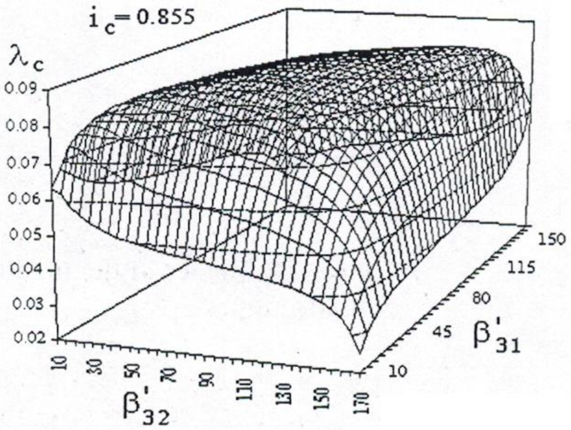

2b)The moment coefficient of the pump at stop mode




2c) Efficiency coefficient

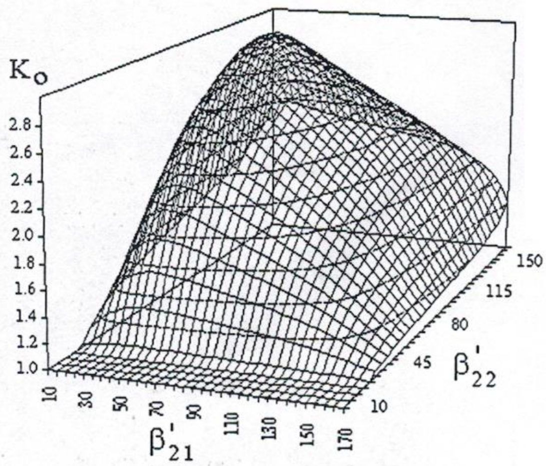



2d) Transparency coefficient;

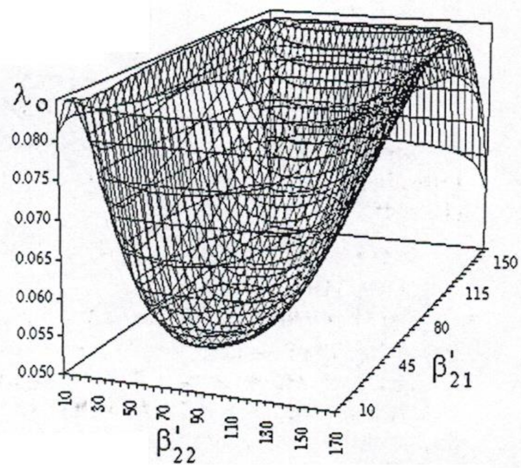



2e) The moment coefficient of the pump at clutch mode

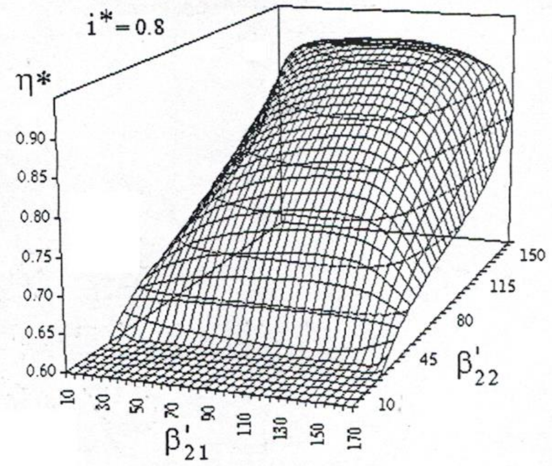
**Fig.2. Influence of the reactor wheel.blade angles;**



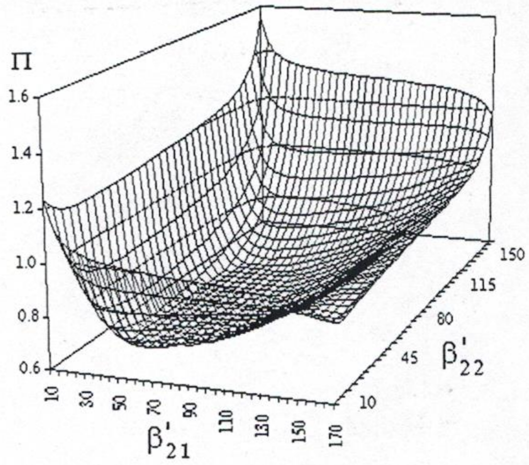

3a) Stop mode coefficient of transformation



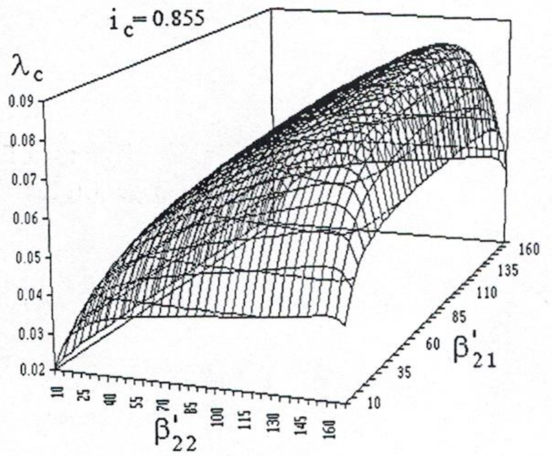

3b)The moment coefficient of the pump at stop mode




3c) Efficiency coefficient

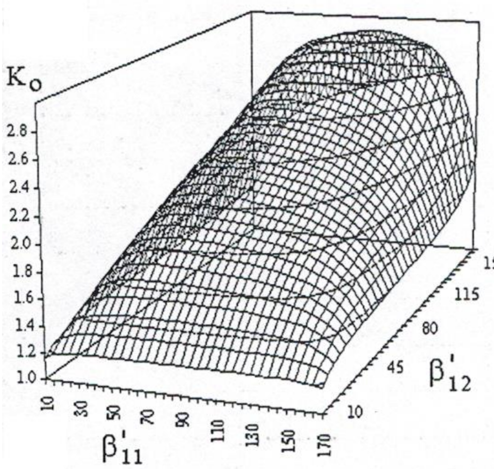



3d) Transparency coefficient

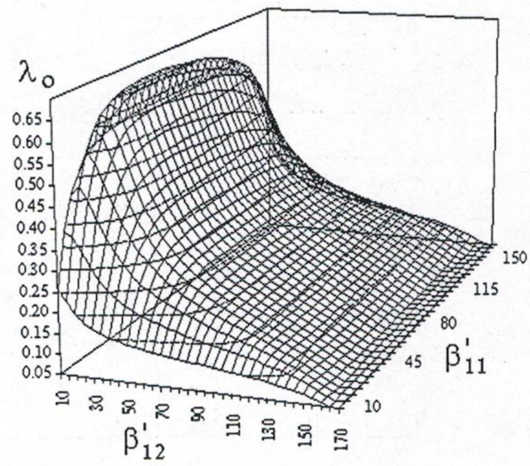



3e) The moment coefficient of the pump at clutch mode

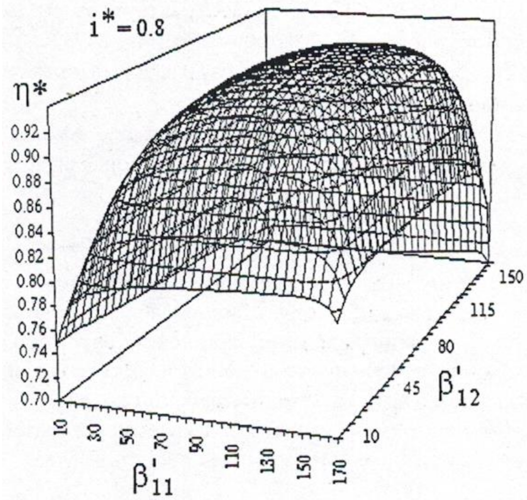
**Fig.3. Influence of the turbine blade angles**



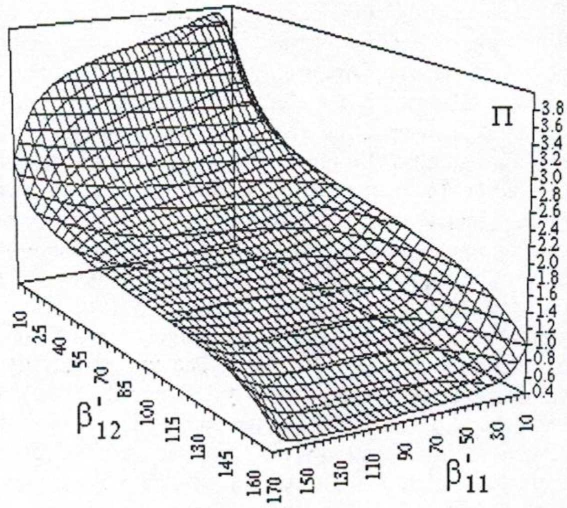

Stop mode coefficient of transformation



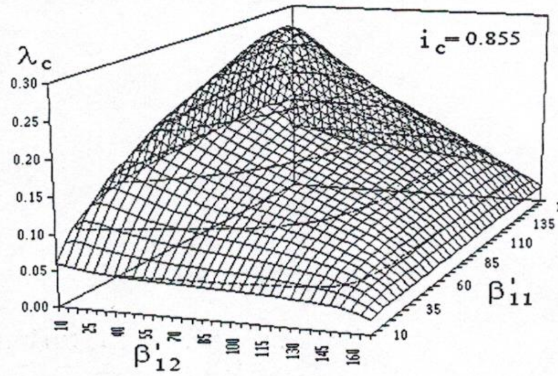

4b) The moment coefficient of the pump at stop mode




4c) Efficiency coefficient




4d) Transparency coefficient




4e) The moment coefficient of the pump at clutch mode

**Fig.4. Influence of the pump blade angles**

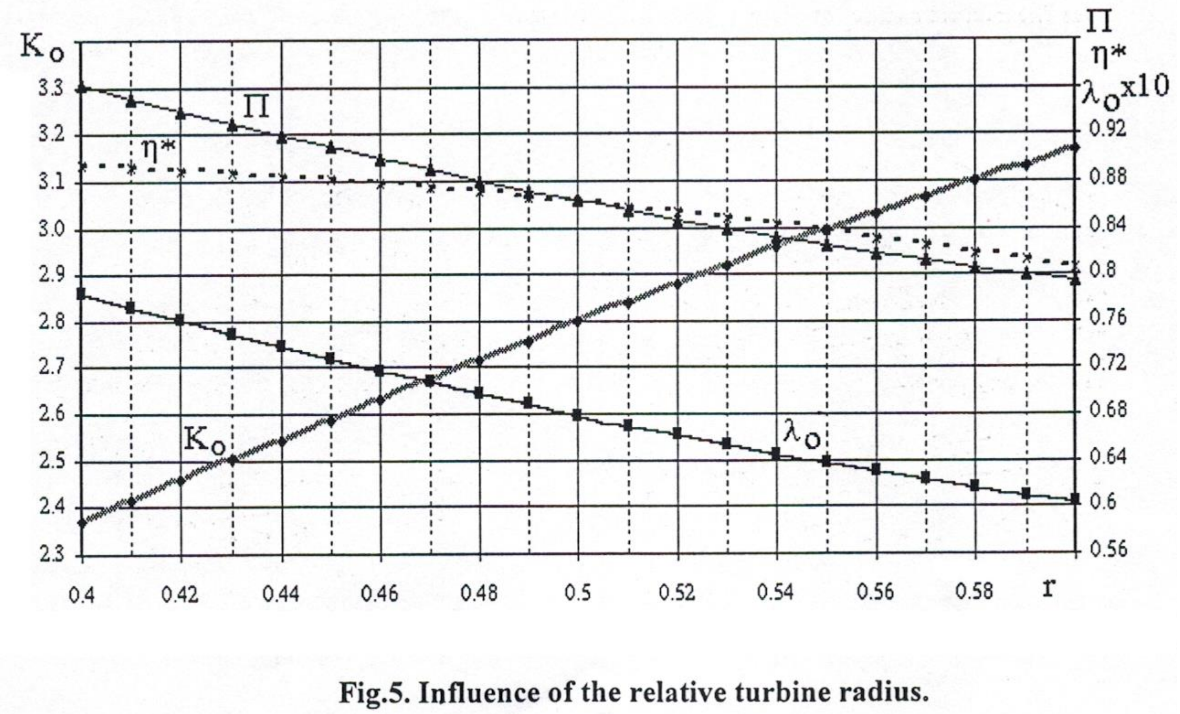



**Fig.5. Influence of the relative turbine radius.**

## Conclusion

The analysis of the results give evidence that the highest resource for improvement of the transformation properties of the transformer ( $K_0$ up to 3.8) has the reactor (Fig.2a). The pump parameters influence mostly on the energy capacity and the transparency (Fig.4b and d), but in a very small angle range. The transparency can be increased by the reactor angles, while for the turbine wheel those parameters are reduced in almost the total angle range (Fig.3b and d). For very small exit angle of the reactor blades the highest efficiency coefficient is obtained for transformer mode - approximately 0.95 (Fig.2c). The pump and the turbine work with relatively high efficiency coefficient in a wide angle range. The energy capacity in clutch mode can be significantly influenced only by the geometrical characteristics of the pump.(Fig.4e) When the relative radius of the turbine is increased up to 0.6 (Fig.5.) the transformation coefficient for the stop mode is increased (up to 3.2) and a negligible decrease of the efficiency coefficient (up to 0.81), but simultaneously the energy capacity is decreased and the reverse transparency of the torque converter is increased.

## LITERATURE

[1]. Лаптев, Ю.Н., Автотракторные гидротрансформаторы., М., Машиностроение, 1973.

[2]. Нарбут А.Н., Гидротрансформаторы., М., Машиностроение, 1966.

[3]. Wolf M. Strömungskupplungen und Strömungswandler. Berechnung und Konstruktion.,Springer – Verlag, Berlin /Göttingen/Heidelberg, 1962.

Резюме

В статията са изследвани чрез изчислителен експеримент показателите на обикновен хидротрансформатор, намиращ приложение при леките автомобили и мотокарите в зависимост от входящите и изходящите ъгли на лопатките на неговите работни колела.

ГИГОВ Б.И. , "За влиянието на геометрията на хидротрансформаторите върху техните свойства"