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THE CONTRIBUTION TO DIMENSIONING THE RIBS IN THE JACKET OF THE MULTIROPE KOEPE PULLEY OF THE HOISTING MACHINE

Summary: The development of the elastostatics of the smooth jacket of the multirope Koepe pulley of the hoisting machine has been presented in the paper below. Results of the study of the models of the jackets reinforced by one rib have been illustrated as well as the study of the model of the jacket reinforced by two ribs and the conclusions have been put down.

1. INTRODUCTION

Generalized forces appearing in the jacket of multirope Koepe pulley of the hoisting machine have been defined for the first time by O.Popowicz in a theoretical way, and next in the same way by P.L. Ševčenko. Theoretically calcalated values of the generalized forces needed empirical revision. So the investigations on the steel models of the smooth jacket [1], [2], have been done and their results confirmed the rightness of the theoretical works [7], [8].

In the theoretical considerations the jacket of Koepe pulley is treated as the coat inside which there is a two - way state of stresses. In the smooth jacket the maximum meridional moments - bending generating lines of the jacket - appear on the arc loaded by the rope. Behind this arc the moments gradually decay to the zero state. Maximum parallel moments bending circles, and caused by the discontinuity of load on the parallel, appear in the surroundings of these discontinuities. Maximum meridional moments decisively influence the effort of the material of the jacket. The stresses caused by them are twice as much as the stresses caused by maximum parallel moments, and also several times greater than the stresses caused by the membranous forces [3].

The author of this paper has made the investigations on the model of Koepe pulley made of metaplex along with a smooth jacket, [4], and next also on the model made of metaplex strengthening the jacket by one rib - that was ring - shaped - located under the rope and in the middle of the generating line [5], [6]. The results of the studies point out at the important difference between stresses being present in the smooth jacket and those present in a ribbed one. In the jacket reinforced by the rib maximum meridional moments which are located on the rib have insignificant values in comparison to meridional moments in the smooth jacket. However, local meridional moments - according to the theoretical term are present in the jacket in a proper distance from the rib. Maximum parallel moments act in the plane on which the symmetric axis of the arc loaded by the rope is laying (angle $\alpha = 0$ fig.1). The quantity of parallel local moments depends on the height of the rib just in the smooth jacket in depends on its thickness.

Using Clapeyron's law of elastic strain energy the author has derivated the formula for the determination of the maximum parallel moment in the rib of the multicable Koepe pulley of the hoisting machine [5], [6]. The radial rib in the multirope Koepe pulley is placed under the rope and the pairs of ribs responding to the pairs of rope used simultaneously: one, two and more.
The question arises: how do the ribs work together while carrying the load caused by the pull of the ropes?
It was decided to carry out further research works on models described in the paper.

2. RESEARCH WORKS ON MODELS WITH RIBBED JACKET

The research works were given deep consideration at the Institute of Mining Mechanization of the Technical University of Silesia in Gliwice.

The model of Koepe pulley made of metaplex was taken um in the works - measurements of the strain of the rib and of the jacket being made before (fig. 1). The jacket of Koepe pulley was reinforced by one rib placed under the rope and in the middle of the generating lines of the jacket. Dimensions of the rib: height 0,021 m and thickenes 0,01 m, thickness of the jacket being 0,003 m. Already existing test stand was used, fig. 1, as well as measuring apparatus from works previously carried out The measurements of the main strains were done by the method of the resistary extensome - tery. The model of Koepe pulley loaded by force Z, fig. 1., realized by steel weights parallely hung at the and of the rope directly girding the arc πr. During the measurements the model was being turned by hand by angle 2π rad with peripheral speed at about 0,06 m/s, and next in the opposite direction to the starting position.

In this way two diagrams were obtained on the recorder x - y. The potentiometr united due to coupling with the shaft of Koepe pulley was reacting to the change of angular displacement α, giving a value of the abscissa on the diagram, however, the bridge was reacting to values of the strains corresponding to the ordinates. The tensometery rosattes were stuck to the interior side of the rib and to the interior and external sides of the jacket, fig. 1. The jacket of Koepe pulley was loaded by the force which was causing the effort of the material below the limit according to Hooke's law.

The strains were measured in three stages. During the first stage the jacket was reinforced by one rib with the tensometery rosettes stuck to its interior side. The load of the rope was then Z = 100 N. During the second stage the jacket was reinforced by two ribs - both 0,21 m high and 0,01 thick. The second rib was stuck to the jacket keeping 0,03 m of distance between the ribs. There were no tensometers on the stuck rib. The jecket was directly loaded by the rope with the tension Z = 100 N, and the ropes were placed over the with the tensometers. During the third stage the forse Z = 200 N was put to the rope placed over the rib without tensometers in conditious as before. The measurements of the strains were done three times of each tensometer receiving in this way six diagrams because Koepe pulley was being turned in two directions.

3. ANALYSIS OF THE RESULTS

The parallel and meridional strains of the rib are shown in fig. 2a and fig. 2b from the first stage of the works. The maximum parallel strains, fig. 2b, appear on the symmetric axis of the arc loaded by the rope and they are about twice as much as the maximum meridional strains, fig. 2a.

Parallel and meridional strains of the rib are shown in fig. 2c, and fig. 2d, from the second stage of the works. Maximum parallel strains are observed in the same position as in the first stage and they are approximately twice less than the strains shown in fig. 2b, in the jacket with one rib. The conclusion is obvious now that in the two - ribbed jacket the load of the rope is carried evenly by two ribs, that is in accordance to Bettie and Maxwell's laws of mutuality of displacement.

We can assume that transmission the load by the ribs is not even if the distance between those ribs is bigger. Proportion between the maximum meridional and parallel strains is the same as in the first stage. The plot of the strains from the third stage is presented in fig. 3a and fig. 3b - accordingly for the meridional and parallel strains. Characteristics of the strains resemble those presented at stage one and two.

Maximum values of parallel strains are approximately twice as big as those presented in fig. 2d, while load is doubled. That would confirm the conclusion concerning the colaboration of two ribs while carrying the load put on one rib only. ε_p and ε_r strains presented in fig. 3a and fig. 3b, were charged into strains according to generalisd Hooke's law,

$$\sigma_p = \frac{E}{1 - \vartheta^2} (\varepsilon_p + \varepsilon_r) ;$$
$$\sigma_r = \frac{E}{1 - \vartheta^2} (\varepsilon_r + \varepsilon_p) ; \qquad (1)$$

whills

$E = 3 \cdot 10^9$ N/m^2 - Young's modulus[1)]

$\vartheta = 0,4$ - Poissone's number[1)]

The apparatus constant being $2,352 \cdot 10^{-5}$ has been taken into account and responded to the values of $\varepsilon = 0,01$ m plotted on the diagrams.

Characteristics of the stresses have been shown in fig. 3c and fig. 3d meridional and parallel accordingly.

It has been noticed that maximum meridional stresses are about three times less than maximum parallel ones. At that, meridional stresses have got minus charge in majority. In the smooth jacket these stresses have got plus charge. The conclusions are as follows: two - way state of stresses appearing in the smooth jacket is almost one - way state of stresses in the rib, and effort of the rib material decisivly influences the parallel stresses.

4. CONCLUSIONS

You can analysis the, results of researches of the multirope Koepe pulley model and you can observe that:

1. The radial ribs displace upon the Betti's and Maxwell's reciprocal theorem.
2. The meridional stress is negative at the point of the maximum negative circumferential stress of the rib.
3. Parallel stress decisivly influences the effort of the rib material.

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1) values measured empirically for a material the pattern of studied pulley had been made.

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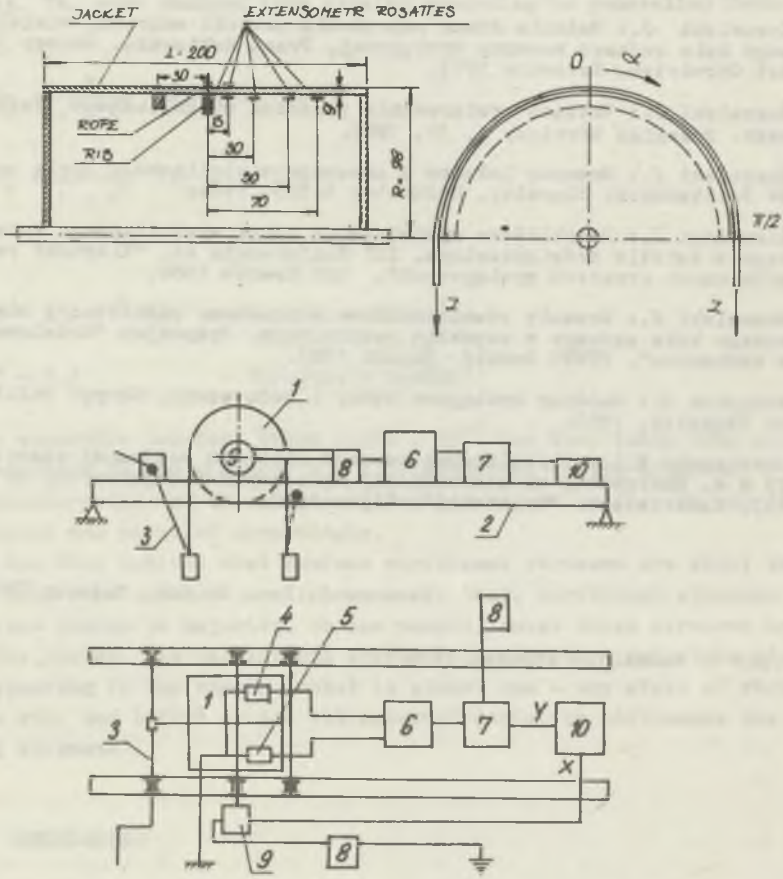

Fig. 1. Diagram stand:

1-- pattern driving - wheel, 2 - structure carrying, 3 - system loading, 4 - deformetr measure, 5 - deformetr compensation, 5 - bridge deformator, 7 - pre amplitior, 8 - feeder cable stabilize, 9 - potentiometr, 10 - recording RXY-101

Rys. 1. Stanowisko badawcze

1 - model koła pędnego, 2 - konstrukcja nośna, 3 - system obciążający, 4 - tensometry pomiarowe, 5 - tensometr kompensacyjny, 6 - mostek, 7 - przedwzmacniacz, 8 - stabilizator, 9 - potencjometr, 10 - rejestrator - RXY-101

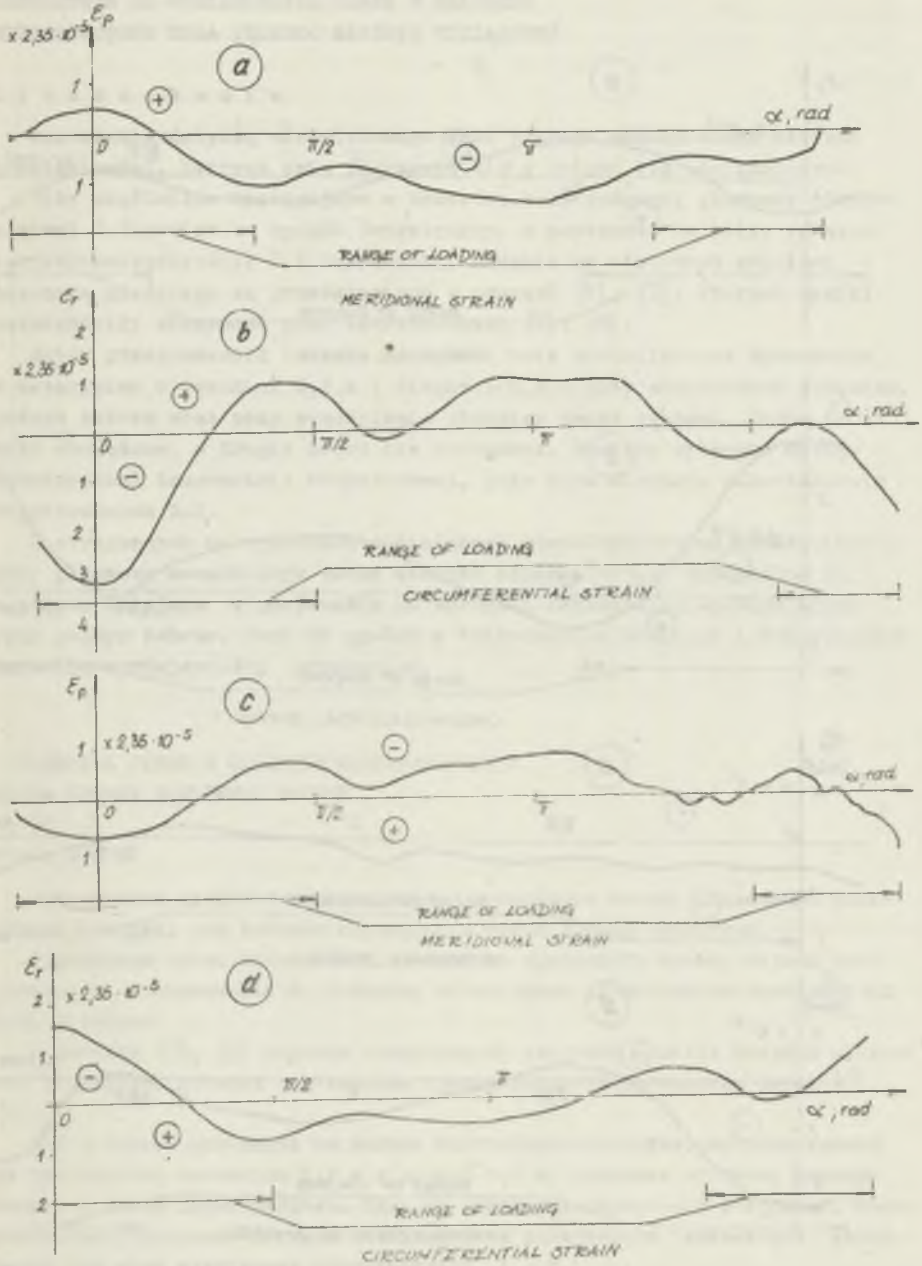
a
ε_p
x 2,35·10⁻⁵
α, rad
π/2
π
RANGE OF LOADING
MERIDIONAL STRAIN
b
σ_r
x 2,35·10⁵
α, rad
π/2
π
RANGE OF LOADING
CIRCUMFERENTIAL STRAIN
c
ε_p
x 2,35·10⁻⁵
α, rad
π/2
π
RANGE OF LOADING
MERIDIONAL STRAIN
d
ε_r
x 2,35·10⁻⁵
π/2
π
α, rad
RANGE OF LOADING
CIRCUMFERENTIAL STRAIN

Fig. 2.
Rys. 2.

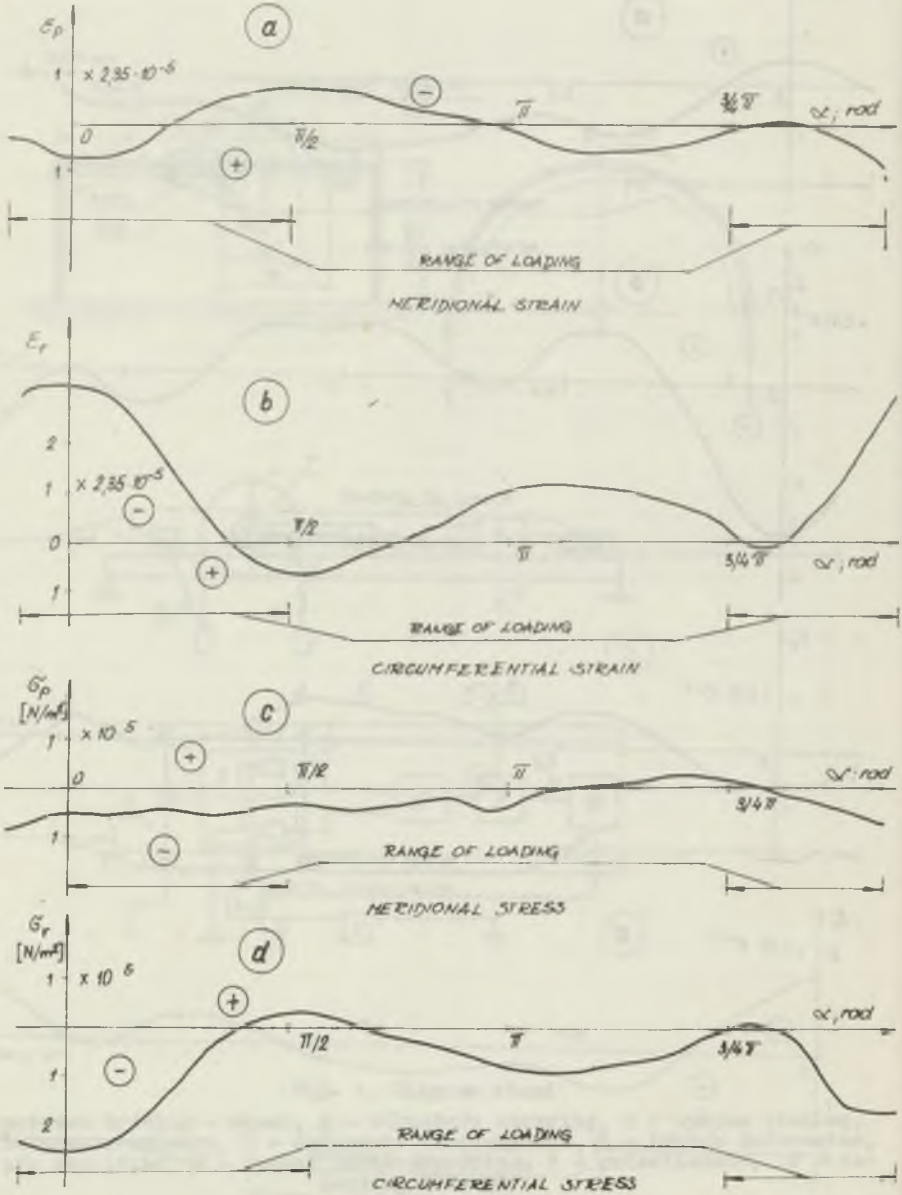
a
ε_p
1
× 2,35 · 10⁻⁵
0
1
π/2
π
3/4 π
α ; rad
RANGE OF LOADING
MERIDIONAL STRAIN
b
ε_r
2
1
× 2,35 10⁻⁵
0
1
π/2
π
3/4 π
α ; rad
RANGE OF LOADING
CIRCUMFERENTIAL STRAIN
c
σ_p [N/m²]
1
× 10⁵
0
1
π/2
π
3/4 π
α : rad
RANGE OF LOADING
MERIDIONAL STRESS
d
σ_r [N/m²]
1
× 10⁶
1
2
π/2
π
3/4 π
α, rad
RANGE OF LOADING
CIRCUMFERENTIAL STRESS

Fig. 3.
Rys. 3.

PRZYCZYNEK DO WYMIAROWANIA ŻEBER W PŁASZCZU WIELOLINOWEGO KOŁA PĘDNEGO MASZYNY WYCIĄGOWEJ

S t r e s z c z e n i e

Rozważania dotyczą wielolinowego koła pędnego wzmocnionego żebrami promieniowymi, których osie pokrywają się z osiami lin obciążających.

Siły uogólnione występujące w płaszczu koła pędnego, pierwszy zdeterminował O.Popowicz w sposób teoretyczny, a następnie te siły, również teoretycznie, określił F.L.Szewczenko. Badania na stalowych modelach płaszcza gładkiego są przedstawione w pracach [1], [2], których wyniki potwierdziły słuszność prac teoretycznych [7], [8].

Autor przeprowadził badania na modelu koła wielolinowego wykonanego z metapleksu o średnicy 0,2 m i długości 0,2 m przy wzmocnieniu płaszcza jednym żebrem oraz przy wzmocnieniu płaszcza dwoma żebrami. Jedno żebro było obciążone, a drugie żebro nie obciążone. Pomiary wykonano metodą elektrycznej tensometrii rezystorowej, przy czym mierzono odkształcenia rejestratorem X-Y.

Z otrzymanych na wykresach odkształceń równoleżnikowych wynika, że: przy płaszczu wzmocnionym dwoma żebrami odkształcenia maksymalne są o połowę mniejsze w porównaniu do wartości odkształceń występujących przy jednym żebrze. Jest to zgodne z twierdzeniem Bettiego i twierdzeniem Maxwella o wzajemności przesunięć.

О РАЗМЕРАХ РЁБЕР В ОБОЛОЧКЕ МНОГОКАНАТНОГО ШКИВА ТРЕНИЯ ПОДЪЁМНОЙ МАШИНЫ

Р е з ю м е

Рассуждения касаются многоканатного приводного шкива, усиленного радиусными рёбрами, оси которых совпадают с осями тросов натяжения.

Обобщённые силы, находящиеся в оболочке приводного шкива, первым теоретически детерминовал О. Попович, затем также теоретически определил их Ф.Л. Шевченко.

В работах [1], [2] описаны испытания на стальных моделях гладкой оболочке, результаты которых подтвердили правильность теоретических работ [7], [8].

Автор провел испытания на модели многоканатного шкива, изготовленного из плексигласа диаметром 0,2 м и длиной 0,2 м, усиливая оболочку сначала одним, а затем двумя рёбрами. Одно из ребер находилось под нагрузкой. Измерения были выполнены методом электрической резисторной тензометрии, деформации при этом измерялись регистратором X - У.

Полученные графики параллельных (широтных) деформаций свидетельствуют о том, что при оболочке, усиленной двумя рёбрами, максимальные деформации

наполовину меньше по сравнению с величинами деформаций, появляющихся при одном ребре. Соответствует это утверждениям Беттие и Максвелла о взаимоперемещениях.