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Standard Formula for the Determination of Bending Stresses in V-Belt Sheave Arms

MPTA STANDARD

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Abstract
This standard provides a method for calculating bending stresses in v-belt sheave arms.

Foreword

This Foreword is provided for informational purposes only and is not to be construed to be part of any technical specification.

This standard is a revision of MPTA SAS-79, 2000. It has been re-formatted for consistency with other MPTA documents. The only change to the content was the change of the symbol “W” to “H” in the I-beam arm diagram.
Suggestions for the improvement of, or comments on this publication are welcome. They should be mailed to Mechanical Power Transmission Association, 6724 Lone Oak Blvd., Naples, FL 34109 on your company letterhead.

Scope

This standard is intended to provide a method to provide consistency and accuracy in determining bending stresses in sheave arms caused by torque and eccentric belt loading.

Step 1: Bending Stresses caused by torque. (St)

$$St = \left[\frac{(T_1 - T_2)\ N\ D}{2n\ Zx}\right] \bullet \left[\frac{Di - Dn}{Di}\right] \quad \text{(psi)}$$

Step 2: Bending Stresses caused by eccentric belt loading. (Se)

$$Se = \left[\frac{(T_1 + T_2)\ Ne}{4.5\ Zy}\right] \bullet \left[\frac{Di - Dn}{Di}\right] \quad \text{(psi)}$$

Step 3: Combined bending stresses. (Sc)

A) For Rectangular & I-Beam Arms.

$$Sc = St + Se \quad \text{(psi)}$$

B) For Oval Arms.

$$Sc = \sqrt{St^2 + Se^2} \quad \text{(psi)}$$

The combined stress must be less than 10% of the minimum tensile strength of the material used. This 10% value is derived by assuming a 40% endurance limit and derating 50% for possible residual stresses and another 50% for a safety factor.

LIST OF SYMBOLS

$(T_1 - T_2)$	=	Effective tension per belt. (lb.)
$(T_1 + T_2)$	=	Total belt pull per belt. (lb.)
N	=	Number of grooves or belts.
D	=	Sheave pitch diameter. (in.)
Di	=	Inside diameter of sheave rim (in.)
Dn	=	Outside diameter of sheave hub. (in.)
n	=	Number of sheave arms.
Z(x&y)	=	Section modulus at hub. (in^3)
e	=	Eccentricity of belt load (in.)

<u>DETERMINATION OF T1 & T2</u>

Effective Tension (per belt) = $(T_1 - T_2)$ = $\dfrac{33{,}300\,(HP)\,(SF)}{V \quad N}$ (lbf)

Total Belt Pull (per belt) = $(T_1 + T_2)$ = $\left[\dfrac{2.5 - A_c}{A_c}\right] \bullet \left[T_1 - T_2\right]$ (lbf)

Where:

N	=	Number of belts.
SF	=	Service factor for the drive.
HP	=	Total Drive horsepower, before SF is applied.
V	=	Belt speed in feet per minute, (FPM).

Arc Correction Factors (A_c)

$\dfrac{D-d}{C}$	Correction Factor (A_c)
.00	1.00
.10	.99
.20	.97
.30	.96
.40	.94
.50	.92
.60	.90
.70	.88
.80	.87
.90	.85
1.00	.83
1.10	.80
1.20	.78
1.30	.75
1.40	.72
1.50	.69

Where:

D	=	Large sheave pitch diameter in inches.
d	=	Small sheave pitch diameter in inches.
C	=	Drive center distance, inches.

NOTE: Since the end use of the sheave is unknown, stock sheaves are designed as follows:

1. Calculate total drive HP based on the highest applicable belt HP ratings as shown:

$$HP = \left[\begin{array}{c}\text{Basic HP per belt}\\ \text{at 1,000 fpm/belt}\end{array} + \begin{array}{c}\text{Highest speed}\\ \text{ratio add-on}\end{array} \right] \bullet \left[\begin{array}{c}\text{Highest belt length}\\ \text{correction factor}\end{array} \right] \bullet N$$

2. Use V = 1,000 FPM.

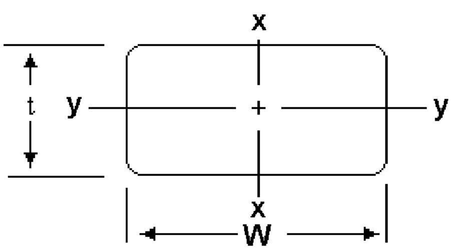
3. If SF for drive is also unknown use: SF = 1.0.

4. Calculate $T_1 + T_2$ (when spokes are off rim center line) using value of $A_c = 1.0$.

DETERMINATION OF SECTION MODULUS

Zx and Zy Arm Dimensions, Measured at Hub

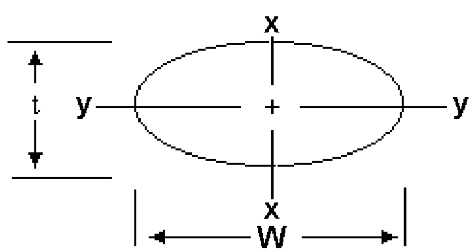
For Rectangular Arms



$$Zx = \frac{tW^2}{6} \ (in^3)$$

$$Zy = \frac{Wt^2}{6} \ (in^3)$$

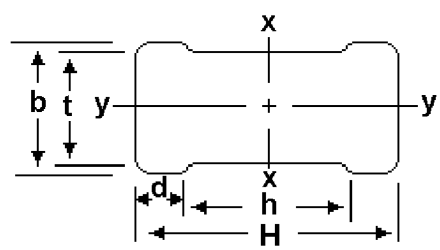
For Oval Arms



$$Zx = .098\, t\, W^2 \ (in^3)$$

$$Zy = .098\, W\, t^2 \ (in^3)$$

For I–Beam Arms



$$Zx = \frac{bH^3 - h^3(b-t)}{6H} \ (in^3)$$

$$Zy = \frac{2db^3 + h\,t^3}{6b} \ (in^3)$$

END OF PUBLICATION

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