Convenient Design-Method of Pressure Tank Used for Oil-Immersed Transformer

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In this paper, the easy design-method of trasformer tank is described. Using nomographs induced here, the bending moments on the oval tank or round cornered rectangular tank which is used for usual transformer, are briefly calculated. And the relation between the type of transformer and the distribution of bending moment is cleared. Using these results, even electric engineer who has poor knowledge for strength of materials, can easily design a most suitable tank.

§ 1. Introduction

Recently power equipments become larger and larger, then unit capacity of the transformer increases rapidly, and the oil-tank to put it in becomes huge. Therefore it's quite important to design the tank economically and to reduce its weight. Usually as the transformer is designed by electric engineers, electric parts of the machine are calculated in detail, but they have a poor hand in strength-calculation for mechanical parts Therefore when once the strength has been calculated, it is desirable that the results can be applied to every other case. But these machines are almost order production, and then case by case dimension and style are different. Therefore it's necessary to repeat the strength-calculation whenever the tank is designed.

We induced a new method, with which the necessary reinforcements of the tank can be obtained without complicated calculation, if the dimension and style are decided from the condition for transportation, demand of customer, and necessary electrical insulating distance.

In this paper, we explain only about transformer tank, but the same method can be applied to the design for usual oil-immersed electric machine, for example, circuit breaker and so on.

§ 2. The Way of Thinking for Mechanical Strength of Transformer Tank

Since the transformer must be performed vacuum oil preservation, and oil tight test, its tank requires enough mechanical strength. Fig. 1 shows the pressure distribution on the tank. Here we consider a transformer shown in Fig. 1 (a). The pressure distribution at operating condition, oil tight testing condition and vacuum testing condition are shown in Figs. 1 (b), (c), and (d) respectively. In general, Fig. 1 (d) shows the most severe condition, so we calculate only for Fig. 1 (d).

There are two ways to set the principal stay, one is regarding horizontal stay as principal one (see Fig. 2 (a)), and another is regarding vertical stay as principal one (see Fig. 2 (b)). Generally, from the limitation for transportation, the tank

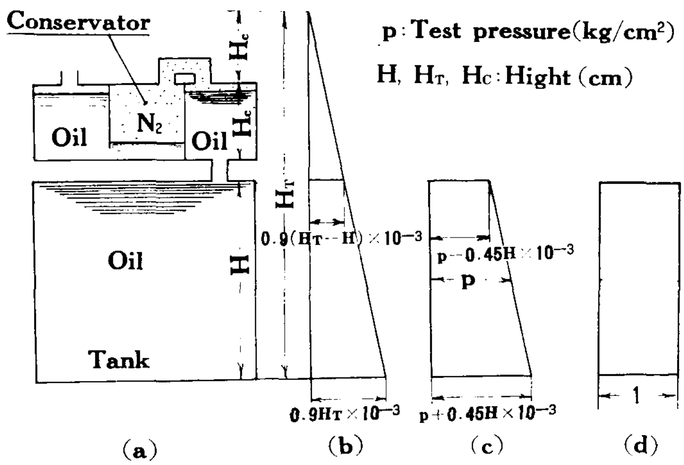


Fig. 1. Pressure distribution of a transformer tank.

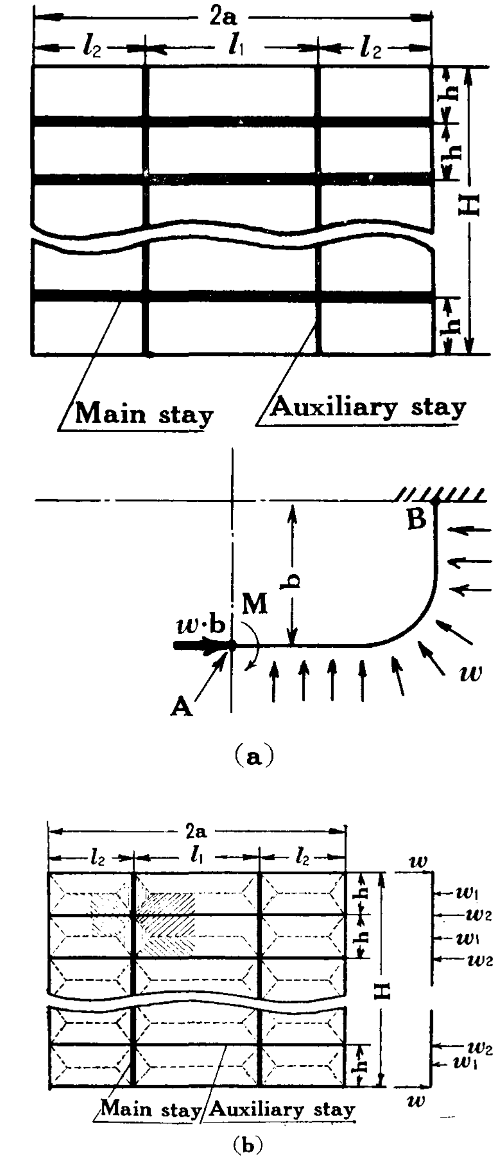


Fig. 2.

is divided into sections horizontally. Therefore we induce the method of convenient calculation for Fig. 2 (a) in which we regard horizontal stay as principal one. But for reference, the calculating equations for Fig. 2 (b) are found briefly too.

Though we describe the method of calculation for principal stay here, for auxilliary stays, flanges, wall plate and so on will be described later. And as the proofs of equations are complicated, we describe only the results.

§ 3. The Calculating Method of Strength, Regarding Horizontal Stay as Principal One

The general way of thinking in this case is as follows.

It is difficult to calculate the strength of a tank such as shown in Fig. 2. So we assume a canti lever which correspond to a quarter of circumference of the tank, then we can perform strength-calculation of tank by this canti lever. Namely, the canti lever which has fixed end (B) and free end (A), takes uniformly distributed load w, and takes concentrated load $w \cdot b$ and bending moment M about free end (A). Where M is the statically indeterminate moment which acts the rotating angle of the end (A) to be zero.

Since, in case of vacuum testing, force per unit area is $1 kg/cm^2$, equation becomes as follows:

$$w = 1 \cdot h \ (kg/cm),$$

Where w is the distributed load per unit length of beam, and h is the pitch of horizontal stays.

(1) *A tank having general form.*

We consider a tank having general form as shown in Fig. 3.

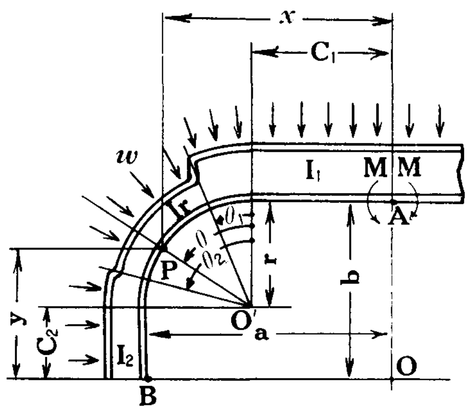


Fig. 3.

As the thickness of tank is negligible, we assume that the dimensions on the wall of the tank are represented by the inside length 2a and 2b. In Fig. 3, the moment of inertia is denoted by I_1 in the region of $\theta \leqq \theta_1$, I_r in the region of $\theta_1 < \theta < \theta_2$, and I_2 in the region of $\theta \geqq \theta_2$. The co-ordinate of any point (P) is represented (x, y) or (r, θ). Other symbols see Table 1.

(a) Bending moment.

Assuming the load of a tank as that shown in Fig. 2 (a), the bending moment M at any point (P) is

$$M = M_{x=0} - \frac{w}{2} b^2 + \frac{w}{2}(x^2 + y^2). \quad (1)$$

Table 1. List of symbols.

Symbols	Interpretation of Symbols	Units
M	Bending moment (positive direction ; ).	kg · cm
$M_{x=0}$, $M_{y=0}$	Bending moments at $x=0$ and $y=0$.	kg · cm
w	Load per unit length of beam (external pressure is defined as positive).	kg/cm
a, b, r	Inside dimensions of tank (see Fig. 3).	cm
x, y	Co-ordinates at any point (P) (measured from the center of tank).	cm
C_1	$=a-r$; Length of straight section (see Fig. 3).	cm
C_2	$=b-r$; Length of straight section (see Fig. 3).	cm
S_1	$=a+r\ (\pi/2-1)$; A quarter circumference of tank.	cm
S_2	$=a+b-r\ (2-\pi/2)$; A quarter circumference of tank.	cm
θ	Co-ordinate at any point (P) on the curved section.	radian
θ_1, θ_2	Changing positions of stay.	radian
θ_m	Position at which the bending moment has extreme value.	radian
θ_0	Position at which the bending moment is zero.	radian
α	$=b/a$; Constant determined by form of tank.	—
β	$=r/a$; Constant determined by form of tank.	—
x_{01}, x_{02}, y_{01}, y_{02}	Positions at which bending moment are zero.	cm
K_{01}~K_{04} K_{r1}~K_{r2}	Reference to Eqs. (12), (15). (18), (20), (23), (26), (29) and (32).	—
I	Moment of inertia.	cm^4
Z	Modulus of section.	cm^3
S	Cross-section of stay.	cm^2

The moment $M_{x=0}$ at $x=0$ or (A) is

$$M_{x=0}=B/A, \tag{2}$$

where

$$A=\frac{C_1+r\theta_1}{I_1}+\frac{r(\theta_2-\theta_1)}{I_r}+\frac{C_2+r(\pi/2-\theta_2)}{I_2}$$

$$B=-w\Big[\frac{1}{6}\Big(\frac{C_1^3}{I_1}+\frac{C_2^3}{I_2}\Big)+\frac{r}{2}\Big(C_1^2-2C_2r\Big)\Big(\frac{\theta_1}{I_1}+\frac{\theta_2-\theta_1}{I_r}+\frac{\pi/2-\theta_2}{I_2}\Big)$$
$$+\frac{1}{2}\Big(a^2-b^2\Big)\frac{C_2}{I_2}+r^2\Big\{\frac{C_1(1-\cos\theta_1)+C_2\sin\theta_1}{I_1}$$
$$+\frac{C_1(\cos\theta_1-\cos\theta_2)+C_2(\sin\theta_2-\sin\theta_1)}{I_r}+\frac{C_2(1-\sin\theta_2)+C_1\cos\theta_2}{I_2}\Big\}\Big].$$

The moment $M_{y=0}$ at $y=0$ or (B) is induced from Eqs. (1) and (2).

$$M_{y=0}=C/A, \tag{3}$$

where

$$C = -w\left[\frac{1}{6}\left(\frac{C_1^3}{I_1}+\frac{C_2^3}{I_2}\right)+\frac{r}{2}\left(C_2^2-2C_1r\right)\left(\frac{\theta_1}{I_1}+\frac{\theta_2-\theta_1}{I_r}+\frac{\pi/2-\theta_2}{I_2}\right)\right.$$

$$-\frac{1}{2}\left(a^2-b^2\right)\frac{C_1}{I_1}+r^2\left\{\frac{C_1(1-\cos\theta_1)+C_2\sin\theta_1}{I_1}\right.$$

$$\left.\left.+\frac{C_1(\cos\theta_1-\cos\theta_2)+C_2(\sin\theta_2-\sin\theta_1)}{I_r}+\frac{C_2(1-\sin\theta_2)+C_1\cos\theta_2}{I_2}\right\}\right].$$

(b) Maximum and minimum value-points of bending moment.

Let θ_m is the angle at the extreme value-point of bending moment on curved section, we find

$$\tan\theta_m = C_1/C_2. \qquad (4)$$

On the straight section, the point (A) and (B) give the extreme values.

(c) Zero points of bending moment.

(i) $x_{01} = \sqrt{-2M_{x=0}/w}, \quad y_{01}=b,$

where

$$0 \leqq x_{01} \leqq C_1.$$

(ii) $x_{02}=a,\ y_{02}=\sqrt{-\frac{2M_{x=0}}{w}-a^2+b^2},$

where

$$0 \leqq y_{02} \leqq C_2.$$

(iii) $\cos(\theta_m-\theta_0) = -\frac{2M_{x=0}+w(C_1^2-2C_2r)}{2wr\sqrt{C_1^2+C_2^2}}.$ (5)

(2) *Oval tank.*

The equations for the oval tank as shown in Fig. 4 are induced from example (1), as special case.

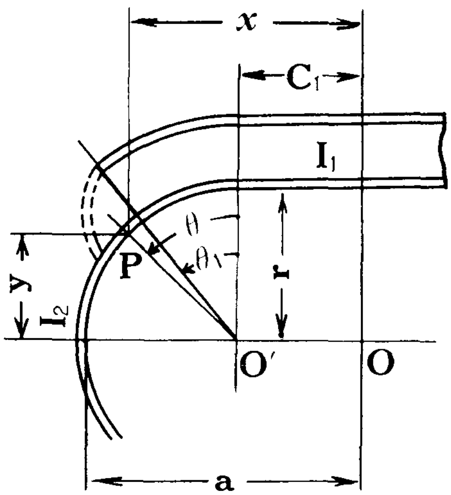


Fig. 4.

(a) Bending moment.

$$M = M_{x=0} - \frac{w}{2}b^2 + \frac{w}{2}(x^2+y^2), \qquad (6)$$

$$M_{x=0} = B_1/A_1, \qquad (7)$$

where

$$A_1 = \frac{C_1+r\theta_1}{I_1}+\frac{r(\pi/2-\theta_1)}{I_2},$$

$$B_1 = -wC_1\left\{\frac{C_1^2}{6I_1}+\frac{C_1r}{2}\left(\frac{\theta_1}{I_1}+\frac{\pi/2-\theta_1}{I_2}\right)\right.$$

$$\left.+r^2\left(\frac{1-\cos\theta_1}{I_1}+\frac{\cos\theta_1}{I_2}\right)\right\}.$$

The moment $M_{y=0}$ at $y=0$ is

$$M_{y=0} = C_1/A_1, \qquad (8)$$

where

$$C_1 = -wC_1\left\{\frac{C_1^2}{6I_1}-\frac{C_1(a+r)}{2I_1}\right.$$

$$\left.+r^2\left(\frac{1-\theta_1-\cos\theta_1}{I_1}-\frac{\pi/2-\theta_1-\cos\theta_1}{I_2}\right)\right\}.$$

(b) Maximum and minimum value-points of bending moment.

The points which give extreme values are only two points at $x=0$, and $y=0$ Each moment at these two points is given by Eq. (7) and Eq. (8) respectively.

(c) Zero point of bending moment.

Only the following one point gives the zero point of bending moment.

$$x_{01} = \sqrt{-2M_{x=0}/w}, \quad y_{01}=b,$$

where

$$0 \leqq x_{01} \leqq a-r,$$

or

$$\sin\theta_0 = \frac{r\{(I_1-I_2)\cos\theta_1+I_2\}-I_2C_1^2/3r}{I_2(C_1+r\theta_1)+I_1r(\pi/2-\theta_1)},$$

where

$$0 \leqq \theta_0. \qquad (9)$$

(3) *Oval tank which has stays with uniform cross-section.*

(a) Bending moment.

From Eqs. (6), (7)

$$M=\frac{w}{2}(x^2+y^2)-\frac{w}{2S_1}\Big(\frac{C_1^3}{3}+\frac{\pi}{2}C_1^2r+3C_1r^2+\frac{\pi}{2}r^3\Big), \qquad (10)$$

where

$S_1=\text{circumference}/4=a+r(\pi/2-1).$

Eq. (10) can be written as follows

$$M=\frac{w}{2}(x^2+y^2-K_{01}a^2\times10^{-2}), \qquad (11)$$

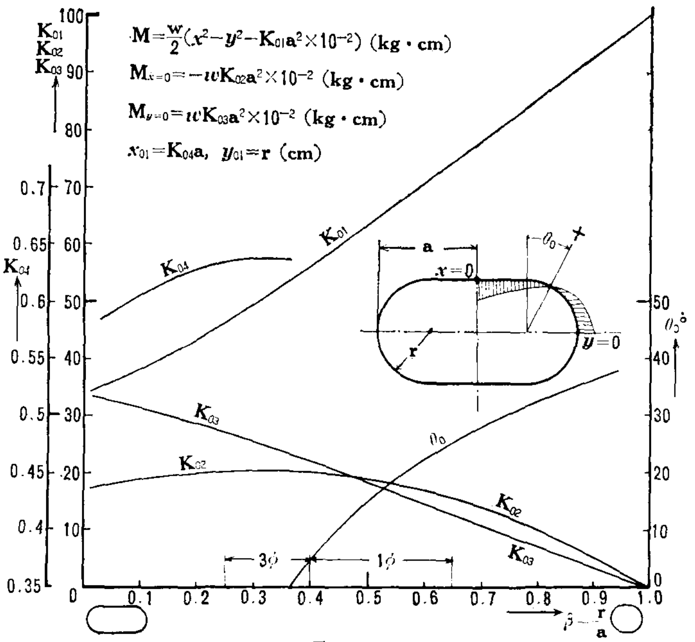


Fig. 5.

where

$$K_{01}=\frac{10^2}{1+\beta(\pi/2-1)}\Big[\frac{(1-\beta)^3}{3}+3\beta^2(1-\beta)+\frac{\pi\beta}{2}\{(1-\beta)^2+\beta^2\}\Big], \qquad (12)$$

$\beta=r/a.$

K_{01} is a function of only β. Therefore, when r/a is obtained, K_{01} is unconditionally determined. The relation between β and K_{01} is shown in Fig. 5. The moment at any point is briefly determined by this graph and Eq. (11). Here we consider the moment of particular points.

From Eq. (10)

$$M_{x=0}=-\frac{w}{S_1}C_1\Big(\frac{C_1^2}{6}+\frac{\pi}{4}C_1r+r^2\Big). \qquad (13)$$

Eq. (13) can be written as follows

$$M_{x=0}=-wK_{02}a^2\times10^{-2}, \qquad (14)$$

where

$$K_{02}=\frac{10^2}{1+\beta(\pi/2-1)}\Big\{\frac{(1-\beta)^3}{6}+\frac{\pi\beta}{4}(1-\beta)^2+\beta^2(1-\beta)\Big\}, \qquad (15)$$

simi'arly

$$M_{y=0}=\frac{wC_1}{S_1}\Big\{-\frac{C_1^2}{6}+\frac{C_1}{2}(a+r)+r^2\Big(\frac{\pi}{2}-1\Big)\Big\}. \qquad (16)$$

Eq. (16) can be written

$$M_{y=0}=wK_{03}a^2\times10^{-2}, \qquad (17)$$

where

$$K_{03}=\frac{10^2}{1+\beta(\pi/2-1)}\Big\{-\frac{(1-\beta)^3}{6}+\frac{(1-\beta)^2(1+\beta)}{2}+\beta^2(1-\beta)\Big(\frac{\pi}{2}-1\Big)\Big\}. \qquad (18)$$

Also the relations between β and K_{02}, K_{03} are determined from Fig. 5. Therefore, the moments $M_{x=0}$ and $M_{y=0}$ are obtained from Eq. (14) and Eq (17) respectively.

(b) Zero point of bending moment.

From Eq. (9),

$$x_{01}=K_{04}a\ ,\quad y_{01}=r,$$

where

$$0<x_{01}\leqq a-r,$$

or

$$\theta_0=\sin^{-1}\Big[\frac{3\beta^2-(1-\beta)^2}{3\beta\{(1-\beta)+(\pi/2)\beta\}}\Big], \qquad (19)$$

where

$0\leqq\theta_0$.

And

$$K_{04}=\sqrt{2K_{02}}\times10^{-1}. \qquad (20)$$

From Eqs. (19), (20) when β is given, θ_0 and K_{04} are unconditionally determined. The relations between β and θ_0, K_{04} are also shown in Fig. 5.

(4) *Round cornered rectangular tank which has stays with uniform cross-section.*

(a) Bending moment.

From Eqs. (1) aud (2)

$$M=\frac{w}{2}(x^2+y^2)-\frac{w}{2S_2}\Big\{\frac{1}{3}(C_1^3+C_2^3)+C_1b^2+C_2a^2+2r^2(C_1+C_2)+\frac{\pi r}{2}(C_1^2+C_2^2+r^2)\Big\}, \qquad (21)$$

where

$S_2=\text{circumference}/4=a+b-r(2-\pi/2)$.

Eq. (21) can be written as follows

$$M=\frac{w}{2}(x^2+y^2-K_{r1}a^2\times10^{-2}), \qquad (22)$$

where

$$K_{r1}=\frac{10^2}{1+\alpha-(2-\pi/2)\beta}\Big[\frac{1}{3}\{(1-\beta)^3+(\alpha-\beta)^3\}+(1-\beta)\alpha^2+(\alpha-\beta)+2\beta^2(1+\alpha-2\beta)+\frac{\pi\beta}{2}\{(1-\beta)^2+(\alpha-\beta)^2+\beta^2\}\Big], \qquad (23)$$

where

$$\alpha=b/a\ ,\quad \beta=r/a\ .$$

The relation between α, β and K_{r1} is shown in Fig. 6.

From Eq. (2)

$$M_{x=0}=-\frac{w}{2S_2}\Big\{\frac{1}{3}(C_1^3+C_2^3)+C_2(a^2-b^2)+2r^2(C_1+C_2)+\frac{\pi r}{2}(C_1^2-2C_2r)\Big\}. \qquad (24)$$

Rewriting Eq. (24)

$$M_{x=0}=-wK_{r2}a^2\times10^{-2}, \qquad (25)$$

where

$$K_{r2}=\frac{10^2}{1+\alpha-(2-\pi/2)\beta}\Big[\frac{1}{6}\{(1-\beta)^3+(\alpha-\beta)^3\}+\frac{1}{2}(\alpha-\beta)(1-\alpha^2)+\beta^2(1+\alpha-2\beta)+\frac{\pi}{4}\beta\{(1-\beta)^2-2(\alpha-\beta)\beta\}\Big]. \qquad (26)$$

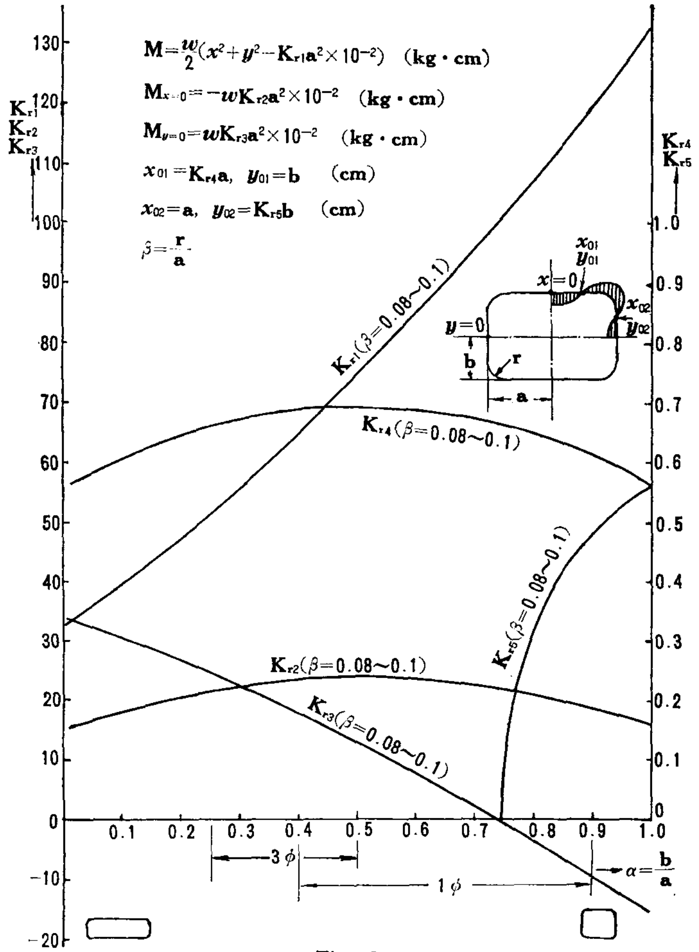


Fig. 6.

From Eq. (3)

$$M_{y=0}=\frac{w}{2S_1}\Big\{-\frac{1}{3}(C_1^3+C_2^3)+(a^2-b^2)C_1-2r^2(C_1+C_2)-\frac{\pi r}{2}(C_2^2-2C_1r)\Big\}. \qquad (27)$$

Eq. (27) can be written

$$M_{y=0}=wK_{r3}a^2\times10^{-2}, \qquad (28)$$

where

$$K_{r3}=\frac{10^2}{1+\alpha-(2-\pi/2)\beta}\Big[-\frac{1}{6}\{(1-\beta)^3+(\alpha-\beta)^3\}+\frac{1}{2}(1-\alpha^2)(1-\beta)-\beta^2(1+\alpha-2\beta)-\frac{\pi}{4}\beta\{(\alpha-\beta)^2-2(1-\beta)\beta\}\Big]. \qquad (29)$$

Similarly in the case of K_{r1}, using Fig. 6, K_{r2} and K_{r3} are obtained as a function of α, β. Therefore each bending moment $M_{x=0}$, $M_{y=0}$ at $x=0$, $y=0$ is obtained briefly by Eqs. (25), (28), respectively.

(b) Maximum and minimum value-points of bending moment.

The point which gives the extreme value of bending moment on curved section of the oil-tank is given by Eq. (4), and the co-ordinates (x, y) of its point can be obtained from Fig. 3, because it is an intersected point of side wall of the tank and the extension line $\overline{OO'}$, then the extreme value of bending moment is given by substituting the co-ordinates (x, y) into Eq. (22) While, on the straight section, the point (A), and (B) give the extreme values, and they are given by Eqs. (25), (28) respectively.

(c) Zero points of bending moment.

From Eqs. (5)

$$\left.\begin{array}{l} \text{(i)}\quad x_{01}=\sqrt{2K_{r2}}\,a\times10^{-1},\qquad y_{01}=b, \\ \text{where} \\ \qquad 0\leqq x_{01}\leqq C_1. \\ \text{(ii)}\quad x_{02}=a, \\ \qquad y_{02}=\sqrt{(2K_{r2}\times10^{-2}-1)a^2+b^2}, \\ \text{where} \\ \qquad 0\leqq y_{02}\leqq C_2. \end{array}\right\} \quad (30)$$

Eqs. (30) can be written

$$\left.\begin{array}{l} \text{(i)}\quad x_{01}=K_{r4}a\ ,\quad y_{01}=b\ , \\ \text{where} \\ \qquad 0< x_{01}\leqq C_1\ . \\ \text{(ii)}\quad x_{02}=a\ ,\quad y_{02}=K_{r5}b\ , \\ \text{where} \\ \qquad 0\leqq y_{02}\leqq C_2\ . \end{array}\right\} \quad (31)$$

And

$$\left.\begin{array}{l} K_{r4}=\sqrt{2K_{r2}}\times10^{-1}, \\ K_{r5}=\dfrac{1}{\alpha}\sqrt{2K_{r2}\times10^{-2}-1+\alpha^2}. \end{array}\right\} \quad (32)$$

The relations between α, β and K_{r4}, K_{r5} are also shown in Fig. 6.

§ 4. Calculating Method of Strength, Regarding Vertical Stay as Principal One

Load-distribution diagram of the principal stay is shown in Fig. 2 (b). It is assumed that the beam is simple beam. In Fig. 2 (b), w_1, and w_2 are

$$\left.\begin{array}{l} w_1=h^2/2\ , \\ w_2=\dfrac{h}{2}(l_1+l_2)-w_1\ . \end{array}\right\} \quad (33)$$

The maximum bending moments are

$$M_{2n-1}=\frac{H^3}{128n^3}+\left(\frac{1}{16}-\frac{1}{64n^2}\right)(l_1+l_2)H^2, \quad (34)$$

$$M_{2n}=\frac{H^3}{12(2n+1)}+\frac{(1+1/n)(l_1+l_2)}{4(2+1/n)^2}H^2, \quad (35)$$

where M_{2n-1} and M_{2n} represent the cases that the number of horizontal stays is $2n-1$ (odd) and $2n$ (even) respectively. If n is larger than 3, the maximum bending moment is approximately given by Eq. (36).

$$M \fallingdotseq \frac{l_1+l_2}{16}H^2. \quad (36)$$

§ 5. Calculating Method of Necessary Dimension for the Stay

As above mentioned, the maximum bending moment arising in the principal stay has been calculated, next we must calculate the required modulus of section. Let σ be the allowable stress of material, the required modulus of section is given by the next equation.

$$Z=M/\sigma. \quad (37)$$

Table 2 shows dimensions, moments of inertia I, moduli of section Z, and sectional areas S of principal stays used generally. From this table, the most economical beam that satisfies Eq. (37) is determined. In this calculation, it is assumed that the wall of tank reacts as a part of stay, namely only 40 times as large as thickness t. The symbols used in the table are cleared in Fig. 7.

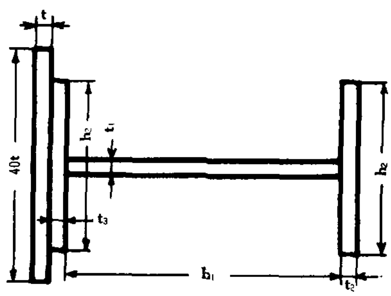


Fig. 7. Construction and dimensions of the stay.

§ 6. Relation between Type of Transformer and Distribution of Moment

Here we consider the relation between α and β which are a function of tank-form, and distribution of bending moment.

(1) *Oval tank with uniform cross-section stays.*

(a) In the case of single-phase transformer tank, β is,

Table 2. Constants for typical stays used generally.

t	t_1	h_1	t_2	h_2	t_3	I	Z	S
(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(cm^4)	(cm^3)	(cm^2)
4.5	6	75	6	50	0	173	30.7	7.5
4.5	6	100	6	50	0	31.5	44.1	9.0
6	6	100	9	50	0	48.1	60.3	10.5
6	6	100	9	75	0	60.0	81.3	12.8
6	6	150	6	75	0	1,110	102	13.5
6	6	150	6	100	0	1,260	122	15.0
6	9	150	9	100	0	1,650	174	22.5
6	9	150	12	100	0	191	211	25.5
6	9	175	12	100	0	262	253	27.8
6	9	175	12	125	0	289	297	30.8
6	9	200	9	150	6	453	352	40.5
6	9	200	12	150	6	523	429	45.0
9	9	150	12	100	0	265	231	25.5
9	9	175	12	100	0	362	278	27.8
9	9	200	9	150	0	501	358	31.5
9	12	200	12	150	6	693	484	51.0
9	12	200	16	150	6	811	590	57.0
9	16	250	16	150	6	1,323	811	73.0
12	12	175	12	100	0	462	315	33.0
12	12	200	12	100	0	613	375	36.0
12	12	200	16	150	0	891	597	48.0
12	16	250	16	200	9	19,500	1,068	90.0

$$0.4 \leqq \beta \leqq 0.65.$$

In the case of three-phase transformer tank, β is,

$$0.25 \leqq \beta \leqq 0.4.$$

(b) When β is smaller than 0.479, the bending moment at $y=0$ takes the maximum value, that is, when the tank is slender, such as three-phase transformer, the maximum bending moment exists on the major axis.

When β is larger than 0.479, the bending moment at $x=0$ takes the maximum value, and then, in the case of a tank such as single-phase transformer tank, the bending moment on the minor axis is equal to the bending moment on the major axis, or slightly larger than that.

(c) When β is smaller than 0.366, zero point of bending moment is on the straight section, and when β is larger than 0.366, it is on the curved section.

For the usual transformer, θ_0 exist within 30°.

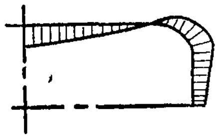
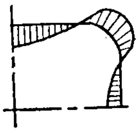
(d) If β is smaller than 0.366, the co-ordinate x_{01}, which gives the zero point of bending moment, lies between 0.60a and 0.64a, namely x_{01} is almost constant independently of β.

The above mensioned summary is shown in Table 3.

Table 3. Relation between form and bending moment of oval tank.

β	0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Number of phases	(0.25 – 0.4) ←3→ ; (0.4 – 0.65) ←1→
Maximum value & its position	(0 – 0.479) ← $M_{y=0}$, $(y=0)$ → ; (0.479 – 1.0) ← $M_{x=0}$, $(x=0)$ →
Zero point of M	(0 – 0.366) ← On $y=r$ → ; (0.366 – 0.65) ← $0° < \theta_0 < 30°$ →

Table 4. Relation between form and bending moment of round cornered tank.

α	0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Number of phases	←3→ (0.3 – 0.5); ←1→ (0.4 – 0.9)
$M_{x=0}$	← Dec. ← $M_{x=0}=M_{y=0}$ → Max. → Dec. →
$M_{y=0}$	← Inc. ← $M_{y=0}=M_{x=0}$ → Dec. → 0 → Dec. →
x_{01}	→ Inc. → Max. → Dec. → $x_{01}=y_{01}$
y_{02}	0 → Inc. → $y_{02}=x_{01}$
Deflecting direction at $y=0$	← (+) → ← (−) →
Diagrams of bending moment	 

(2) ***Round cornered rectangular tank with a uniform cross-section stays.***

(a) When $0.08 \leqq \beta \leqq 0.1$, the influence of β affecting $K_{r1} \sim K_{r5}$ is negligible. (When $0.7 < \alpha < 0.9$ and $0.06 \leqq \beta \leqq 0.1$, similarly the influence of β is negligible.)

(b) In the case of a single-phase transformer tank, α lies between 0.4 and 0.9. In the case of a three-phase transformer tank, α lies between 0.25 and 0.50.

(c) When $\alpha < 0.3$, the maximum bending moment on the major axis is larger than that on the minor axis. In the case of a tank with $\alpha \fallingdotseq 0.3$, such as three-phase transformer tank, the maximum bending moments on the major and minor axis are nearly equal. And when $\alpha > 0.3$, the maximum moment on the minor axis is larger than that on the major axis.

(d) When $\alpha > 0.74$, the deflection on the major axis takes opposite direction compared with that in the case of $\alpha < 0.74$, and therefore the deflecting direction is the same as that on the minor axis.

(e) Independently of α, K_{r2} is almost constant. (Therefore when the modulus of section of stay at this point is designed so that it is proportional to a^2, the stay has sufficient strength.)

(f) Indepenpently of β, the co-ordinate x_{01}, which gives the zero-point of bending moment, lies between 0.6a and 0.7a.

The above mensioned summary is shown in Table 4.

§ 7. Conclusion

The convenient calculating method, with which we can briefly design the tank of large power transformer, has been developed.

Using this method, we can calculate more shorter time than usual method (less than one-hundredth times), and also the errors which arise from complicated calculation, can be avoided. Moreover, the general tendencies such as how the points of maximum or zero bending moment move and how the deflecting direction becomes are cleared. These tendencies are very useful for the designer to grasp the key points. Using this method we have already designed many transformer tank, and obtained the satisfactory results.