POSTER

Correcting the Thread Standards for Graphite Electrodes by Using Equations of thread Profiles

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INTRODUCTION

For the sockets of Graphite electrodes and nipples, the taper threads are usually used. There are some differences between different country standards and the standard of international electrotechnical commission (IEC) in dimensions of various thread elements of taper threads. It is more complex to calculate them than those of straight threads. The equations for calculating the dimensions have been derived. The results calculated by the equations can be used for correcting the errors in dimensions and unifying the standards of taper threads. The equation can also be used for the designing of new profiles conveniently. As the greater root radii would reduce stress concentration, the equations for maximum root radii which do not interfere with the crest of mating threads are given in this paper too. The root radii calculated from the theoretical equations are greater than those given by present standards.

SYMBOLS AND EXPLANATION

H: Height of fundamental triangle
h : Thread height.
h_c: Truncation of ridge.
h_a: Height of addendum.
h_d: Dedendum.
R_{max}: Maximum root radius.
p : Pitch
β : Flank angle.
φ: Oblique angle of taper thread, i.e. the acute angle formed by the pitch line and the thread axis.
s : Axial distance of crest.
s\`, s\`\`, p\`, p\`\`: See figure 1.
λ: The ratio of h_c to p, $\lambda=h_c/p$.
k: The ratio of s to p, k=s/p.

Equations

$$H = p\cot\beta(1-\tan^2\beta\tan^2\varphi)/2 \quad (1)$$
$$p' = p(1-\tan\beta\tan\varphi)/2 \quad (2)$$
$$p'' = p-p' = p(1+\tan\beta\tan\varphi)/2 \quad (3)$$
$$s = 2\lambda p\tan\beta/(1-\tan^2\beta\tan^2\varphi) \quad (4)$$
$$= kp \quad (5)$$
$$s' = \lambda p\tan\beta/(1+\tan\beta\tan\varphi) \quad (6)$$
$$= kp(1-\tan\beta\tan\varphi)/2 \quad (7)$$
$$= kp' \quad (8)$$
$$s'' = s-s' \quad (9)$$
$$= \lambda p\tan\beta/(1-\tan\beta\tan\varphi) \quad (10)$$
$$= kp(1+\tan\beta\tan\varphi)/2 \quad (11)$$
$$= kp'' \quad (12)$$
$$h_c = kH \quad (13)$$
$$h_a = H/2-\lambda p = (1/2-k)H \quad (14)$$
$$h_d = H/2-R(\mathrm{cosec}\beta-1) \quad (15)$$
$$h = H-\lambda p-R(\mathrm{cosec}\beta-1) \quad (16)$$
$$= (1-k)H-R(\mathrm{cosec}\beta-1) \quad (17)$$
$$R_{max} = \lambda p/\cos\beta(\cot\beta+\tan\varphi) \quad (18)$$
$$= kp(1-\tan\beta\tan\varphi)/2\cos\beta \quad (19)$$
$$= s'/\cos\beta \quad (20)$$
$$k/\lambda = 2\tan\beta/(1-\tan^2\beta\tan^2\varphi) \quad (21)$$
$$= p/H \quad (22)$$
$$\lambda p = kH \quad (23)$$

RESULTS AND DISCUSSIONS

The independent variables of equations above are four. There are p, β, φ, and λ (or k, or h_c, or s). In the four variables: λ, k, h_c and s, one only is independent. Here have been given the equations for computing the dimensions of various thread elements from λ and k respectively, and for presenting the simple relationship between s and p, s\` and p\`, s\`\` and p\`\`, h_c and H, etc. From them, it can be seen that the calculations will be simple, if k is taken as an independent variable or is known previously. However, it is λ that is taken as an independent variable in present standards and k calculated from λ is an infinite decimal.

For the taper thread of graphite electrodes, when $\beta=30^0$, $\tan\varphi=1/6$, $\lambda=0.18$ (according to IEC 239-1987), then the theoretical values calculated from the equations above are shown in table 1. Contrasting the value of axial distance of crest indicated in IEC with that of theoretical value, an error which shows in table 2 is found. The values in DIN (German Industrial Standard) are computed accurately to the third decimal place, but they are a few different from the theoretical values. The contrast of them are shown in table 3. There are also somewhat different in dimensions of minor diameter of electrodes between the standards: IEC, DIN, JIS and ГОСТ, etc. The maximum difference between them is

0.03mm. It shows that h_a in the standards are not the same(h_a=2.105 in IEC, DIN and JIS, 2.11 in ГОСТ).

A male-female taper thread electrode which treading a new profile has been planned to develop by a company in USA. The oblique angle $\varphi=25^0$, which is greater than that of the common electrodes. But it can be found that the ratio s/h_c in the sample book of the company is quitly different from the theoretical value computed by the equation(4). And the values of p`, p`` and H are slightly differ from the theoretical values computed by the equations, the differences between them being 0.01-0.02mm.

The equations (17)-(19) are used for calculating the maximum root radius which wouldn't cause to interfere with the engaging with the crest of mating thread. In IEC and many country standards for graphite electrodes, the root radii are determined by the following equation: $R_{max}=h_c/2$. According to the knowledge of geometry, it can be known that the center of the root radius in present standards is placed at center of the crest of mating thread(when $\beta=30^0$). Actually, when $\varphi=\beta=30^0$, the maximum root radius is really placed at the center of the crest of mating thread. The value of R_{max} is inversely proportional to that of φ. When φ is smaller than 30^0, it is possible that the root radius may have a greater one than $h_c/2$. The value of R_{max} from present standards is only 82.2% of the theoretical value. The greater root radius would reduce the stress concentration. It may be important for nipples which are subjected to impact and fatigue during the steel-making. Thus, it is advantageous to use the greater root radius calculated from the equation above for increasing the strength of joint. With the threaded sockets of electrodes and nipples machining more precision and the errors being less, it becomes possible to increase maximum root radii from $h_c/2$ to the theoretical value now.

CONCLUSIONS

The equations in this paper can be used for correcting and unifying the standards in the threads of graphite electrodes and for designing the new profiles. For the straight threads, with $\tan\varphi=0$, then the equations in this paper can also be used for them.

REFERENCES

1. IEC 239-1987
2. JIS R7201-1979, R7202-1979
3. DIN 48601-1981

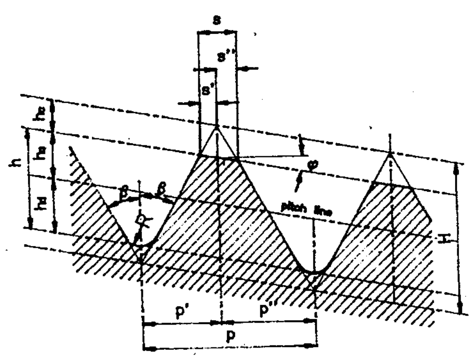

Fig. 1. --- Illustration of taper thread profile.

Table 1.--- Theoretical values of various thread elements. mm

Threads per inch	p	p`	p``	s	s`	s``	H	h_c	h_a	h_d	h	Rmax
4	6.3500	2.8695	3.4805	1.3322	0.6020	0.7302	5.44834	1.14300	1.58117	2.02906	3.61023	0.695
3	8.4667	3.8260	4.6407	1.7762	0.8026	0.9736	7.26446	1.52400	2.10823	2.70541	4.81364	0.927

Note: 1 inch=25.4mm

Table 2. --- Contrast of the values of axial distance of crest for 4 treads per 25.4mm. mm

Theoretical Value	Value in IEC
1.332	1.32

Table 3. --- Contrast of theoretical values and values in DIN mm

Threads per inch		p'	p''	s	s''	H	h_a
4	Theoretical values			1.332	0.730	5.448	1.581
	DIN			1.333	0.731	5.446	1.580
3	Theoretical values	3.826	4.641	1.776	0.9736	7.264	2.108
	DIN	3.827	4.640	1.778	0.975	7.260	2.106