

## AGNI-KUNḌAS—A NEGLECTED AREA OF STUDY IN THE HISTORY OF ANCIENT INDIAN MATHEMATICS

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*Agni-kunḍas* (fire-pits) of prescribed form and size were meant to hold consecrated sacred fire to which oblations were offered. Their sections represented various geometrical figures such as circle, semi-circle, polygon (triangle, square, etc.), and forms resembling lotus flower and *pippal* leaf. However, they have not found due place in studies related to ancient and medieval Indian mathematics. The present paper highlights various aspects (historical, metrological, mathematical, and practical) of the *agni-kunḍas* and pleads for giving attention to them similar to that which is given to *citis* (Vedic altars). A working bibliography of *kunḍa* works from the vast source material available, is included in the paper.

**Key words :** Ancient India, Fire-altars, Fire-pits, Geometry, *Kunḍa* works.

### INTRODUCTION AND VEDIC PERSPECTIVE

In order to attain certain desired objectives religiously, the Vedic Indians performed some *kāmya-yajñas* (votive sacrifices) according to the *śrauta* or Vedic tradition. Depending on the nature of the sacrifice or sacrificial rite, specific type of *agniciti* (fire altar) was to be piled or constructed. The various forms of altars as mentioned in the *Taittirīya Samhitā* (V.4.11) of the *Kṛṣṇa Yajurveda* are as follows.<sup>1</sup>

- (i) *Syenaciti* (in the shape of a hawk) for attaining heaven because the hawk is "the best flier among the birds."
- (ii) *Kaṅkaciti* (in the form of a heron) for progress in heaven.
- (iii) *Alajaciti* (in the form of *alaja* bird) for reputation in heaven.

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- (iv) *Praugaciti* (isosceles triangle) for repelling foes.
- (v) *Ubhayataḥ-praugaciti* (rhombus) for repelling present and future enemies.
- (vi) *Rathacakraciti* (in the form of a chariot wheel) for defeating enemies.
- (vii) *Dronaciti* (in the form of a trough—square or circular) for gaining food.
- (viii) *Samuhyaciti* (in the form of a petaled circle ?) for gaining herds of cattle.
- (ix) *Paricāyyaciti* (in the form of a large circle) for gaining village.
- (x) *Śmaśānaciti* (cemetery altar in the form of a trapezium)<sup>2</sup> for success in the world of forefathers.

There are other forms of altars such as the obligatory *Dakṣiṇāgni* (in the form of a semicircle) and the votive *Kūrmaciti* (in the shape of a tortoise) which is constructed by one who desires victorious career in the *Brahmaloka*<sup>3</sup>. Thus there was a well defined and established-vedic or *śrauta* (i.e., following *śruti*) tradition of drawing geometrical figures of various forms and shapes.

Exactly the same mathematical practice was continued later on when various type of *agni-kunḍas* (fire-pits) were constructed to achieve certain objectives as prescribed according to the *smārta* tradition (i.e., one based on *smṛti*). A *kunḍa* of specific shape and size was dug in the ground to hold the consecrated sacred fire to which *āhutis* (oblations) were offered during a *havana-yajña* (obligatory sacrificial ritual).

Broadly speaking, the objectives to be achieved include success (*siddhi*) in some enterprise, enrichment (*puṣṭi*) of business, desire of worldly things (*bhukti*) wealth, son, etc., freedom from disease, and emancipation (*mukti*) from cycle of birth and death.<sup>4</sup> *Havana-yajña* is also performed on the occasion of religious acts, rituals and celebrations such as building of a temple, construction of a tank, making great donations (e.g., *tulādāna*), chanting of great *mantras*, and averting evil planetary influences.

In the case of a single *kuṇḍa* used for the fulfilment of a particular desire, the specifications of the shapes, according to the ancient classical work *Śāradātilaka*,<sup>5</sup> are as follows :

- (i) Square *kuṇḍa* for wished general or overall success (*sarvasiddhi*).
- (ii) *Yoni kuṇḍa* (whose shape resembles a leaf of the *pippal* tree, *Ficus religiosa*) for birth of a son.
- (iii) Semicircle (or half-moon form) for general good and auspiciousness (*śubham*).
- (iv) (Equilateral) triangle for destruction of one's foes.
- (v) Circular *kuṇḍa* for peace-and pacification rite of evil effects (*śānti-karma*).
- (vi) (Regular) hexagon for subjugation and killing of enemy (*chedamāraṇa*).
- (vii) Lotus shaped for enrichment (*puṣṭi*) and desired rain (*vr̥ṣṭi*).
- (viii) (Regular) Octagon for health and freedom from disease (*roga śamanam*).

Many more forms of *kuṇḍas* were added later on which include pentagon, heptagon, etc. All these figures involve lot of mathematics in their dimensional calculations and geometrical constructions. The point is that while the various type and forms of Vedic *citis* have been extensively studied and analysed *via* the main *śulba-sūtras*, the subject of *kuṇḍas* has not received the attention they deserve especially from the angle of history of science.

In fact the full treatment and analysis of the *kuṇḍas* would involve historical (both literary and scientific), metrological, mathematical, and practical (*i.e.*, constructional) aspects of the interdisciplinary subject. The purpose of the present article is to draw attention to this basically a religious but significantly a secular nature of the science of *kuṇḍas*.

### SOURCE MATERIAL

A vast amount of source material is available for the study of *Kuṇḍas*. A large number of Sanskrit works on *Kuṇḍas* have been written. Relevant material is also found in various works on *Dharmaśāstra* and other religious literature. For convenience of easy reference, an alphabetically arranged list of primary sources is given in the selected preliminary Bibliography towards the end of the present article.

On *Kuṇḍas*, Harikrishna Venkataram is said to have published an important compilation called *Kuṇḍa-grantha-vimśati* (Bombay, 1887). It contains, as the title indicates, 20 Sanskrit works on *Kuṇḍas* by various authors. The first work printed in it is the (*Maṇḍapa*) *Kuṇḍasiddhi* (A.D. 1620) of Viṭṭhala-Dīkṣita of Varanasi. The author himself wrote a commentary on the work which had become very popular as shown by a large number of its manuscripts. The *Kuṇḍa-kādambarī* composed by Gokulanātha Upādhyāya in 1741, is important for knowing various views on different aspects of the subject.

The *Kuṇḍaratnāvalī* written by Rāmacandra Kṛṣṇabābū Dīkṣita (alias Jaḍe) in the 19th century, is perhaps the last significant work collecting traditional material on the subject in North India. The treatise is quite comprehensive and further exposition is found in author's own commentary (called *Mañjūṣā*) on it.

About 200 *Kuṇḍa* manuals are listed in the famous *New Catalogus Catalogorum*, Vol. IV (Chennai, 1968). Recent studies on the subject have been carried out by Gupta, Hayashi, and Kulkarni but they are still introductory, thereby needing comprehensive probe.<sup>6</sup>

### HISTORICAL ASPECTS

Historical study of the subject of *Agni-kuṇḍas* should cover both literary and scientific aspects. The former should be about the history of the literature on *Kuṇḍa* i.e., various works and their authors. Chronological order of the manuals has to be considered an important feature of study.

Why was this literature created ? When did it originate ? According to Kulkarni,<sup>7</sup> *śrauta* sacrifices became less popular among the Hindus by the 15th–16th century. On the other hand *smārta-yajñas* became more common. These needed *agni-kunḍas* for the performance of *havanas*, and this gave rise to the writing of so many manuals on *Kunḍas*. However, it must be remembered that some traditional works also contain substantial material on the subject. For example, the *Agni-purāṇa* (whose present form is dated between A.D. 700 to 1000) contains a full chapter devoted to *Kunḍas*.<sup>8</sup>

Another point may be the absence of a standard early comprehensive treatise on the subject. Also the vastness of the Indian subcontinent and the existence of several schools following different traditions is to be kept in mind.

The History of Science aspect in regard to *Kunḍas* should investigate particularly the evolution of the various forms of the firepits and the development of the mathematical techniques to construct and transform geometrical figures involved therein. Historians of Mathematics would like to know as to how the prescribed rules were obtained or found with the then known tools of scientific knowledge.

It is believed that in the beginning the number of *Agni-kunḍas* was small. The *Agni-purāṇa* (Chapter 24) mentions three type namely, square, circle, and semi-circle (*ardha-candra*). These forms are same as those of the three Vedic *nitya* (obligatory) *agnis* i.e., *Āhavanīya*, *Gārhapatya*, and *Dakṣiṇa* respectively. It should be noted that the tradition of three *agnis* is older than even the *R̥gveda* which mentions it.<sup>9</sup>

Later on the type (or forms) of *kunḍas* increased to 5, 8, 10 or even more when some peculiar forms (such as *sūrpaka*, flag, bow and arrow) were developed to perform rites to avert the threatened evil influence of planets. Also there were ceremonies (such as *pañca* or *nava kunḍī-yajña*) in which a number of different *kunḍas* were used simultaneously. These *kunḍas* were usually arranged around the *vedi* which was a raised platform and whose shape depended on the type of the ceremony.<sup>10</sup> The *vedi* in a *havana-yajña* seems to symbolize the ancient Vedic *citi*.

### METROLOGICAL ASPECT

The dimensions of a *kuṇḍa* must be constructed accurately so that the prescribed area-measure or volume is obtained. Otherwise what to say of achieving a desired objective, even adverse effects might be caused. Some of the warnings given are as follows.<sup>11</sup>

- (a) *Mānādhikye bhaved rogo mānahīne daridratā* i.e., “when the area is more (than the prescribed amount), there will be disease; when in deficit, there will be poverty.”
- (b) *Mānādhike bhaven mṛtyur-mānahīne daridratā*.
- (c) *Khāte’dhike bhaved rogo hīne dhenudhana-kṣaya*.

To arrive at the true practical measurements of a *kuṇḍa* requires not only the correct mathematical calculations but also the proper understanding of the various units and measures of length etc., used. For instance, according to *Maṇḍapa-kuṇḍa-siddhi* (I, 3-4),<sup>12</sup> the *āṅgula* measure to be used for finding the area of a *kuṇḍa* is the *deha-āṅgula* i.e., the *āṅgula* related to the body of the *yajamāna* (sacrificer). This is usually defined with the help of *pauruṣāyāma* which is the full height of the *puruṣa* (sacrificer here) with arms raised upwards. That height is then taken to be equal to 120 *āṅgulas*. There are other views also.<sup>13</sup>

In fact the subject of metrology in general and that of units and measures in particular is a very sensitive topic of ancient Indian sciences as there are many conventions, definitions, and other considerations. Taking the same example, it may be pointed out that *āṅgula* is defined in many more ways and is of many types. The various mentioned *āṅgula* measures include *mānāṅgula*, *mānāntara-āṅgula* (each category has atleast three type—*uttama*, *madhyama*, and *adhama*), *mātrāṅgula* (with 3 subtypes), *muṣṭi-āṅgula* (which is related to the width of fingers).<sup>14</sup> According to the *Paraśurāma-paddhati*,<sup>15</sup> the *āṅgula* of 8, 7, and 6 *yavas* is called Maheśa, Viṣṇu, and Brāhmā *āṅgula* respectively. We come across *āṅgula* of 5, 4½, *yavas* etc. also. In Jaina sciences, there are several *āṅgula* measure. Thus special attention and care are needed to deal with the linear units and measures.

### MATHEMATICAL ASPECTS

Certain aspects in the calculations and construction of the *Agni-kunḍas* involve stringent mathematical discussions along with or irrespective of historical facts. Some of the matters require advanced mathematics. There are also some features which need modern mathematics to judge, support (or reject) presumed ancient mathematical implications.

According to Seidenberg,<sup>16</sup> the circle is older than square as a geometrical figure. The construction of a circle, say by peg and cord, is very ancient and easier than that of a square. Later on in India the square was considered to be superior and was associated with gods and Brāhmaṇas.<sup>17</sup> It was taken as a symbol of perfection and the *Śulbasūtras* preferred it to favour.

For constructing the diagrams of the various *kunḍas*, there are two common methods. The older one of them is that of starting with a suitable square figure in each case.<sup>18</sup> This is recognised in several places e.g., when it is said that the square is<sup>19</sup>:

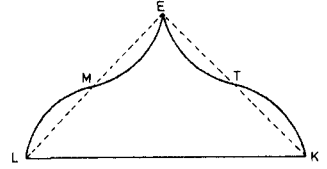
*sarveṣāṃ kuṇḍānāṃ mūlam (or prakṛti bhūtam) ;*

Or, *Sarvakunḍesu kāraṇam*, etc. i.e., square is the basic figure for all the *kunḍas*. The tradition and transformation geometry of the *śulba-sūtras* support this method. The other method is to start with an appropriate basic circle and derive the desired figure. Kamalākara's construction of the *kunḍas* goes beyond traditional methods.

However, several of the calculations and constructions are not so accurate or exact as claimed. Some of them have intrinsic weaknesses e.g., in the use of the value  $\pi = \sqrt{10}$  by Kamalākara in his methods. Moreover, modern mathematics has proved that it is not possible to convert circle and square mutually (with preservation of area) by ruler and compass, because  $\pi$  is transcendental in nature.

Interestingly, ancient mathematics of the *kunḍas* can provide many good example and exercises for non-routine problems for classroom mathematics. Since *yajñas* are still performed, modern mathematics can

be used to achieve greater accuracy in the calculations and construction of *kuṇḍas*. It can also be used to point out some fallacies. For instance Kulkarni<sup>20</sup> is wrong in saying that the petal on LK (of the right  $\triangle ELK$ ) can be obtained by drawing semicircles on ME and ET (see Fig. 1) because these will not touch at E as shown (but rather intersect there).



### MISCELLANEOUS ASPECTS

The ground where the *maṇḍapa* (pavilion) for conducting the *yajñā* is located should be made absolutely level. For this, instruments like the *avalagnaka* or *dārūyantra* were employed.<sup>21</sup> Main cardinal points were marked with help of a gnomon or pole-star etc. These directions were needed to give prescribed orientation to the *maṇḍapa* and *kuṇḍas*. Methods used were those found in the *śulba-sūtras* and the *jyotiṣāśāstra*.

Generally speaking, the plan of the pavilion was square. But the dimensions depended on the number of *kuṇḍas* made in it. Often the caste consideration of the sacrificer also played the role in deciding the size of the pavilion. It has been pointed out that the word *maṇḍapa* comes from *maṇḍa* or *māṇḍa* meaning intoxicating drink, and *maṇḍapa* originally stood for a place where people gathered to drink it.<sup>22</sup> Not only the dimensions of the pavilion but also the heights and layout of the pillars, location of the doors, etc. are all laid down in the manuals on the *kuṇḍas* and *maṇḍapas*.

We have already mentioned that some *vedis* were also constructed (see Section 1) in the pavilion along with the *kuṇḍas*. Necessary accessory structures were also constructed for *kuṇḍas* and *vedis*. These include *mekhalā* (belt), *kaṇṭha* (throat), *nābhi* (navel) and *yoni* which was a sort of a pouring cup (made at the top of a *mekhalā*) to receive liquid oblations. Shape and dimensions of these accessories are also prescribed.



## EPILOGUE

The Vedic tradition of Indian geometry comprises of rules evolved in the construction of various forms of *citis* (fire-altars). The subject is found coded in somewhat systematic manner in the *Śulba-sūtras* which are the oldest mathematical manuals of India. Later on the elaborate sacrificial rites requiring piling of *citis* became less practical and somewhat unpopular. On the other hand the religious rites which required *agni-kunḍas* (fire-pits, became more popular and common. The abandonment of some earlier Vedic sacrifices involving killing of animals also marks a progressive step towards *ahimsā*.

In fact it seems that the word *kunḍa* became so popular and common that it started denoting both the religious structures namely piles (*citis*) and dug pits.<sup>23</sup> Of course both are for keeping sacrificial fire.

In medieval India, the *tāntric* tradition (based on *tantra* in the sense of peculiar yogic practices and mysticism) also became popular. This gave rise to increased literature in the field and the development of mystic diagrams—*cakras*, *yantras*, *maṇḍalas*, etc. Thus there is a related continuous geometrical tradition from the *śrauta* fire-altars, *smārta* fire-pits to *tantric cakras* and *yantras* in making diagrams. Even the *kolam* or *raṅgoli* diagrams (as a combination of religious tradition and folk art) used in various forms of *pūjā* and decorations (for welcoming guests) is a link in the unbroken chain.<sup>24</sup>

## SELECT BIBLIOGRAPHY ON KUNḌAS

Hundreds of Sanskrit works on *Kunḍas* were composed by various authors and most of them are still available. But only a few of them are printed. Commentaries on many of them were also written. Below we present a select list of *Kunḍa* manuals arranged alphabetically. Information given is mainly based on the two well known reference works namely the *New Catalogus Catalogorum* (Vol. IV, Chennai, 1968) and the *Census of the Exact Sciences in Sanskrit*, series A (vol. 5, Philadelphia, 1994). Also see *Science and Technology in Medieval India—A Bibliography* (by A. Rahman), New Delhi.

*Agni Purāṇa* (whose Chapter 24 is devoted to *kuṇḍas*) 1982, pp. 577-596 ; edited by Baladeva Upādhyāya, Chowkhamba, Varanasi, 1966.

*Ajita Āgama* being the 5th of the 10 *Śaiva Āgamas*. It deals with *kuṇḍas* in detail and was published by the France Inst. of Indology, Pondicherry, 1964 and etc.

*Caturvarga Cintāmaṇi* of Hemādri (13th century A.D.). *Kuṇḍas* are treated in the *Dānakhaṇḍa* (of this encyclopedic work) which is printed as Vol. I by Asiatic Soc., Calcutta, 1871.

*Gṛhyāgnisāra* (1640) of Nārāyaṇa Bhaṭṭa. *Kuṇḍa* portion is found in a manuscript (no. 8613) at Oriental Inst., Baroda.

*Karmakāṇḍa-kramāvalī* (A.D. 1073) of Somaśambhu, published in Kashmir Series of Texts and Studies, No. 73, 1947.

*Kuṇḍa-camatkāra* of Tryambaka Bhairava. Ms. no. 1300 in Oriental Inst., Baroda.

*Kuṇḍacitra, Bahuvīdha*, Indian Museum, Calcutta, Ms. 2925A.

*Kuṇḍa-darpaṇa* (1724) of Malleśvara Ārādhye. see CESS(A), V, p. 286 for manuscripts and extract.

*Kuṇḍa-dīpa* of Majī with autocommentary (A.D. 1600). See CESS(A), V, p. 269 for manuscripts and extracts.

*Kuṇḍa-gaṇita* with commentary (anonymous). cf. ms. no. 203 in Bhandarkar Oriental Research Inst., Pune (see NCC, vol. 4, p. 178).

*Kuṇḍagrantha-vimśati* (= KGV), a collection of 20 *Kuṇḍa* texts published by H. Venkataram, Aryasevaka Printer, Mumbai, 1887. Works included in KGV are : (*Maṇḍapa*) *Kuṇḍa-siddhi*, *Kuṇḍārka*, *Kuṇḍa-maṇḍapa darpaṇa*, *Kuṇḍa-mārtanḍa*, *Kuṇḍa (Maṇḍapa)-kaumudī* *Kuṇḍa-kārikā*, *Kuṇḍa-śulba-kārikā*, *Kuṇḍāpradīpa*, *Kuṇḍodadhi*, *Kuṇḍa-ratnā kara*, *Kuṇḍārṇava*, *Kuṇḍāṅkuśa*, *Kuṇḍodyota*, *Kuṇḍa-prakaraṇa*, *Kuṇḍa-tattva-pradīpa*, *Kuṇḍa-kalpadruma*, *Kuṇḍa-racanā*, *Kuṇḍa-maṇḍapanirnaya-lakṣaṇa*, *Kuṇḍākṛti*, and *Kuṇḍa-martcimālā*. See below for details of each work of this collection (same set was also printed in 1916 and 1925).

*Kuṇḍa kādambarī* (1741) of Gokulanātha, ed. by D. Jha and K. Jha, Sanskrit Univ., Darbhanga, 1982.

*Kuṇḍa-kalpadruma* (1655) of Mādhava Śukla (who also wrote a commentary on it). It is printed as 16th work in KGV.

*Kuṇḍa-kalpalatā* of Ḍhundhirāja Śaiva (16th cent) see CESS(A), V, 126 for manuscripts and extract.

*Kuṇḍa-kārikā* of Lakṣmīdhara. It is 6th work in KGV.

*Kuṇḍākṛti* (1449) of Rāmacandra Vājapeyī. It is an early and well known work on the subject. Author himself wrote two commentaries on it. Printed as 19th work in KGV.

*Kuṇḍa-lakṣaṇa* as the 25th *pariśiṣṭa* of *Atharva-veda* see NCC, IV, 185 for manuscripts and printed version.

*Kuṇḍāloka* is the name of author's own commentary on *Kuṇḍa-maṇḍapa-kaumudī* (q.v.).

*Kuṇḍa-maṇḍana* of Gokulanātha frequently quoted by him in his *Kuṇḍa-kādambarī* (q.v.).

*Kuṇḍa-maṇḍana* of Narahari Saptarṣi with auto-commentary. See CESS (A), V, 164-165 for mss. and abstract.

*Kuṇḍa-maṇḍapa-darpaṇa* (1578) of Nārāyaṇa (son of Ananta). It is 3rd work in KGV.

*Kuṇḍa-maṇḍapādi-lakṣaṇa*, an anonymous compendium of quotations. Ms. no. 4616 (a) at Oriental Inst., Baroda.

*Kuṇḍa-maṇḍapa-kaumudī* (16th cent.) of Viśvanāth Deva. It is the 5th work in KGV.

*Kuṇḍa-maṇḍapa-nirṇaya-lakṣaṇa* from *Rudra-paddhati* or *Paraśurāma-paddhati* attributed to Paraśurāma. It is the 18th work in KGV.

*Kuṇḍa-maṇḍapa-vidhi* of Bodhāyana. Ms. no. 10440 in Prajñā Pāṭhaśāla, Wai, Satara. see NCC, vol. XIV (2001), p. 104.

*Kuṇḍa-marīcī-mālā* of Viṣṇu as 20th work in KGV.

*Kuṇḍa-mārtanḍa* (1691) of Govinda, son of Gadādhara It is the 4th work in KGV.

*Kuṇḍa-mārtanḍa* by Śaṅkara. Ms. no. 223 in Sanskrit School, Rajapur, Ratnagiri. See NCC, IV, p. 184.

*Kuṇḍa-nidhi* (or *Kuṇḍa-vidhi*) of Vīreśvara, son of Lakṣmaṇa. Ms. 9511 at Oriental Inst., Baroda.

*Kuṇḍānkuśa* of Gaṅgādharaṇanda, printed as the 12th work in KGV.

*Kuṇḍa-paddhati* of Nāgoji Bhaṭṭa (c. 18th cent.) see CESS (A), V, 168 etc. for more on the author.

*Kuṇḍa-prabandha* (1632) of Kālidāsa, son of Balabhadra. See NCC, IV, p. 180 for more information.

*Kuṇḍa-pradīpa* (1639) of Mahādeva who also wrote a commentary on it. Printed as the 8th work in KGV.

*Kuṇḍa-prakarāṇa* from the *Nārada-pañcarātra* (a well known work). It is printed as 14th text in KGV.

*Kuṇḍa-prakāśa* (c. 1700) of Rudradeva Toro. See CESS (A), V, pp. 505-506 for more on the author and the work.

*Kuṇḍa-racanā* (sūtra and commentary). It is the 17th work in KGV.

*Kuṇḍa-ratnākara* (16th century ?) of Viśvanātha Dvivedī (who also wrote a commentary on it). It is the 10th work in KGV. Its earliest manuscript is dated 1588.

*Kuṇḍa-ratnāvālī* (1868) of Rāmacandra Dīkṣita (alias Jāḍe), with commentary *Mañjūśā*, published by Nirnaya Sagar Press, Bombay, 1912.

*Kuṇḍārka* (17th century) of Śaṅkara Bhaṭṭa, son of Nīlakaṅṭha. It is the 2nd work in KGV.

*Kuṇḍārṇava* os Śrīdhara Agnihotri, son of Sūrjia. It is the 11th work in KGV.

*Kuṇḍasāra* of Vināyaka Pāṇḍuraṅga Khānāpūrakara (born 1858).

*Kuṇḍa-siddhyudāhṛti* of Gaṇeśa, son of Śrīdhar. It is a prose commentary on a portion of *Maṇḍapa-kuṇḍa siddhi* of Viṭṭhala, ed. by Takao Hayashi in *Bulletin of the National Museum of Ethnology, Osaka*, 12(1) (1987), 199—.

*Kuṇḍa-śiromaṇi* (1599) of Viśrāma, son of Puruṣottam See *CESS (A) V*, 658-659 for manuscripts and extract.

*Kuṇḍa-śulba-kārikā* as 7th work in *KGV*.

*Kuṇḍa-tattva-pradīpa* (1623) of Balbhadra Śukla (who also wrote a *ṭīkā* later on). It is 15th work in *KGV*.

*Kuṇḍa-vibhūṣaṇa* of Rāma Deva. See *CESS(A), V*, 426.

*Kuṇḍodadhi* of Ramacandra as 9th work in *KGV*.

*Kuṇḍoddyota* (17th cent.) of Nīlakaṇṭha Bhaṭṭa as the 13th work in *KGV*. His son Śaṅkara wrote two commentaries on it.

*Maṇḍapa-druma* (1654) of Mahādeva Sūri, son of Maṇilava, ed. by Sreekrishna Sarma in *Adyar Library Bulletin* Vol. 22, parts 1-2 (1958), 119-157.

*Maṇḍapa-kuṇḍa-siddhi* (1620) of Viṭṭhala Dīkṣit. It is a standard and popular work and is 1st item in *KGV*. There is an auto-commentary. See *CESS(A), V*, 638-643 for details.

*Śāradātilaka* (15th cent. or earlier) of Lakṣamaṇadeśi Kendra. Rāghavabhaṭṭa's commentary on it is dated 1493.

*Siddhānta-tattva-viveka* (1658) of Kamalākara with auto-commentary. *Āgni-kuṇḍas* are dealt with in the Chapter III. See *Gaṇita-Bhārati*, vol. 20 (1998), 8-24, for a study.

*Vācaspatyam*, a Sanskrit encyclopedia, Vol. III (reprinted, Varanasi, 1990), deals with *kuṇḍas* (pp. 2076-2087).

*Vedī-kuṇḍa-nirṇaya* (c. 1600) of Viśvanātha, son of Ananta. Ms. no.1759 in Anup Sanskrit Library, Bikaner.

## NOTES AND REFERENCES

1. See A.B.Keith (transl.), *The Veda of the Black Yajus School entitled Taittiriya Sanhita*. Two parts, reprint Motilal Banarsidass, Delhi, 1967, Part II, p. 438; and D. Pingree, "Jyotiḥśāstra" (Astral and Mathematical Literature) in *A History of Indian Literature*, ed. by Jan. Gonda, Vol. VI, Fasc 4, Weibaden, 1981, p. 3.
2. The form is trapezium according to *Baudhāyana Śulba Sūtra* see S.N. Sen and A.K. Bag, *The Śulba-sūtra*, INSA., New Delhi, 1983, pp. 6 and 225. The *Āpastamba Śulba Sūtra*, 14.8, gives it square or circle, *Ibid.*, pp. 49, 13. Also see A. Seidenberg, "The Ritual Origin of the Circle and Square", *Archive Hist. Exact Sciences*, 25.4 (1981), pp. 306, 312.
3. *Baudhāyana Śulba Sūtra*, 20.1, see Sen and Bag, *op. cit.*, pp. 36, 98.
4. R.P. Kulkarni, *Engineering Geometry of Yajñ-a-kunḍas and Yajñ-a-manḍapas*, Jnana Prabodhini Samstha, Pune, 1998, p. 25.
5. *Śaradātilakam* (15th cent. or earlier), III, 85-87; text edited and published by Jibananda Vidyasagara, Calcutta, 1892, p. 28. Some verses quoted in *Vācaspatyam* (Vol. III, p. 2081) and by B. Pathak in his commentary (p. 30) on *Manḍapa-kunḍa-siddhi* (Benares, 1926 ed.) (see ref. 12 and ref. 19 below).
6. R.C. Gupta, Kamalākara's Mathematics and Construction of Kunḍas, *Gaṇita Bhārati*, 20 (1998), 8-24; Takao Hayashi, "Ritual Application of Mensuration Rules in India : An Edition of Gaṇeśa's *Kunḍasiddhayudāhṛti*", *Bulletin National Museum of Ethnology, Osaka*, 12.1 (1987), 199-224; and R.P. Kulkarni (ref. 4 above).
7. Kulkarni, *op.cit.* (ref. 4), p. 1.
8. *Agnipurāna*, ed. by Baladeva Upadhyaya, Chawkhamba Varanasi, 1966; chapter 24, p. 29-31.
9. See Seidenberg, *op. cit.* (under ref. 2 above), p. 271.
10. Kulkarni (ref. 4), p. 13, mentions four type of Vedis namely *Svastika*, *Padminī*, *Sṛidharī*, and *Sarvatobhadra*, and gives their details.
11. See Hayashi (cited under ref. 6), p. 200; and Gupta (ref. 6), p. 11.
12. *Manḍapa-kunḍa-siddhi* with B. Pathak's Sanskrit commentary and Hindi translation, ed. by his son Ganeshdatt, Benares, 1926, p. 3.
13. E.g. see Kulkarni (ref. 4), p.96, for *Puruṣa* measures of 120 and 125 *anḡulas*.

14. See *Kuṇḍa-kādambarī* ed. by D. Jha and M. Jha, Darbhanga, 1982, p. 5.
15. As quoted by Kulkarni [ref. 4], p. 96.
16. Seidenberg (see under Ref. 2), pp. 291 and 305.
17. *Ibid.*, pp. 306 and 312.
18. See T. Hayashi's review of Kulkarni's book (ref. 4), in *Gaṇita Bhārāti*, 23 (2001) p. 140.
19. See Kulkarni (ref. 4), p. 32; and *Vācaspatyam* compiled by Taranatha Tarkavachaspati, Vol. III, reprinted Chawkhamba, Varanasi, 1990, p. 2082, and also *Kuṇḍakādambarī* (ref. 14), p. 49
20. Kulkarni (ref. 4), p. 14.
21. *Ibid.*, pp. 2-3, and *Kuṇḍa-kādambarī* (ref. 14), pp. 8-9.
22. See Gadadhar Singh, *Ai se The Hamāre Guruji* (in Hindi), Varanasi, 1976, p. 98.
23. Mahadevasūri says, *kuṇḍam khātam vā citam vā* ; See his *Maṇḍapa-druma* (1654) ed. by S. Sarma, *Adyar Library Bulletin*, 22.1-2, (1958), 154.
24. Cf. the Vedic well known dictum 'atithi devo bhava.'