ANCIENT SCRIPTURES ON MECHANICAL ENGINEERING

By: Divya Murjani | 3982Views | 0 Comments

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Introduction

There are several references to machines and mechanical devices in Sanskrit literature, from the ancient *Vedas* to modern plays and secular publications like the *Yantrarnava* and *Yantra-sarvasva*. Let us peep into this range.

- The *Vedas* talk of wheels and apparatus for churning milk and producing fire and shuttle of handloom.
- In the *Mahabharata*, the continuously circulating fish that Arjuna shot down to win the hand of Draupadi in marriage is, of course, well known.
- The *Bhagavata-purana* refers to an oil-expelling device, with description of a gear arrangement.
- Kautilya's *Arthashastra* (4th Century BCE), the masterpiece on statecraft, describes 32 machines including one for throwing stones and a weighing balance of unequal beam, indicating theoretical development of mechanics and sophistication of technology to sustain it.
- Aryabhata (5h Century AD) describes a perpetual motion machine.
- In *Uttara-rama-charita*, a drama written by Bhavabhuti, a king requests the royal tutor to teach the prince the art of making machines driven by fire, air, water etc., which is indicative of the importance that royalty placed on physical and mechanical sciences.

Machine - Definition & Attributes

Dandaiscakraisca dantaisca saranibhramanadibhih I
Sakterutpadanarn kirn va calanarn yantramucyate II

Translated as - The generation of energy or motion, through the continuous movement or rotation of shafts, wheels or wedges is called a machine.

Yathavadbijasamyogah sauslistyarn slaksntapi ca I
Alaksyatanirvahanarn laghutvarh sabdahinata II
Sabde sadhye tadadhikyarnasaithilyarnagadhata I
Vahanisu samastasu sauslistyarn casaladgatih II
Yathestarthakaritvarn layatalanugarnita I
Istakalerthadarsitvarn punah samyaktvasarhvrtih II
Anulbanatvarh tadrupyarn dardhyamasrnata tatha II
Cirakalasahatvafica yantrasyaite mahagunah II

Translated as - These are the great attributes of machine - proper union of effort and result, good

contact, smoothness, requiring no attention, sustaining, lightness, and noiselessness, when sound is required its predominance, not loosening or clogging, good contact in all moving parts, no break in action, attainment of results as desired, adherence to rhythm and timing, showing results at the moment desired, returning to normalcy at other times, not bulging and staying in shape, strength, softness and durability.

Source

Yantrarnava (14th Century AD)

Sarnarangana-sutradharah, Chapter 3 I, Raja Bhojah (11th Century AD)

Notes

1. Yantra + arnava = the ocean of machines. This is a collection of materials dealing with machines of various kinds.
2. We find these attributes echoed in today's brochures of a variety of products like air-conditioners (no noise), car-stereo (enhanced sound output), scooters requiring (no attention).

Machine - Physical Balance

Paficavirnsatipalaloham
dvisaptatyangulayarnarn sarnavrttam karayet I
Tasyah paficapalikam mandalarn
badhva samakaranarn karayet I
Tatah karsottarapalarn phalottaradasapalarn
dvadasa paficadasa virnsatiriti padani karayet
Tata asatad dasottararn karayet I
Aksesu naddhripinaddham karayet

Translated as - Make (the beams) balance at 72 finger-widths for an iron piece of 25 pal a weight; on it bind a 5-pala ring and make it balance. Then on the opposite side, make gradation of eleven, twelve, fifteen and twenty (palas). From there, make steps of ten (palas) up to hundred (palas).

Source

Arthashastra, Adhyayah 2, Section 35, Slokai:J 16, Kautilyah (4th Century BCE)

Notes

Wedge = A shaft that is thick at one end and sloping to a thin edge at the other.

Units of measure

3 Tolas = 1 Pala
40 Palas = 1 Veesa
1 Veesa = 1.400 kg.

These measures were in day-to-day usage till the metric system was adopted In the 1950s.

Machine - Earth Model

Kasthamayarn samavrttarn samantatah
samagururn laghum golam I
Parada-taila-jalaistam bhramayet svadhiya ca
kalasamam II

Translated as - A small wooden sphere with its weight distributed uniformly on all sections fixed

on its axis should be rotated by mercury, oil and water (for one revolution per day).

Source

Aryabhatiya, Golapadah, Siokah 22, Aryabhata (499 AD)

Etymology

Kala + samam = In equal time = in a day = uniformity

Notes

This sphere is a model of the earth. It is kept on its axis passing through north and south poles and is free to rotate on bearings. Assuming the first zodiac, Aries, on eastern horizon; a nail is inserted on western side on its equator. Bhaskara describes this point as the centre of Virgo and Libra. One end of the thread is hooked to this nail, the thread is wound anti-clockwise and a pumpkin is suspended at the other end. A pot having circular cross-section and deep bottom (Sarna vrtta & Dirgha Tala) is placed between North and South towards east. It is filled with water having volume equivalent to six 'Ghatikas'. Ghatika is a unit of time. Here, it means that the volume of water should be such that it empties from the pot through a small hole made at the bottom in a period of six 'Ghatikas'. The water is filled and float is placed on the water surface at sun set.

Then as the water comes out through the hole its level should fall and the float should descend making the sphere to rotate one revolution per day automatically.

Machine - Carts

Dvicakrabahye vistararn sat saptastavitastiyugarn
Cakranabhicchayarnoksantarasya ca II

Translated as - The outside length of the line between hubs of the two wheels may be six, seven or eight sets of extended palms.

Madhyabharopari tula madhyanirgamanagratah
Aksarnoksantararn cakramadbharopayanakarn II
Potitakarasarnyuktarn ayahpattairdhikrtarn I

Translated as - Weight should be balanced in the middle. The center (of the laden weight) may be stretched forward. The laden weight (may be placed) between the two axis.

Source

Vastusastram, Ratha-laksanam, Visvakarrna (6th Century AD)

Notes

While the ideal is to keep the weight in the centre of the cart, the direction for error is to move the weight to the front. This is essential for any animal/human-drawn vehicle, since the locomotion is in the front. If the weight were to be towards the rear, then there would be the risk of the vehicle tilting. This format answers the norm of prescribing the ideal and also suggesting the direction for error.

Unit of Measure

Vitasti = Palm length

Vitasti + yuga = Set of palm lengths = two palm lengths.

Table of linear measures

8 paramanus = 1 trasarenus

8 trasarenus = 1 ratharenus
8 ratharenus = 1 kosas
8 kosas = 1 tilabijas
8 tilabijas = 1 sarsapas
8 sarsapas = 1 yavas
8 yavas = 1 angulas
12 angulas = 1 vitasti
2 vitasti = 1 hasta
4 hastas = 1 danda
2000 dandas = 1 krosa
4 krosas = 1 yojana

• Written in *Aryabhatiya* by Aryabhata, Edited by Kripa Shankar Shukla Page number x1iii

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