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DESIGN AND CONSTRUCTION OF CAMBERED V-DOORS

by

Klaus Lange

Institut für Fangtechnik
Bundesforschungsanstalt für Fischerei
Palmaille 9, D-22767 Hamburg

ABSTRACT

Based on the assumption of a circular camber the upper and lower section of a cambered V-door can be considered as parts of the surfaces of two intersecting circular cones. The surface of a circular cone is developable. The dimensions of the flat plate to be transformed into the final shape of the door section can be calculated. A numerical example is presented to explain the design process.

Since the first publications on V-doors in the early sixties [1], [2], [3], [4] this type of door has become popular all over the world especially with inshore trawlers. The form (V-shape) enables the door to pass easily over obstacles on the sea bottom which is an important advantage on rough fishing grounds compared to the traditional flat rectangular doors. The main disadvantage of V-doors is the comparatively low lift coefficient of c_L = 0,7 [5]; 0,85 [6] which is even less than the corresponding coefficient of the flat rectangular otterboard c_L = 0,95 [5], [7], [8].

Since the investigations of OERTZ with flat and cambered trawl doors the positive influence of camber on the lift coefficient is known [9], [10], [11], today most trawl doors are cambered. Wind tunnel tests with flat and cambered V-doors proved the increase of the lift coefficient c_L when giving a camber to a flat V-door [12]. The results were confirmed by full scale trials with flat and cambered V-doors of the same projected area [13]. Similar results were found with model tests in flume tanks [8].

In contrast to these published data on the hydrodynamic performance of cambered V-doors there is no publication until now on the design procedure of this type of otterboard. This paper describes a method how to design a cambered V-door with circular camber.

With
h = height of the trawl door
l = length of the trawl door
c = camber
γ = V-angle

we make the following assumption:

projected area of the door	A = h x l	= 4,5 m²
aspect ratio	AR = h/l	= 0,5
camber	10 % = 0,1 l	= 0,3 m
V-angle		= 15°

From $A = 4{,}5\ m = l \times h$
$AR = 0{,}5\ m = l/h$

we get $l = 3{,}0$ m
$h = 1{,}5$ m

Upper and lower part of the otterboard are equal. They are considered as parts of the surfaces of two equal circular cones intersecting at half of the height h of the otterboard.

The radius R_i of the cone at the intersecting curve is calculated (see Fig. 1)

$$R_i^2 = (l/2)^2 + (R_i^2 - c)^2$$

$$R_i = \frac{(1/2)^2 + c^2}{2 \times c} = 3,90 \text{ m}$$

The corresponding radius at the upper edge of the board R_a is

$$R_a = R_i + 1/2 \times tg\,\gamma$$
$$= 4,101 \text{ m}$$

The lengths of the generating lines m_i, m_a are:

$$\sin\gamma = \frac{R_i}{m_i} = \frac{R_a}{m_a}$$

$$m_i = \frac{R_i}{\sin\gamma} = 15,068 \text{ m}$$

$$m_a = \frac{R_a}{\sin\gamma} = 15,844 \text{ m}$$

On the developed surface of the cone the arc b_i being part of a circle with the radius R_i becomes part of a circle with the radius m_i.

The length of the arc b_i is calculated as follows:

$$\sin\alpha/2 = \frac{h/2}{R_i} \quad ; \quad \alpha = 45,24°$$

$$b_i = \frac{2\,\pi\,R_i}{360} = 3,079 \text{ m}$$

The corresponding arc of the upper edge of the board b_a is

$$b_a = \alpha\,\frac{2\,\pi\,R_a}{360} = 3,238 \text{ m}$$

On the developed surface of the cone the angle ß corresponding to the arcs b_i and b_a is calculated:

$$\frac{2\,\pi\,m_i}{360} = \frac{b_i}{ß}$$

$$ß = \frac{b_i \times 360}{2\,\pi\,m_i} = 11,73°$$

The lengths of the corresponding cords are

$$\sin(\beta/2) = \frac{s_i}{2\, m_i} \qquad s_i = 3{,}063 \text{ m}$$

$$\sin(\beta/2) = \frac{s_a}{2\, m_a} \qquad s_a = 3{,}221 \text{ m}$$

The maximum camber of the arc is

$$c_i = m_i\,(1 - \cos\beta/2) = 0{,}078 \text{ m}$$
$$c_a = m_a\,(1 - \cos\beta/2) = 0{,}082 \text{ m}$$

The distance d between the two cords s_i and s_a is

$$d = (m_a - c_a) - (m_i - c_i) = 0{,}772 \text{ m}$$

With these figures the sector of the cone's surface can be designed on a flat plate to be formed into the cambered upper and lower part of the V-door.

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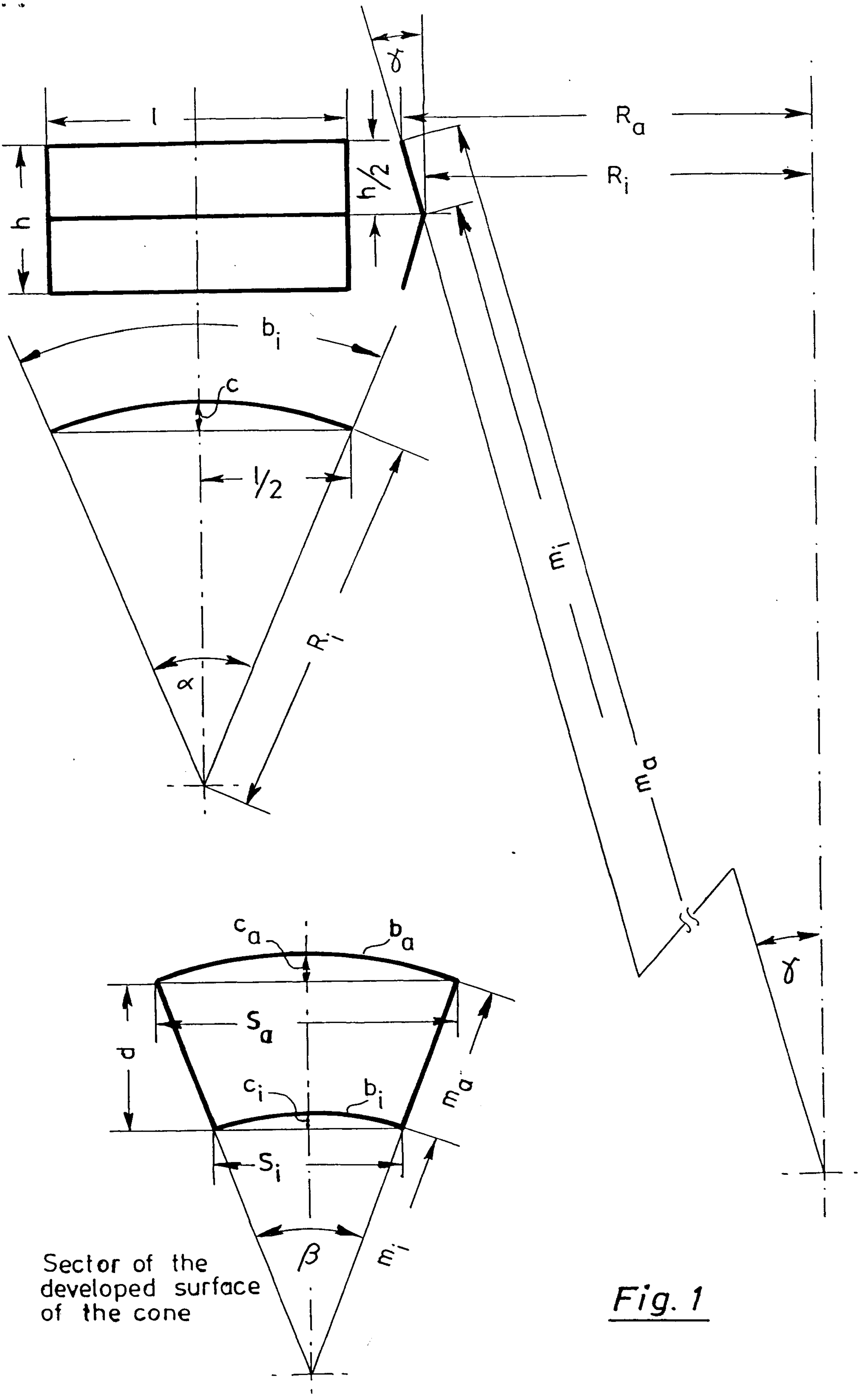

Sector of the developed surface of the cone

Fig. 1