Impeller Thrust Stabilizer For Waterborne Craft Using MEMS and Embedded Controllers

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Abstract—Aconventional waterborne craft generally rolls because its hull is doing what it is supposed to do – stay always in level with water underneath it. Conventional fin stabilizers jut from the bottom of a watercraft's hull port and are utilized for stabilizing the waterborne craft at the time of roll .The setup is hydraulically actuated and the power is taken from the engine of the craft. The proposed system is an improvised model for propelling and stabilizing waterborne craft with a rotary Impeller which is downwardly projected and is having atransverse thrust which inturn is controlled using feedback sensors and an embedded system.

Index Terms-Impeller, Stabilizer, Thrust, Channel, Gyro Servo Mechanism, Embedded Controllers.

1. INTRODUCTION

A water craft rolls because of its own hull which tries to stay in level with water underneath it. But when the water under the hull changes its angle, the hull also changes its angle accordingly hence thereby causing the roll. The roll moment of most power watercrafts which are built today ranges from 50' to 150' and is between two to six seconds, with four seconds being found common in most of the watercrafts.

The hydraulically actuated Conventional fin stabilizers jut from the bottom of a watercrafts hull port and starboard and the power for this is taken from the engine. In order to make it effective the watercraft needs to be moving at a minimum of 6 knots with the assistance of conventional fin stabilizer. New, "zero-speed" stabilizing fins are also utilized on the watercraft when at rest but on other hand they are quite expensive too.

Stabilizing fins have many drawbacks. The drag created by them is dependent on the fins size which can reduce a watercraft's speed by as much as a knot. Excluding expensive and very large zero speed fins, a normal stabilizing fin does not work at rest. Zero-speed fins on the other hand consume high power and creates excessive noise. The proposed system relates to an improved modeling for propelling and stabilizing waterborne craft. The proposed system also relates it to be used for the outboard propulsion. Rotary Impeller which is downwardly projected with outboard housing having its axis and direction of thrust transverse to the impeller housing which on the other hand is placed at end of the channel at either sides below the surface of water can be swiveled with relation to the craft to vary the thrust in horizontal direction.

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This provides a more efficient and economical control for both the propulsion, maneuvering as well as for the stabilizing of the craft against tipping off in any specific direction. The use of gyro sensor provides an ultra-high stability, low drift and extraordinary signal to noise ratio.

2. CONVENTIONAL SYSTEM STRATEGIES

Movements about the roll axis are the most troublesome out of all motions experienced on watercrafts. This is experienced immediately when passengers step off the dock onto the small craft. This disturbing heel is caused due to the weight as a resulta rolling oscillation of the hull is created. Rapid rolling motions are even caused from waves from a passing craft hits thewatercraftswhen anchored at a dock. It slams the watercraft against the dock, which is dangerous for both passengers as well as the craft.

In early nineteenth century, power for watercrafts were primarily sails, which, provided a steady moment. With the advancement of technology the use of steam power resulted in consequent absence of masts and sails, watercraft motion and control became a major concern, and by the late nineteenth century, steps weretaken to stabilize ships mainly in the roll axis.

The earliest (around the year 1870) attempts appeared in form of bilge keels—extending flat longitudinal plates placed diagonally from both the sides of the bottom of the hull. Similarly slosh tanks was the first (1880) successful used as dynamic roll control devices—an arrangement consisting of water containers inside the hull designed in a way that large amount of water (about 5% to 6% of watercraft displacement) to shift from side to side in phase with the roll oscillation

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hence it dampened the rolling impulse. Actively controlled external fins were introduced in about 1925 and are used widely in ships for roll suppression even today.

Fin stabilizers are generally not employed for small watercraftwhereas they are widely used in huge ships because they mostly underway at cruise speed as compared to small watercrafts.

Another type of roll stabilizing device, used in watercrafts, including the commercial fishing craft, is an arrangement of horizontal planning fins, called paravanes. During tilt this paravanes rigged out on cables, booms on either side of the watercraft providing a stabilizing force acting on the watercrafts hull. Paravanes on other hand if not used with skill, could be awkward and very dangerous. Also they havebeen found to be of limited use. A similar system used for stabilizing a watercraft at rest employs flat plates (in lieu of the fins) which resist being pulled up through the water column, and hence exerts a damping effect on the roll axis.

Another device used for roll suppression is gyroscopic roll stabilizers or control movement gyros. The first to develop them was Otto Schlick, in 1906 (U.S. Pat. No. 769,493). A control moment gyro ("CMG") is a torque amplification device which uses controlled precession of stored angular momentum for producing large control torques. CMG can resist roll oscillation, but cannot resist a continuing roll angle, e.g. -all common occurrences on ships such as a sustained heel caused by a turn, a large quartering wave, or a high beam wind. On the other hand, fin stabilizers can remain deflected as long as necessary to counter a continuing heeling moment. Similarly fin stabilizers when used are ineffective at low (or no) speed is not a problem for ships because when they are in a seaway, they are normally at cruise speed. Thus while CMGs were effective on ships, they appear to have a technology with broader capabilities.

3. PROPOSED SYSTEM MODELING

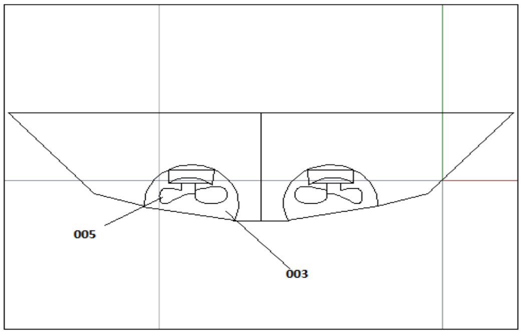

Fig 1: Front view of the watercraft

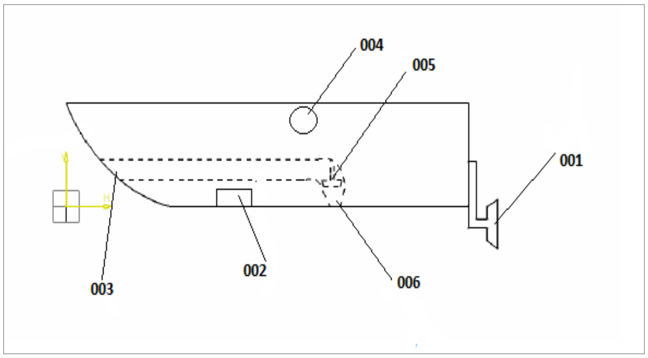

Fig 2: Side View of the Watercraft

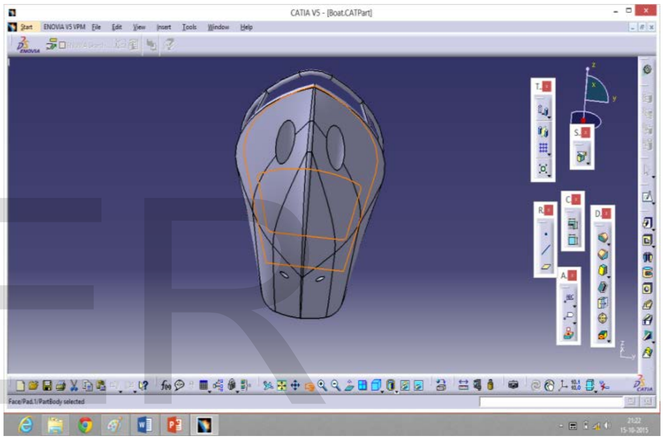

Fig 3: CATIA design of proposed system

The proposed system involves the use of metacentric height. When the metacentric height of the watercraft is reduced to a minimum level, the watercraft tends to tipping in any specific direction mostly side wise. This condition can also happen due to sudden increase in load on either sides of the watercraft. In this situation the gyro sensors allows the calculation of orientation, rotation and is analyzed in the microcontroller. The input to a servo is usually a very small signal. It is too weak to move the load by itself, so some sort of power amplification must take place within the servo. The input to the servo is sometimes so small it can be measured with a millimeter. To develop enough power to move the great weight of a guide arm requires currents in the ampere range. Feedback is a principle upon which the operation of all servos is based this feedback is a communication channel which reports the condition (speed, position) of the output back to the error detector in the microcontroller.

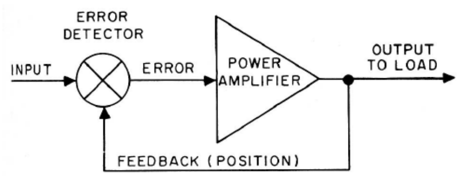

Fig 4: Feedback mechanism circuit diagram

Thus the required power is made available at the side Impeller in very short duration hence the impeller rotates at a high rpm and create the required thrust to stabilize the watercraft.

In earlier mechanism the projecting outboard housing and a rotary Impeller unit takes some time to initiate where as in our invention due to the presence of side channels the impeller will be rotating and it takes lesser time to initiate.

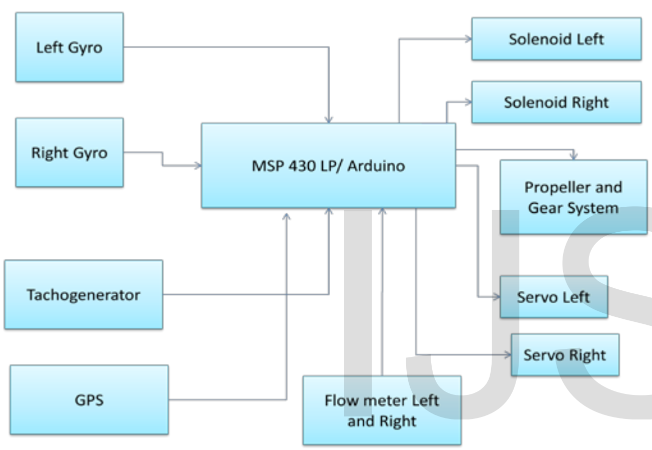

Fig 5: Block Diagram of the Circuit

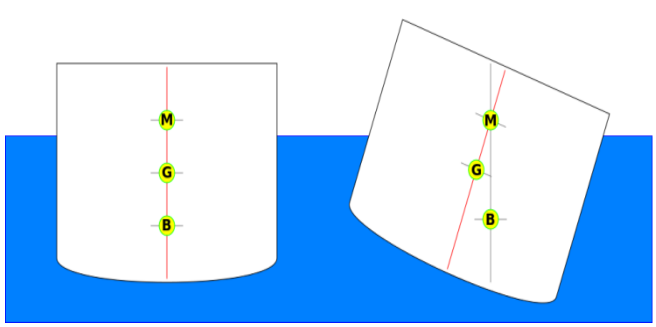

Fig 6: Metacenter of a watercraft

GM = wx/ W tanθ

Where, wis the added load

W is the weight of the watercraft

x is the distance from the center to any side of the watercraft, **θ** is the angle of heel.

The period of roll can be estimated from the following equation

$$T = \frac{2\pi\, k}{\sqrt{g\overline{GM}}}$$

Where, g is gravitational acceleration, k is the radius of gyration about the longitudinal axis through the center of gravity, $\overline{GM}$ is the stability index and as per Fig 6, G is the center of gravity , B is the center of buoyancy and M is the metacenter with ship upright and heeled over to one side moving.

4. SYSTEM MODELLING

001- This part consists of an impeller that is been utilized for the forward motion of the watercraft.

002- Tachogenerator is used to measure the speed of the watercraft and the output from the tachogenerator is given to the MSP 430 (Micro conroller)

003- A channel is created which is opened and closed by a solenoid mechanism. These channels are utilized for the basic stability of the watercraft during high speed, and is used for creating high velocity jet during emergency situations.

004-A gyro sensor is utilized to measure the angular rotation of the watercraft. The output is given to the microcontroller.

005- The impeller is used to produce high velocity jet of the water.Its reaction is utilized to create a stabilizing thrust during unbalanced situation.

006- Nozzeled end again increase the jet velocity which further adds to the stability of the watercraft.

Condition 1

With the operation of 001 the watercraft moves in forward direction. The speed of the watercraft is measured using 002.During high speed condition i.e when the speed exceed nominal range then the 003 gets actuated and side way channels are opened which stabilizes the watercraft during high speed.

Condition 2

With the operation of 001 the watercraft moves in forward direction.When ever a tilt or rolling condition occur due imbalance load or due to water action underneath 004 measures the change in the angular rotation . This information is passed to microcntroller.At these situation 005 activates and a velocity flow of jet is created with the water flowing through 003.This velocity is further increased by passing through 006.This in turn creates a opposing or balancing thrust which stabilizes the rolling effect.

5. CALCULATIONS

The resulting force due to Mass flow and Flow Velocity

The resulting force along x-direction due to mass flow and flow velocity can be expressed as:

$R_x = m\, v\, (1 - \cos\beta)$

$= \varrho\, A\, v^2\, (1 - \cos\beta)$

$= \varrho\, \pi\, (d / 2)^2\, v^2\, (1 - \cos\beta)$

Where

R_x = resulting force in x-direction (N)

m = mass flow (kg/s)

v = flow velocity (m/s)

β = turning bend angle (degrees)

ϱ = fluid density (kg/m^3)

d = internal pipe or bend diameter (m)

π = 3.14...

The resulting force along y-direction due to mass flow and flow velocity can be expressed as:

$R_y = m\, v\, \sin\beta$

$= \varrho\, A\, v^2\, \sin\beta$

$= \varrho\, \pi\, (d / 2)^2\, v^2\, \sin\beta$

R_y = resulting force along y direction in N

The resulting force on the bend due to force along both x- and y-direction can be expressed as:

$R = (R_x^2 + R_y^2)^{1/2}$

Where

R = resulting force on the bend (N)

Example

Resulting force on a bend due to mass flow and flow velocity

Consider a 90^o bend with

- diameter *80 mm = 0.08 m*
- water with density *1000 kg/m³*
- flow velocity *50 m/s*

Can be calculated by as

Resulting force along x-direction:

$R_x = (1000\ kg/m^3)\ \pi\ ((0.08\ m) / 2)^2\ (50\ m/s)^2\ (1 - \cos(90))$

$= \underline{12566.37}\ (N)$

Resulting force along y-direction:

$R_y = (1000\ kg/m^3)\ \pi\ ((0.08\ m) / 2)^2\ (50\ m/s)^2\ \sin(90)$

$= \underline{12566.37}\ (N)$

Resulting force on the bend

$R = (12566.37\ (N)^2 + 12566.37\ (N)^2)^{1/2}$

$= \underline{17771.53}\ (N)$

Note – if turning bend angle (β) is *90^o* the resulting forces along both x- and y-directions are the same.

Average weight of a person = 600 N

So maximum no of people could be stabilized = R/600

= 30 people

6. CONCLUSION

The proposed system relates to an improved apparatus for propelling and stabilizing waterborne craft. Direction of thrust transverse to the housing which is placed at end of the channel at either sides below the surface of water can be swiveled with relation to the craft to vary horizontal direction of thrust, thus thereby providing a more economical and efficient control both for the propulsion, maneuvering and for stabilizing the craft against tipping off in any specified direction

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REFERENCE

1. Text on Fluid Mechanics and Hydraulic Machinary, R K Bansal, Laxmi Publications Pvt.Ltd.(2010 edition).
2. Ship Stability For Maters and Mates,Bryan Barrass and Capt D R Derrett,Publisher Butterworth Heinemann, Published on september 2012.
3. Website viewed on 26/08/2014, 20:00,http://www.watercrafttest.com
4. US2987027 – propeller thrust stabilizer control
5. US2130929 – Stabilizing equipment for vehicals particularly ships
6. US2809603 – Apparatus for the stability of ships