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Adaptation Of Watt's Indicator Mechanism In Altitude Measurment

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I. *ABSTRACT*

In today's world, air travel has become the primary mode of fast and reliable transport. In fact, in the broad arena of international travel, air travel has established itself as the one and only mode of transportation. More and more aircraft operators are getting into business each and every year and the competition is fierce.

In this situation, it is but natural to expect safe transportation and involvement of better technologies to dispel fears among the general public regarding air travel. We can confidently say that the number of incidents and accidents involving aircrafts have come down than it used to be in the 19th century and that the 20th century has seen aircrafts evolving using high end technologies to fight against any problems that nature or machine can throw up on the aircraft and in turn, the crew. In fact, we can be firm in saying that air travel is the safest mode of transportation

In this context, I would like to bring forth a problem that has been suppressed but not eradicated in the main systems and the main information that any crew would need for the effective operation of an aircraft,

The Altitude Measuring Systems.

The most commonly used systems are the following:

1. The Pitot – Static System
2. Sensors

Due to inherent problems due to man and nature in the above two systems of measuring the altitude and the vertical speed of the aircraft, I hereby propose a different method of measuring the above two parameters, ***The Watt's Indicator Mechanism.*** *This technical paper strives to solve the problems due to the Pitot – Static system and the Sensors.*

The detailed problems regarding the above two systems of Altitude and Vertical Speed Measurement involving case studies and the theoretical eradication of the problems concerning Altitude Measurement using the Watt's Indicator Mechanism is portrayed below.

II. PROBLEMS IN THE PITOT – STATIC SYSTEMS

The Pitot – Static Systems in an aircraft are mounted towards the side of the aircraft or are seen as small pipes that are projected towards the front of the aircraft. During the cleaning of the exterior of the aircraft, it is often a usual practice to cover the pitot tubes by a tape in order to avoid contamination of the liquid inside the tube which senses the changes in pressure. But if the tapes are not removed after cleaning, then the pitot tubes will get blocked resulting in erratic altitude readings

Also, if the flights are parked on the ground for long times, and as per regulations if the pitot tubes are not covered properly, it may result in some contaminant settling in the pitot tubes and once the flight is operated, it may lead to complete pitot – static failure and the flight will be in jeopardy.

If the two reading of the vertical speed, one of the captain and the other of the first officer, do not agree with each other, the auto – pilot may simply disengage. Also, if both the pilots' readings agree but with the wrong value, it is a great cause of concern.

EXAMPLES:

1. Aero Peru 603, lifted off at Lima, Peru and crashed soon after into the Pacific ocean due to the Pitot – Tubes being covered with tape during the cleaning of the aircraft and was not removed prior to flight.

2. Birgenair 301, took off from the Dominican Republic, and also crashed very soon due to a small insect called the Mud Dobberwasp building its nest in the secluded area of the Pitot – tube. This was the result of the Pitot tube not being covered when the flight was parked on the ground.

3. Air France 447, the most recent one in the line of events, crashed into the Atlantic Ocean after lifting off from Rio – de – Janeiro due to suspected Pitot – Tube problems. It is to be noticed that the aircraft flew into very bad weather over the Atlantic.

III. PROBLEMS IN THE SENSORS

The same problems with the Pitot – Tube can be correlated with the sensors too. The aircraft's sensors may get burdened by ice when the flight flies through heavy thunderstorms and convective activity around an area. This may lead to erratic reading and lack of agreement between the captain's and the first officer's air speed reading. This may lead to the auto – pilot summarily disengaging. The same problem can in fact cause disagreement of Altitude Readings also. An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

EXAMPLES:

1. Air France 447, had its Speed Sensors Malfunctioning and even gave an automatic message to the ground station indicating complete Electrical System Failure, 4 hours into the flight.

IV. THE WATT'S INDICATOR MECHANISM

The Watt's Indicator Mechanism is a simple mechanism consisting of a piston used to sense the external pressure. The piston is connected to a link and the link is, in turn, connected to a V- Shaped chain. One end of the V- Shaped Chain is connected to a point which is pivoted and fixed. The other end of the V- Shaped Chain is free to move over a vertical scale.

The point, worth noting, in the Watt's Indicator Mechanism is that the free link that moves over the scale generates a straight line. This is the primary reason, why the Watt's Indicator Mechanism is also called as the Straight Line Mechanism.

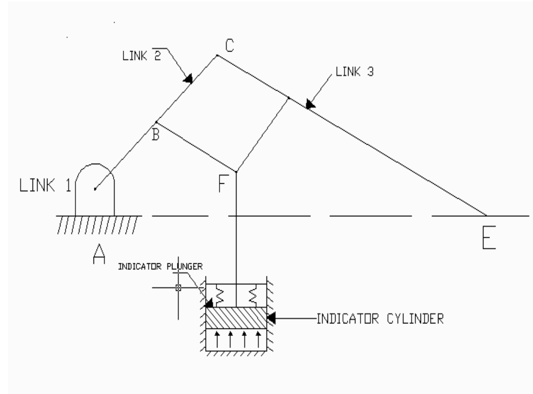

Fig. 1 Schematic Diagram of the Watt's Indicator Mechanism

The above diagram shows a schematic diagram of the Watt's Indicator Mechanism. Here, in the bottom portion, there exists an indicator cylinder, which is acted upon by external pressure as depicted by arrows. The indicator cylinder is also supported by two properly designed springs, whose functions are explained later.

The indicator cylinder is connected to the V- Shaped link at Point F. The point F is connected to the Links 2 and 3 at points B and D respectively. It should be noted that point F is the point that moves with corresponding reciprocation of the Indicator Mechanism.

Link 1 is pivoted at Point A, so that the movement of Point F will induce only an oscillatory motion in the Link 1. Link 2 terminates at Point E, which is free to move over the calibrated scale which will bear the altitude markings.

V. APPLICATION OF WATT'S INDICATOR MECHANISM TO ALTITUDE MEASUREMENT

The Watt's Indicator Mechanism, as such depicted in the article above is useless, unless the scale that is to be fitted at Point E is properly calibrated. The data for calibration and the procedure to calibrate the scale is given below.

TABLE 1:

AIR PRESSURES AT DIFFERENT ALTITUDES

S. No.	Altitude (In ft)	Air Pressure (In bar)
1	Sea Level	1.01325
2	5000	0.815013
3	10000	0.655560
4	15000	0.527303
5	20000	0.424139
6	25000	0.341158
7	30000	0.274413
8	35000	0.220725
9	40000	0.177541
10	45000	0.142806

The above table, gives the Air Pressure (in bar), at altitude in increments of 5000ft up to a hypothetical altitude of 45000feet. Here, from this table, it can be seen that, the atmosphere starts to thin, as we climb further upward. The maximum Air pressure of 1.01325 bar is present at Sea Level. So, the mechanism, which has to be designed for the maximum, has to be designed in such a way that it undergoes full compression at Sea Level.

Let us assume that, for a properly designed indicator cylinder diameter, if we give a pressure of 1.01325 bar, the freely moving link, which terminates at Point E, moves over the calibrated scale for a distance of 10cm, then we can convert the distance measured into a corresponding altitude, and mark the distance of 10cm as Sea Level or 0feet.

In this manner, we can, supply pressures in the increasing order, and correspondingly note the distances moved by the needle. Surely, the distance moved by the needle, when we give the pressure at Sea Level will be much higher than the distance moved when the pressure at an Altitude of 40000feet is given. So, accordingly, the distances can be converted into corresponding altitudes.

The springs, deserve a special mention here, for the fact that, if the plane climbs, say from 20000feet to 25000feet, then the corresponding air pressure decreases. So, there is no mechanism by which the indicator cylinder responds to the change in air pressure. The compressed springs, push the indicator cylinder down, till the point where the force exerted by the spring is same as the force exerted on the cylinder by the air pressure. Consequently, the needle comes down, thereby indicating the correct altitude.

VI .DESIGN FMEA PROCEDURE FOR THE MECHANISM:

S. NO	FAILURE MODE	FAILURE EFFECTS (KPOV)	CAUSES FOR FAILURE (KPIV)	SEV	OCC	DET	RPN
1	Failure of Springs	Erratic Altitude	Mechanical Breakdown and Wear	9	6	5	270
2	Failure of Links	Erratic Altitude	Mechanical Breakdown of Bolts	9	4	2	72
3	Ripping of Indicator Cylinder	No Measurement of Altitude	Flight in uncontrollable dive due to other problems	9	1	5	45

TABLE : 2

DESIGN FMEA PROCEDURE

The above design FMEA Study on the Watt's Indicator Mechanism reveals a startling prospect. The Risk Priority Number (RPN) is more than the standard of 125 for the Failure of Springs. Nevertheless, Preventive Action has been suggested for the first two failure modes.

A. PREVENTIVE ACTION:

1. The springs are subjected to fatigue loading. The springs should be made of a material that resists wear and has a very high endurance limit. Also, it is recommended that the springs be inspected at the end of a certain number of flights, which can be decided once the material has been finalized.

2. The bolts that are used to keep the links in place are subjected to severe loading as the plane climbs or descends, because the altitude is changing per second in these operations. So, it is recommended that the entire assemblies of links are checked each day by

the process of calibration i.e., giving a particular pressure and matching the altitude given with the correct one. Also, during the end of the week, the entire assembly is taken out and the bolts are replaced if necessary.

VII. ADVANTAGES OF THE MECHANISM

1. Less dependence on the use of the Pitot – Static System, the susceptibilities of which have been said earlier.
2. Altitude Measurement Sensors have been replaced by the system, which eradicates the problem of burdening of ice.
3. The problem of fluid contamination in the Pitot – Static System is eradicated as there is no use of fluids in the Watt's Indicator Mechanism.
4. There are no small gaps or crevices in the Mechanism, which makes it impossible for foreign matter to settle on the system.

VIII. DISADVANTAGES OF THE MECHANISM

Like everything and everyone, the Watt's Indicator Mechanism has its own kind of disadvantages which have been mentioned below.

1. The process is completely composed of mechanical components which are susceptible to sudden failure. Constant and thorough inspection is required.
2. In this mechanism, the needle moves backwards as the altitude increases. Pilots should have extensive training on this mechanism, as the needle in any measurement system, will move forward with the increase in the physical quantity. Improper and Insufficient training in this system will be catastrophic.

IX. POSSIBLE INNOVATION

The displacement of the pointer could be sent to a microprocessor which has been fed with the program to convert air pressure into the corresponding altitude readings. This altitude reading could be given to the pilots in a digital format eradicating the calibrated scale.

X. CONCLUSION

This technical paper strives to change the way we travel. The small but critical changes in the way Altitude Measurement is done on the Aircrafts could well be the difference between a safe flight and a jeopardized one. Or at least, let us hope so.