Design and Analysis of Smart Whistle for Pressure Cooker

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Abstract:
The present study comprises of mechanical pressure regulator device for pressure cookers. This system utilizes the vertical motion of dead weight of pressure regulator during whistling. This vertical lift allows an angular motion of dead weight with respect to the pressure cooker by using the principal of cam and follower. This angular movement can be utilized to count the number of whistles by proper referencing on circular scale. The system also alerts the user about the end of cooking process after the number of whistles as set by user for cooking has been attained. Some distinctive whistling sound for last whistle of process could be heard that occurs by manipulating the direction and path of steam flow from cooker to surrounding. The important feature of this system that it stops the pressure built up after the end of cooking process. This has been achieved by manipulating the path and direction of steam flow from cooker to surrounding. The major advantage is the pressure whistle line blockages could never happened with this system.

Keywords: Pressure, whistle, cam, dead weight, pin

I. INTRODUCTION

The use of automation earlier in various kitchen appliances like timer in ovens, food processors are proof of need of technologies. This will reduce the intervention needed by person while cooking. Hence such a device which will reduce the intervention while cooking with pressure cooker is need of time. One of the biggest drawbacks of today’s pressure cooker pressure regulating device which gives stimulus in a form of sound is there incompatibility with a deaf person. It is continuously needed by a deaf person to be in visual contact with pressure cooker to keep the track of number of whistles given by cooker. Mistake by a person to keep an accurate track of number of whistles given by pressure cooker leads to undercooking or overcooking of food which leads to wastage of food material. In case of overcooking it also results in wastage of energy used for cooking.

II. LITERATURE REVIEW

Novel Whistle counter makes use of beam engine mechanism to utilise the vertical motion of whistle to counts by means of mechanical counter. Design has lots of drawbacks like bad aesthetics, cost and low reliability [1]. Pressure cooker whistle counter alarm is an electronic approach to problem of whistle counting. Electronic circuit is utilised here to detect and count and display number of whistle. But it lacks operational requirement as electronics are venerable to water and high temperature when used with pressure cooker [2]. Automatic gas stove is induction based stove which turns off the power as it detects the number of whistle have been done. This system has complex electronic circuit which has sound sensors which recognises the whistling sound and gives a +1 digital count [3].

III. PROPOSED MODEL

The design consist of Cam indicator which is fixed to cooker at steam vent with the help of thread locking this part consist of circular numbering on its top and has circumferential grooved cam path on circumferential periphery where the follower pin is put. The pin and dead weight cylinder together act as dead weight of pressure release system. The Cam indicator is concentrically hollow at centre where moves up and down pin during whistling process.

Figure 1. Schematic diagram
IV. WORKING

This device works on the same principal of dead weight pressure regulator. The dead weight cylinder and pin of a device plays a role of Dead weight. The bottom opening of pin will be subjected to pressure inside the cooker. As soon as pressure force acting on the pin gets equal to weight of dead weight cylinder and the pin due to this the pin will have upward vertical motion. The pin in turn will force the dead weight cylinder in upward direction. The dead weight cylinder has follower pin fixed with it, this pin is provisioned in grooved circumferential path of the Cam indicator. As the dead weight cylinder has vertical motion during pressure release the follower pin which is fixed with dead weight cylinder hits the upper end of grooved path and is directed toward the upper most point of the path due to vertical pressure force. As soon as pressure is released in any of the hole openings the dead weight cylinder moves in vertically downward direction to the next idle sitting point of the follower pin. The path moved by the follower pin in grooved path during consecutive pressure. Follower pin traces its path for consecutive pressure release events. Follower pin which is fixed with dead weight cylinder moves a particular circumferential distance during pressure release due to wedging action. Due to this circumferential motion the dead weight cylinder has some angular displacement with respect to Cam indicator which is fixed to the main body of pressure cooker. This angular movement of dead weight cylinder is exploited to count the number of pressure release events left for end of cooking process as predefined by the user by setting the number of whistles required particular cooking.

V. DESIGN METHODOLOGY

Input Parameters:
- Steam vent Diameter :-7.1mm(Measured from the conventional whistle)
- Base Height :-7 mm(Measured from the conventional whistle)
- Diameter of the hole :-3.2mm(Measured from the Model)
- Pressure of the steam :-15 psi

Weight calculation:-
\[ \text{As,FORCE} = \frac{\text{PRESSURE}}{\text{AREA}} \]  
(1)

As standard pressure P=15 psi=0.1034 N/mm\(^2\)
So, effective area \[ A = \frac{\pi}{4} \times (3.2)^2 \]
Hence, Force = 0.1034 x 7.5477 = 0.78043 N

Table. I. Bill of materials

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>PART NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>STEAM VENT</td>
</tr>
<tr>
<td>2</td>
<td>CAM INDICATOR</td>
</tr>
<tr>
<td>3</td>
<td>HEX NUT</td>
</tr>
<tr>
<td>4</td>
<td>DEAD WEIGHT CYLINDER</td>
</tr>
<tr>
<td>5</td>
<td>PIN</td>
</tr>
<tr>
<td>6</td>
<td>RING</td>
</tr>
</tbody>
</table>

Dead Weight cylinder and pin:

Figure.2. Dead weight cylinder

Figure.3. Pin
Since, in this design outer part and the pin is lifted up hence, sum of weight of the outer part and pin should be less than 79.55g.

In order to preserve its aesthetic look we take length of the outer part 27 mm, and inner diameter of the outer part as 24mm.

Pins dimensions should be such that following conditions are met:
- It should stand on the Steam vent of the lid.
- It should fit inside the Cam indicator.

We will be giving threading to the fixed went.

![Figure 4: Steam Vent](image)

**Figure 4. Steam Vent**

Specifications of Threading are:
- Minor diameter=5.7mm
- Angle=60\(^\circ\)
- Threading length=5mm

As minor diameter is 5.7 mm, selecting diameter of pin as 5.6mm so that it stands on steam vent. Material of the pin is stainless steel SS-304/C-40 which has tensile strength 410 N/mm\(^2\).

Taking factor of safety 5 therefore design stress value \(=\frac{410}{5} = 82\) N/mm\(^2\).

The outer part undergoes shear stress therefore, \(\frac{\rho}{\pi dt} = 82\) \(\Rightarrow\) \(\pi \times d_3^2 \times 82\) \(\Rightarrow\) \(\pi \times d_3^2 = 82\)

Therefore \(d_3 = 5.6\) mm therefore we take \(t\) as 1 mm

In order to maintain the aesthetic value of the whistle we take the height of the pin=31 mm.

Now weight of the pin=\(\pi \times d_2^2 \times L_4 \times \rho\)

\(=\pi \times 0.0056^2 \times 0.031 \times 7860\)

\(=6.194\)g

So, remaining weight should be less than 73.356g.

![Figure 5: Ring](image)

**Figure 5. Ring**

We have included weight of the ring while calculating weight of outer part. We need to design pointer,

The pointer is undergoing bending stress, so \(\frac{M \times d_3^2}{\pi \times d_3^3} = 82\)

\(\Rightarrow\) \(\frac{0.78043 \times 2.4 \times 32}{\pi \times d_3^3} = 82\)

Therefore \(d_3 = 0.615mm\)

So we will take \(d_3 = 2mm\).

The Dead weight cylinder will undergo crushing failure due to ring when it is being lifted. Therefore the area undergoing crushing failure is \(\frac{\pi}{4} \times (D_3^2 - d_3^2)\)

\(\Rightarrow\) \(\frac{0.78043}{\pi \times (30.8^2 - 2^2)} < 82\)

Therefore, \(\frac{0.78043}{\pi \times (30.8^2 - 2^2)} < 82\)

Therefore, \(D_3 < 30.73\)

We take \(D_3 = 26.8mm\)
Cam indicator:

Since the outer part is inserted on the Cam indicator the inner diameter of the outer part is equal to the outer diameter of the Cam indicator therefore, \( D_3 = 23 \text{mm} \) (1 mm clearance) This Cam indicator will be fitted to the steam vent. Hence the diameter in which pin will be inserted will be equal to minor diameter of thread on steam vent i.e. 5.7mm & also \( d_1 = 7.1 \text{mm} \). The following figure is the grooved path which is wrapped on the outside diameter followed by the follower pin.

Cam design:-

Let \( h_4 = 8 \text{mm} \) & \( h_2 = 11 \text{mm} \)

When pointer reaches at height \( h_2 \), steam escapes from first three orifices and the next 3 orifices from other planes in order to produce distinct sound.

After the zeroth (last) whistle, the follower pin get interrupted at dash position as shown in above figure due to this there no blockage of steam vent by pin and steam vent is indirectly open to atmosphere through holes in Cam indicator. Due to this there will be no further pressure built up in cooker volume slowing down the process of cooking hence preventing overcooking.

Therefore \( h_1 = h_4 = 8 \text{mm} \)

We are going to calculate the wedge on which pointer is going to fall by trial and error method.

\[ c - b > 2 \text{mm} \] so that pointer can occupy space in it.

Hence \( c - b = 2.5 \text{mm} \)

Let \( b = 11 \text{mm} \)

If we take \( b = 11 \), then the total length becomes \( 11\times6+2.5 = 68.5 \text{mm} \) which means for the last whistle there would be only 1.5mm left for the pointer to travel and the diameter of pointer is 2mm.

So this is not possible.

Let’s take \( b = 9 \text{mm} \)

If we take \( b = 9 \text{mm} \) the wedge would be before the curve of next part. Dead weight cylinder want’s move from \( n^{th} \) to \( (n-1)^{th} \) whistle. It would be in \( n^{th} \) part itself. Hence it would be difficult to determine the no. of whistles left. So even this value is discarded.

From the above two trials it can be seen that \( b \) should be more than 9mm and less than 11mm.

Let’s take \( b = 10 \text{mm} \).

All components with final dimensions:

**Figure.8. Designed Cam Indicator**
VI. ANALYSIS

Figure 9. Designed Dead Weight Cylinder

Figure 10. Designed Pin

Figure 11. Designed Ring

Figure 12. Deformation of Dead Weight Cylinder

Figure 13. Stress of Dead Weight Cylinder

Figure 14. Deformation of Pin

Figure 15. Stress of Pin
From the above figures, it can be observed that deformation is minute and also stress is minimum. This is because the force applied to the whistle is very less.

**VII. CONCLUSION**

In this work we have tried to simplify the use of pressure cooker by solving various problems faced by user with conventional design. Conventional pressure cooker has numerous disadvantages the most prominent one is need of user intervention in keeping the track of number of whistle given by pressure cooker which is quantitative stimuli of process of pressure cooking. Our design have approached to solve this problem in very structured way. We have considered various parameters in design like aesthetics, reliability, ease of mass manufacturing, safety, and convenience so that it can be successfully put into domestic use. Computer aided analysis and simulation have been carried out to test the design’s operational as well as structural capability. We have found design passes the required operational and structural requirements. Further we will be working more on optimisation as well manufacturing the design’s prototype.

**VIII. SCOPE**

Any work in field of reducing the efforts and user intervention has a very bright future. There exists a further scope in improvement in technical manner it may be reliability, ease and cost of manufacturing, or any additional feature which increases the ease in use of pressure cooker.

**IX. REFERENCES**


