ISSN 2395-1621

Design and Development of an Articulated Hinge for Double Ovens

[#1]A.B. Dixit, [#2]T. S. Jadhav, [#3]C. S. Pathak

[1]abdixit13.scoe@gmail.com
[2]tushar_s_jadhav@whirlpool.com
[3]cspathak.scoe@gmail.com

[#13] Sinhgad College of Engineering. Pune, India, Mechanical Department

ABSTRACT

A hinge is a type of bearing that connects two solid objects. By an ideal hinge those two objects are connected to rotate relative to each other about a fixed axis of rotation. Since it is a very important component of door from aesthetics and structural point of view, it's designing and modeling is a very crucial task. Motion of hinge pivot point during combination of oven and cooktop is very essential. As an extra body is below to the upper door hinge, there should be an enough distance between upper body hinge and lower body door to avoid collision. So the articulated hinges are used to provide some extra motion to the pivot so that it can operate easily without collision with lower oven door body. The basic working mechanism of hinge and detailed mathematics of affecting parameters is studied in this paper. Self opening and self closing force of the door should be higher for children and safer and non-troubling for adults. This force should rapidly decrease to zero for ease of operation. Calculations of spring constant and tolerance are made for input variable by varying each parameter. Four new concepts of articulated hinges are proposed and compared them with existing design.

***Keywords*— Oven Door, Hinge, Articulated Hinge, spring constant, tolerance**

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I.INTRODUCTION

Hinges are part of oven which is fitted between door and oven body. The main function of the hinge is to support the door while opening process for drop down door. It is having only limited angle of rotation, ideally the rotation is about a fixed axis of rotation. The oven ranges are combination of cook top, oven and microwave oven; double ovens are combination of two ovens. The door used for double ovens ranges are heavy (10-17kg). So for the assistance of costumers during door opening and closing process the hinge of the ovens are designed in such way that it can be operated with minimum effort by the customers.

Main functions of hinges are: -

I. Provide support for the door.
II. Provide assistance for the customer while opening and closing of the door.
III. Provide smooth opening and closing operation.
IV. Balance the door weight at any opening position.

While selection of a hinge, primary consideration is given to the type of door and frame for proper hinge configuration. Hinge size is determined by door size, thickness, weight, frequency of use and clearance required.

Fig. 1 Range [1]

Fig. 2 Double Oven [1]

Fig. 3 Existing Hinges [1]

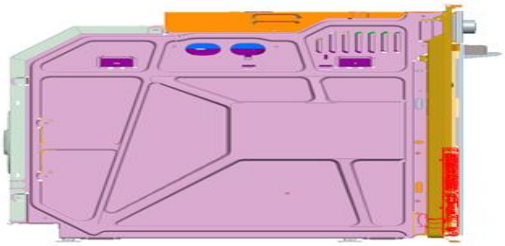

Fig. 4 Position of Hinge in Door [1]

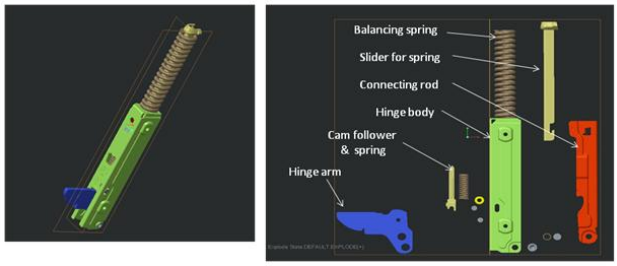

Fig. 5 CAD Model for Existing Hinges [1]

II.DIMENSIONAL ANALYSIS OF CURRENT HINGES

In this analysis the dimensions of door and the hinge have considered. The position of lower outer corner and upper inner corner of the door are crucial. It shouldn't collide with the other body parts while opening and closing operation. The gap between upper and lower door is also area of concern, it directly affect the aesthetics of the oven or range. The existed design is divided into unbalanced region and balanced region. Balanced region is a slider crank mechanism in which spring is attached to slider which provides resisting force. Where as an unbalanced region is a cam follower mechanism. Here cam travelling curve helps for smooth operation during door opening and closing. The mathematical analysis of balanced region is mainly focused on door angle, lever length and eccentricity. Here two ranges are analyzed; [2]

A. First Range

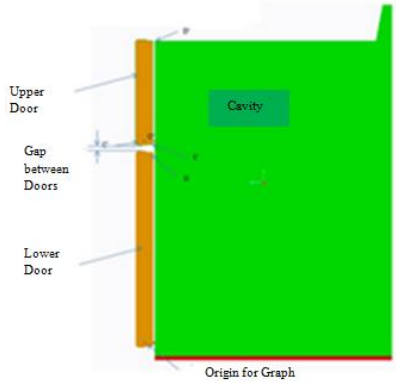

Fig. 6 Schematic view of position of upper and lower door of Range[2]

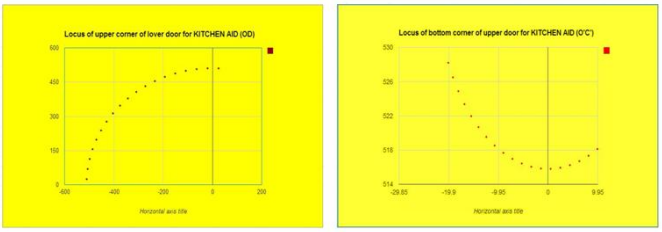

Fig. 7 Motion at Corners [2]

- Here the left graph shows the upper corner of lower door [2]
- And the right graph shows the lower corner of the upper door [2]
- For minimum gap the positions of the points should not intersect with each other than only the design will be safe

B. Double Oven

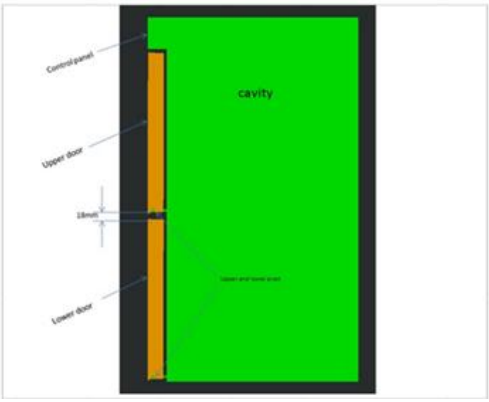

Fig. 8 Schematic view of position of upper and lower door of Double oven [2]

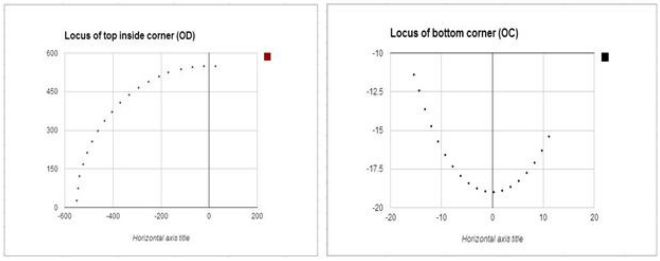

Fig. 9 Motion at Corners [2]

Position of corners of the door

- Here also the left graph shows the locus of top inside corner and the right graph shows the locus of bottom corner. [2]

- So to minimize the gap without collision of the doors there must be some lifting mechanism for the door or we can shift the pivot to the maximum possible corner of the door which is already there. [2]

III.FORCE ANALYSIS OF CURRENT HINGES

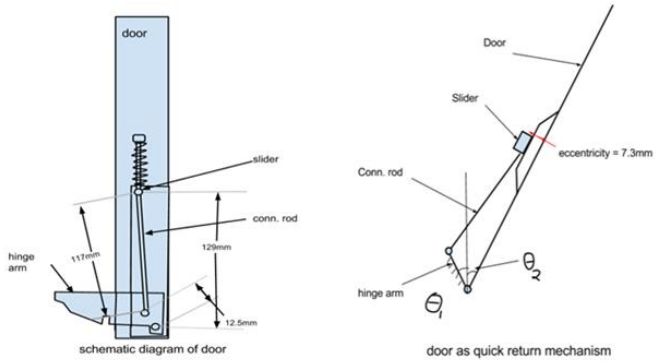

Fig. 10 Line Diagram [3]

The Design can be divided into two parts

1. From the 0^o to $\Theta_F{}^o$ is the "Unbalanced Region" which is taken care of by the secondary spring and the cam.
2. From 0^o to the end of opening, the "Balancing Region" is taken care of by the primary balancing spring.

Balancing Region:

This is basically a Slider Crank Mechanism in which a spring is attached to the slider which provides the resisting force. When the door (attached to crank) is opened the slider moves and compresses (or expands for tensile spring) the spring and it balances torque from door weight. This is almost universally the mechanism used for balancing (It is used in all existing Hinges) [3]

Unbalanced Region:

This region is nothing but a Cam Follower Mechanism.

1. From 0° to Θ_i° the cam compresses the spring. The resisting force of the spring tries to close the door. Hence, it auto shuts.
2. From Θ_i° to Θ_f° the Cam facilitates to Auto Open the door as the inclined plane is such that the expansion of the spring helps it to push the Cam further
3. After Θ_f° the spring becomes disengaged and returns to its initial position. After that only Balancing spring plays any role.

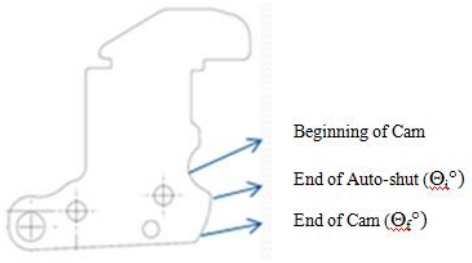

Fig. 11 Hinge Sketch [3]

Let us consider,

Hinge arm= link-1, connecting rod= link-2, slider= link-3, Hinge body along with door = link-4

e= eccentricity

w= distance from pivot to CG of door laterally

Θ = door opening angle

M = mass of the door

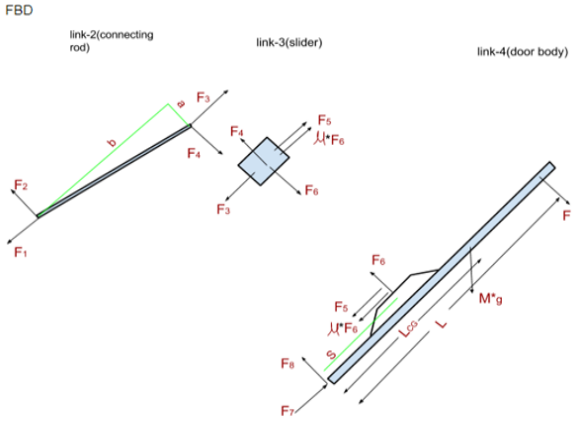

Fig. 12 FBD of Mechanism [3]

F = force applied on the door

L_{cg} = distance from pivot to CG along the door length

L_h = distance from pivot to handle

- The existing hinges are serving the ovens at well level.
- These existing normal hinges are purchased from other suppliers, which is why the cost is more.
- During opening process the lower corner of upper door goes very low.[3]

IV.ARTICULATED HINGES

Articulated hinges are same as normal hinges with some additional features. The main function of articulated hinge is also to provide support and opening/closing function for the door. The difference between normal and articulated hinge is that it provides some additional movement to the pivot of door for smooth operation, in ranges and double ovens there are two doors upper and lower when the upper door opens the lower outer corner of the upper door goes down. So to avoid collision between

door and other oven part they provide space for the movement of the door. This space is in form of gap between upper and lower door. [4]

The main object of the articulated hinge is to minimize this gap between upper and lower door to improve the aesthetics of the door. Minimizing of the gap without collision can be done using articulated hinge because with the help of this hinge we can move the pivot so the door lower corner will not hit the lower body. The articulated hinge provides a lifting mechanism due to which while opening the door get lifted. [4]

A. Study of Articulated Hinge

Current problems in case of regular hinge:

The Existing hinges are performing well but still there are some problems observed; like in case of double oven or range the gap between two doors is more, which is not looking aesthetically good. During opening process the lower corner of upper door goes very low when it is completely open, in that case lower oven door get damage during opening. These existing normal hinges are purchased from other suppliers, which is why the cost is more.

To understand the above current problem, requirements identification and design of an articulated is very important. Currently available articulated hinges in market are studied.

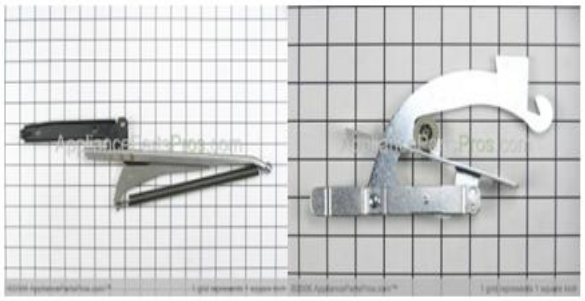

Fig. 13 Door Hinges [4]

Fig. 14 Oven Hinge [4]

Fig. 15 Door Hinge [4]

Fig. 16 Door Hinges [4]

Fig. 17 Range with Articulated Hinges [4]

The gap between doors in the above range is 6mm, the reason behind this less gap is, articulated hinge which is used in upper door. At the time of operation when upper door of the range gets opened, the hinge is designed in such a way that with opening it moves in upward direction and prevents from collision between upper and lower door.

In this range the gap between doors is 6mm which is very less compared to Range shown in Fig. 6

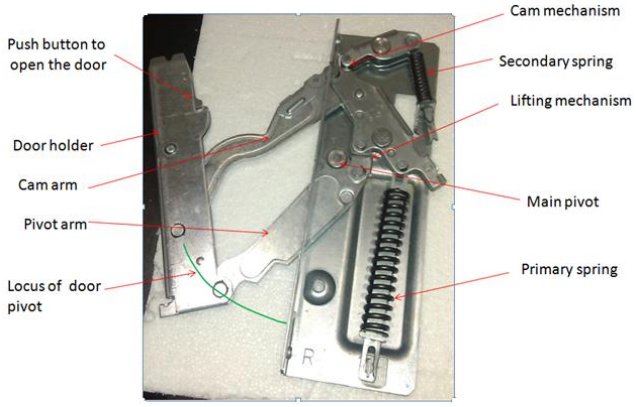

Fig. 18 Hinge used in above Range [4]

B. Required performance specifications of Hinge

- During opening, 20-25^{o} should stop
- After 25^{o} the weight of door should be balanced by spring
- 15-20^{o} auto shut
- Initial opening force should be equal to 40N
- Smooth operation
- Opening and closing force at handle should constant
- Minimize the gap between upper and lower door
- Cost effective

- Good from aesthetic point of view
- Compact and simple removal and replacement
- Reliable and long woke life

C. New Concepts

Concept 1:

Cam profile in hinge arm and slot at hinge body.

- A cam profile is provided at the hinge arm.
- The follower will be fixed with hinge body when door will open due to that the profile the door will lift and avoid the collision with lower door
- Almost same as existing hinge, the only difference is the cam profile in the hinge arm for lifting purpose.
- Small spring is required to provide auto shut and initial opening force.
- The crank length is more compared to existing so spring displacement is more so less stiff spring is required
- Extra friction band due to motion between cam and follower.
- Extra space required for completing cam profile.
- Wear and jerk problem occur due to slot at the pivot.
- Stress concentration will also occur due to the shape of hinge arm and hinge body

Concept 2

- The idea for this design has taken from GE hinge as shown in fig. 19
- In this design the hinge is fixed with the cavity.
- The balancing spring is connected with the body and the hinge arm
- The hinge arm will be provided with a cam mechanism with help of which door will lift along slotted pivot.
- Design is simple and fewer components required.
- The main problem for this design is that it will require space for spring arrangement which can create difficulties for other parts.
- Extra space required bellows the upper door to fix the balancing spring.
- Changing and installation of hinge is complicated as extra space is required.

Concept 3

- Slider mechanism- For this design the amount of lift require for upper door have to be decided.
- For this the thickness of the door and the pivot position in the door is required.
- Minimum gap provided between upper and lower door. And position of upper body.
- Initially there is rapid lift after opening then slows down.
- As all joints are pin and a slider so very less wear occur.
- Less number of components and simple in design.
- Simple installation and replacement

Concept4

- Hinge with gear and rack.
- The door rotates 90^{o} to open.
- A rack is fitted with the pivot slot and the hinge arm pin is provided with gear teeth
- The lift is uniform throughout the opening process.
- Lift is also very limited will depend upon the pinion diameter.
- High stress at teeth of rack and gear and high amount of wear will occur due to friction.
- While providing rack at hinge body it will decrease its strength.
- Not suitable for hinge requirement.

IV.CONCLUSION

After studying the existing hinge design, the problems regarding aesthetics and operations are observed. Those problems can be solved by using articulated hinge, which works in aesthetic requirements and ease in operations. New concepts suggested in hinge design shows development in current articulated hinges to fulfil specification requirements in hinge.

ACKNOWLEDGEMENT

It is precious moment to acknowledge the various individuals who helped during completion of this paper. Firstly, respectful thanks to **GTech Whirlpool India Ltd** for guiding during preparation of paper and institute guide **Prof. (Dr.) C. S. Pathak**, for his valuable guidance, support and continuous encouragement during completion of paper.

REFERANCES

[1] DESIGN OF MACHINERY (An Introduction to the Synthesis and Analysis of Mechanisms) Second Edition By Robert L. Norton.

[2] Hinge Design and Development Report of Research and Development Department of Whirlpool India Pvt Ltd., 2013-14

[3] Project Report on Mathematical Model for Oven Door Hinge by Koondanibha Mitra, GTech Whirlpool India Pvt. Ltd,, 2014

[4] Articulated Hinge Development by Kamlesh Sahu., 2015

