ISSN 2395-1621

Design & Development of Guillotine Damper

[#1]Nikhil Satish Dhumal, [#2]Sanjeev Gupta, [#3]Mohit Sobalkar, [#4] Sandeep Dattatray Suryawanshi, [#5]Prof. S. R. Durgavade

[1]nikhil.dhumal1711@gmail.com
[2]sanjeevjgupta@gmail.com

Department of Mechanical Engineering, I
SB&M School of Technology , Savitribai Phule Pune University

ABSTRACT

Guillotine Dampers are mostly recommended for heavy duty, 100% leak proof and gas tight isolation of duct. Their design permits to be installed into a short length of ductwork. Pressure drop is low across the wide-open damper. Guillotine blades are also better able to withstand furnace puffs and mild over pressure conditions than some other damper designs. Guillotine performance needs can vary from a simple chain fall blanking plate design to fully automated 100% gas tight perfect guillotine. Guillotine dampers are very well suited for applications needing total isolation where low leakage is an essential requirement. The integral mechanical components of a guillotine damper are flap, peripheral seal system, external support members and a drive to move the flap steadily, continuously & uniformly.

Keywords— Guillotine Damper, 100% leak proof, exhaust gas, flow control, flue gas.

ARTICLE INFO

Article History

Received: 29th February 2016

Received in revised form :

1st March 2016

Accepted: 4th March 2016

Published online :

6th March 2016

I. Introduction

Dampers regulate the volume flow of flue gases or feed fluid in or out of the system at different operating conditions of the plant. The alteration of flow of fluid with the help of dampers is inexpensive in terms of money but consumes a considerable amount of energy. Inlet guide vanes are, however, reasonable. The dampers are traditionally not air tight or leak proof when closed. The corresponding rate of leak depends on the number of blades, the area gap and the pressure applied. The leakage can be prevented by overlapping the guide vanes or providing a metal to metal seal. Inlet guide vanes with nominal diameter of less than 900mm have no central support and therefore are open in the middle.

Guillotine Dampers have been extensively used for heavy duty gas tight shut-off of duct. Their design permits to be installed into a short length of ductwork. Pressure drop is low across the wide-open damper. Guillotine blades are also better able to withstand furnace puffs and mild over pressure conditions than some other damper designs. Guillotine performance needs can vary from a simple chain fall blanking plate design to fully automated 100% gas tight perfect guillotine. Guillotine dampers are very well recommended for applications subjected to isolation, low leakage and desired pressure drop. The vital elements of a guillotine damper are a blade, peripheral seal system, external support members and a drive to move the blade steadily and continuously.

All dampers are constructed according to the predefined operating conditions known to us.

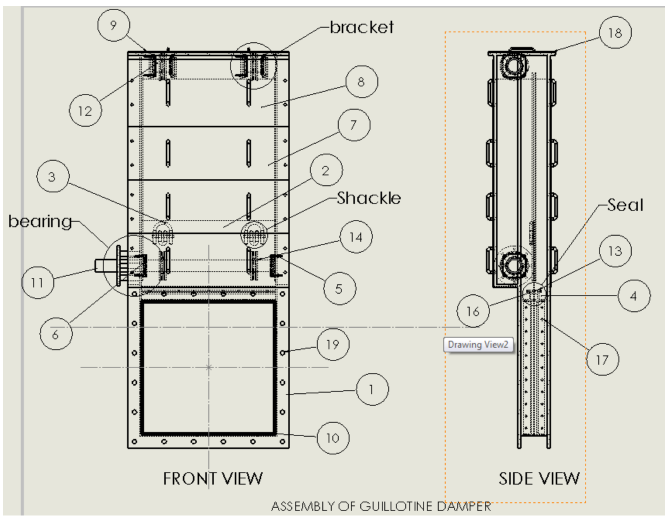

Fig.1 Orthographic view of Guillotine Damper assembly

In general, the shaft of the vanes runs in sleeve bearings. These bearings offer a wide range of application; their advantages are low coefficient of friction, high chemical stability and an extensive range of operable temperature.

Manually operated dampers shall have quadrant control with visual blade position indicator. Dampers suitable for systems requiring air control and very closed low blade leakage characteristics, suitable for high pressure and high velocity applications. The outer flanges are normally supplied un-drilled unless otherwise requested and where the louvers or dampers are suited externally, weather covers can be fitted over the spindle ands and motors for protection against prevailing weather conditions.

Applications wherein the dampers are needed to be placed in round or oval shaped duct, they must be supplied with the suitable option; rectangular ones should be constructed 2 inch larger than the duct dimensions and provided with a sleeve. The sleeve is provided at both ends to the appropriate round, oval or rectangular duct size.

Damper bodies are machined from a single sheet of galvanized steel and reinforced as required for strength. Rectangular framed dampers are made for installation in a section of rectangular duct while the round frames are designed to connect the two sections of round duct. Rectangular Dampers single (parallel and opposed) and double louver design allows safe isolation and desired flow control for applications such as Gas Turbine, Boilers, etc.

II. Literature Review

[1] **Lothar Bachmann** provided an introductory detail in paper entitled **Guillotine Damper,** US 4493311A dated 15 Jan 1985.

"A guillotine damper to be incorporated in a duct system, said damper including a frame establishing a passageway through the damper, a blade, an airtight bonnet dimensioned to accommodate the blade and connected to said frame, said frame having a blade accommodating mouth opening into the bonnet, means operable to reciprocate said blade between an open damper position in which the blade is housed in the bonnet and a closed damper position in which the blade blocks the passageway through the frame, a guide attached to the frame and extending about and into the passageway there through from one end of the mouth to the other end thereof, said blade provided with a marginal channel coextensive with the guide and disposed and dimensioned to slide along and over corresponding portions of said guide, said frame provided with a resiliently flexible metal seal coextensive with and overlying said guide in a manner such as to be entrant of said channel and be compressed thereby into sealing engagement therewith as said damper is closed."

[2] **Roman Chadshay** stated in his paper **Secondary air control damper arrangement,** US 4425855A dated 17 Jan 1984.

"The outline of a tangentially-fired furnace combustion chamber is arranged to show a representative wind box in one corner of the furnace. The secondary air is disclosed as supplied through one set of vertically tillable nozzles mounted in the wind box. The secondary air supply conduit is mounted to feed the tillable nozzles. The secondary air supply conduit section adjacent to the nozzles has straightening vanes forming channels in which independently controlled louvers regulate the total cross-sectional area of the channels to maintain the desired velocity of the secondary air through the nozzles."

[2] **Lothar Bachmann** in his paper entitled **Guillotine dampers with blade sealing means accommodative of thermal expansion forces,** US 4905662A dated 6 Mar 1990

"BACKGROUND OF THE INVENTION

The operation of gas turbines is attended by exhausts gas streams of large volumes and suddenly attained high temperatures which streams are well adapted for use in cogeneration.

A gas turbine exhaust system has, accordingly, a section including a heat recovering steam boiler and a bypass section. During cogeneration, the bypass section must be closed by the use of one or more dampers and when the steam boiler is to be placed out of service for any reason, the section leading thereto must also be closed by the use of one or more dampers. Dampers for use in such exhaust systems may be of either a louver type or a guillotine type but are herein discussed as of the latter type.

Because of the sudden build-up of high temperatures during the operation of gas turbines, it is essential that each such damper be so constructed that it will accommodate thermal expansion forces that would otherwise destroy the effectiveness of the means sealing the clearances between the damper blade and the framework by which it is supported.

THE PRESENT INVENTION

The general objective of the present invention is to provide guillotine dampers in which the sealing means are not distorted by thermal expansion forces.

Guillotine dampers have their blades vertically reciprocating between closed positions blocking the flow paths through the dampers and open positions in which they are housed within bonnets. In each such damper, the blade and the margins of the framework bordering the flow path are sealed in one way or another to render the damper fully effective.

In accordance with the present invention, the framework includes an outer frame, an inner frame spaced therefrom by insulation and a guide connected through the inner frame and the insulation to the outer frame with the connection of a type enabling thermal expansion forces exerted on the guide to be accommodated. The blade is bordered by a U-shaped channel connected thereto by means enabling distortion by thermal expansion forces exerted by the blade to be prevented. The sides and bottom sections of the channel are so dimensioned that the guide is a slid able fit therein as the blade is raised and lowered but with a space between the guide and the closed end of the channel useable as a conduit for sealing air. The top and bottom sections of the channel fit within the bonnet entrance.

III. Design modifications

To overcome the setbacks of the older design of the Guillotine Damper and to ensure 100% leak proof operation in industries, there have been a few important modifications made in the basic design of the Guillotine Damper. The prominent modifications in design are as discussed:-

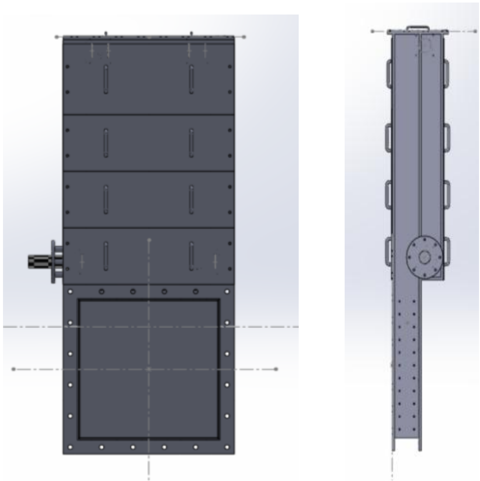

Fig.2. Front view & Side view of Guillotine Damper

BODY

The bracket used in the new modified design is an assembly of two parts which houses the chain pulley in between them. This arrangement helps to keep the chain pulley in place rigidly and prevents any misalignment of the pulley mounted.

FLAP

The damper flap is reinforced to minimize deflection and stress. Guillotine flaps are protected from atmospheric conditions and prevent gas from leaking into the atmosphere. It will provide maximal resistance to heat stresses, corrosion, metal fatigue and distortion.

When an application of heat retention is necessary, flaps can be insulated. For high pressure or high temperature requirements, inspection port and view port for high dust loading applications are necessary.

The flap used in the former design had its end in the form of a plain bar. This orientation of the flap resisted the use of the modified seal hence affecting the sealing capacity. Moreover, the knife edge used in the new design provides the complete i.e., 100%, shut off of the duct. This was not possible in the older design due to the plain bar orientation. Hence, the new flap design is suitable for 100% leak proof working of the damper keeping in mind all the thermal aspects and design considerations.

DRIVE

The drive used in the said guillotine damper was chain drive using counter weight as in case of an elevator. However, this drive proved to be useful in one orientation only i.e., vertical with actuator and flap housing being on upside. This made it easy to operate but the opening and closing operation of the flap was not as quick as required. Moreover, the closing or shut – off was not 100% leaving gaps for the flue gases or fluid to escape resulting in up to 99% sealing.

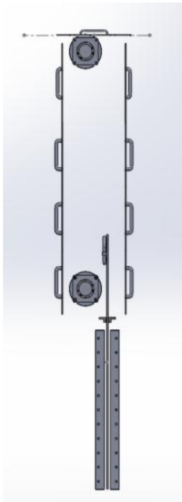

Fig.3. Chain & Pulley Mechanism

The alternate driving mechanism used in the Guillotine Damper overcomes the stated setbacks of the former one. The chain drive used is an assembly of the following integral parts:-

1) Link Chain
2) Shackle
3) Driving & Driven Shaft
4) Pulley
5) Ball bearings
6) Actuator
7) Motor

This drive mechanism has been observed to be uniformly efficient in all possible orientations.

Motor and actuator is coupled with the lower shaft making it the driver and the upper one is the driven shaft.

SEAL

The damper blades are designed with metal-metal or elastic seal systems. Flatness and strict manufacturing ensure optimal sealing in the installation. Guillotine can be supplied with a simple tadpole seal for 99% over sealing efficiency on the cross section. For applications needing 100% sealing efficiency, a modified type of metal to metal seal is needed.

The sealing material used in the traditional guillotine damper was same as the body and flap material. This led to relatively quick wear and tear of the seal. It was also not an efficient sealant due to its low coefficient of friction. It also resulted in increased temperature of that part while in operation increasing local thermal stress and eventually distortion of the material thus affecting the sealing capacity of the damper.

The improved sealing used for the Guillotine damper is widely known as butterfly seal.

Another aspect of the invention is that, in most installations, it is necessary both to reinforce and to insulate the upstream face of the blade. To enable the blade to be adequately reinforced and insulated, the channel is formed been provided on both sides of the flap to prevent any unwanted leakage. It has also been kept in constant contact with the flap. The sealing is of metal to metal type as opposed to metal to soft seal in the previous one. Since the metal to soft option used to cause quick wear leading to continuous leakage and increase in maintenance cost, need of regular check-up and replacement. Also the life of that seal was up to 1-2 years at its best. While the material used for metal to metal seal is SS316 which has exceptional corrosion resistance, wear resistance and is chemically inactive towards the material used for body and flap. SS316 is also a flexible material which prevents the offset of the flap and helps it to stay in required place.

IV. MATERIAL SELECTION

Material selection is a prominent step in designing of an object or product design. The primary task of material selection is to fulfil the desired performance goals while keeping the cost incurred minimum. Selection of the most appropriate material depends on the physical, chemical and thermal parameters the product will be subjected to.

In case of a damper, it is exposed to high temperature, toxic flue gases or fluids. In order to select the material for this application, it should possess good heat conductivity, thermal resistance, resistance to thermal stress, low coefficient of thermal expansion, resistance to corrosion due to oxidation and the fluid which will pass through it. It should also be chemically inert to the fluid that will be used.

Systematic selection of material for a damper is more complex as it is also subjected to high load and stresses. For these reasons the need to replace the material used so far i.e. IS 2062 was anticipated.

TABLE I
CHEMICAL COMPOSITION OF IS 2062

Grade	**C (%)**	**Mn (%)**	**S (%)**	**P (%)**	**Si (%)**	**CE (%)**
A	023	1.5	0.05	0.05	-	0.42
B	0.22	1.5	0.045	0.045	0.04	0.41
C	0.2	1.5	0.04	0.04	0.4	0.39

IS 2062 is well suited for structural applications where it is widely accepted as material for channels, beams and rods. However, the material which was found to be most suitable for damper application was SA387 Gr 11.

TABLE II
CHEMICAL COMPOSITION OF SA 387 GR 11

C (%)	**Mn (%)**	**S (%)**	**P (%)**	**Si (%)**	**Cr (%)**	**Mo (%)**	**CE (%)**
0.05-0.17	0.40-0.65	0.025	0.025	0.50-0.80	1.00-1.50	0.45-0.65	-

SA 387 Gr 11 is classified as pressure vessel application steel. This clearly indicates that it is expected to sustain and work well at elevated temperatures of up to 700ºC and still retain its physical, mechanical and chemical properties.

Moreover, it has been tested to withstand various physical and thermal stresses the damper will be subjected to while in operation in a boiler, exhaust system, fluid flow system, etc.

The material previously used for seal for leak proofing the damper was same as body and flap i.e. IS 2062, but this was not suitable for its application as it could react with the fluid flowing through it and it also had the tendency to deform at temperatures above 300ºC. Hence, an alternate material which is totally chemically inactive was chosen in the form of SS 316.
SS 316 is very popular in chemical and process industries for its corrosion resistance and high temperature applications. This led the material to find its application in dampers too in the form of metal to metal seal to make them 100% leak-proof.

Following table summarizes the materials selected for various components of Guillotine Damper:-

TABLE III
BILL OF MATERIAL

Item No.	**Part Name**	**Material**	**Quantity**	**Weight (kgs)**
01	Body	SA387	1	70.83
02	Flap	SA387	1	15.8
03	Shackle	SA387	2	0.038387
04	Sealing Gland	SS316	2	
05	Bearing Support	Cast Iron	6	0.467
06	Ball Bearing	61805	6	
07	Small Cover	SA387	6	4.73
08	Big Cover	SA387	2	5.91
09	Top Cover	SA387	1	5.48
10	Seal Seat	SA387	8	0.503
11	Driver Shaft	EN8	1	8.36
12	Driven Shaft	EN8	2	0.999
13	Seal Support	SA387	2	0.758
14	Chain Wheel	Cast Iron	4	1.19
15	Chain	MS (GI Coating)	2	0.0106/Link
16	Nut & Bolt (M05)	A193	18	0.00733
17	Nut & Bolt (M10)	A193	54	0.0632
18	Nut & Bolt (M24)	A193	40	0.577
19	Key	AISI 4140	4	0.221

V. CONCLUSION

Earlier the flue gases coming out of the exhaust of a boiler were allowed to be expelled out to atmosphere. However, the heat content wasted in it and the adverse effects of the exhaust on ecosystem led the engineers to reuse it this was achieved with the help of a simple diverter valve placed in the exhaust system.

Nowadays, dampers are being used for exhaust gas recirculation. The traditional Guillotine Damper used so far was incompetent to handle hot flue gases and failed to provide total resistance to leakage. This caused wastage of heat energy in the form of residual heat content of the flue gases. It also disturbed the maintenance operations and leakage of flue gases posed danger to human health. To overcome this, the new design provides total resistance to leakage, provides us to reuse the heat content of the exhaust and provides no leakage condition. This is of utmost importance since it prevents the escape of flue gases, chemical or any fluid passing through it. This can be verified with the help of Liquid Penetrant Test.

ACKNOWLEDGEMENT

It is my privilege to express my deep gratitude to everyone who has rendered valuable help in presenting this dissertation work.

First I would like to extend my gratitude to my guide **Prof. S. R. Durgavade** for whom I have greatest amount of respect and admiration. He has not only afforded me the opportunity to work on this topic but also provided valuable guidance and support throughout my time as a student in Mechanical Engineering Department, ISB&M SCHOOL OF TECHNOLOGY, Pune. His enthusiasm, support, motivation and interest were always a constant source of motivation for my encouragement. I am greatly thanking him for sparing his time, efforts, help and patience in the betterment of my dissertation work.

I am sincerely thankful to **Dr. P. K. Shrivastav**, Principal and **Prof. B. D. Mahadik**, Head of Mechanical Engineering Department, for their kind guidance, cooperation and support during each stage this project work.

I would like to thank to all my friends, especially who have helped me extensively right from the beginning of the project.

And last but not least the backbone of my success & confidence lies solely on the blessing of my parents. I owe my loving thanks to them. Counting out their constant help, cooperation and encouragement, it would have been a very difficult task for us to finish this work.

REFRENCES

[1] https://www.google.com/patents/US4493311

[2] https://www.google.com/patents/US4425855

[3] https://www.google.com/patents/US4905662