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Improvement in Drive Mechanism of Guillotine Damper

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Abstract - *To control the flow through duct, dampers are the most logical choice which is primarily used for isolation purposes where low levels of leakage and pressure drop are required and to permit inspection, maintenance. A damper is a valve that regulates the flow of air inside a duct, chimney and other air-handling equipment. Its operation can be manual or automatic. As dampers are fitted in to the duct and appeared to be part of sheet-metal and ducting, their selection, construction and installation are often left to the suppliers who were bidding on gas ducting, area of design could be neglected here. Failures of dampers can have a serious effect on plant safety, which cause losses of industries and ultimately influence over economic growth of the nation. In this paper, failure of chain conveyers of guillotine damper is considered. The failure of chain may be by uncertain breaking, by sudden closure of damper and elongation of the chain. Elongation leads to slippage of chain over grooves of pulley. These two defects in chain drive are to be removed by studying and modifying the chain design. Chain transmission with two sprockets is used. The effect of the various factors such as friction, lubrication, no of teeths, shock factors on chain system are taken into account, as well as the gravity and the torque on shaft, while calculating the total pull on chain numerically. Improper design and inappropriate selection of chain was root cause for break-down of the chain. By DIN8187 performance curve, suitable roller chain (M2416A) has been selected to use in various high-load and power transmission applications. Replacement of the previous link chain by roller chain will have higher breaking load capacity than previous and made the chain and sprocket arrangement to overcome the issue of slippage. We found that for selected roller chain, maximum stress is 166.71 N/mm^2. Further FEA method may be adopted for analysis and validation to predict new roller chain would be suitable to overcome the chain issue.*

Key Words: **Damper, Guillotine damper, Chain drive, Chain failure, Roller chain.**

1. INTRODUCTION

Guillotine dampers are available with chain drive and electric motor actuators. Self-cleaning stainless steel blade seals are incorporated around the full inside perimeter of the damper frame. The blade seal is furnished along the face and edges of the damper blade to minimize leakage into or from the atmosphere. The schematic diagram of guillotine damper is as shown in Fig. 1.

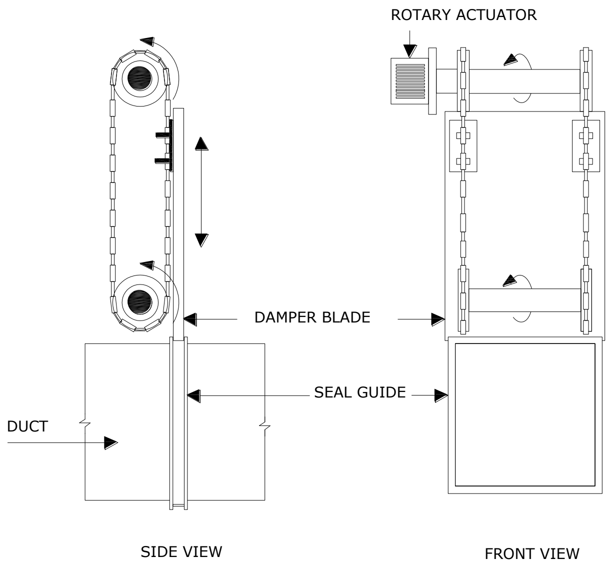

Fig -1: Schematic diagram of Guillotine Damper

2. LITERATURE REVIEW

XU Lixin et. al. 2, 2010, [1] had made the study on dynamic modeling of a roller chain drive system. Roller chain drives are widely used in various high-speed, high-load and power transmission applications, but their complex dynamic behavior is not well researched. Most studies were only focused on the analysis of the vibration of chain tight span, and in these models, many factors are neglected. A mathematical model is developed to calculate the dynamic response of a roller chain drive working at constant or variable speed condition.

The complete chain transmission with two sprockets and the necessary tight and slack spans had used. The effect of the flexibility of input shaft on dynamic response of the chain system is taken into account, as well as the elastic deformation in the chain, the inertial forces, the gravity and the torque on driven shaft. For getting an accurate simulation results, the equivalent contact stiffness must be given reasonably.

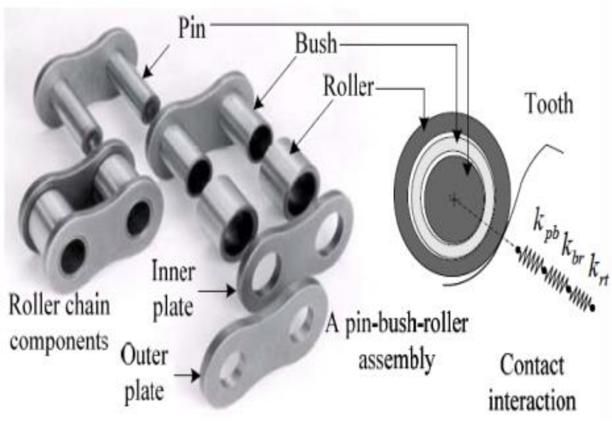

Fig -2: Schematic Components of Roller Chain Link

Since a link is an assembly of several components, the contact effect can be described as a pin-bush-roller assembly contact with the tooth surface. The equivalent contact stiffness can be seen as a series connection of the three contact stiffness. They are contact between pin and bush (kpb), contact between bush and roller (Krb) and contact between roller and tooth surface (krt). Then the equivalent contact stiffness kc can be given by

$$\frac{1}{k_c} = \frac{1}{k_{pb}} + \frac{1}{k_{br}} + \frac{1}{k_{rt}}$$

Tae-Gu KIM et.al. (2010), EISSN: 2093-7997, [2], made a case study on engineering failure analysis of link chain, the effect of chain installation condition on stress distribution that could eventually cause disastrous failure from sudden deformation and geometric rupture. The Fractographic method had used for the failed chain indicates that over-stress was considered as the root cause of failure. 3D modeling and finite element analysis for the chain, used in a crane hook, were performed with a three-dimensional interactive application program, CATIA ANSYS. The results showed that the state of stress was changed depending on the initial position of the chain that was installed in the hook. Especially, the magnitude of the stress was strongly affected by the bending forces. The structural safety of a crane chain was investigated through the prediction of the chain's material behavior and the calculation of maximum allowable load with respect to tension and bending loads. The results are summarized as follows.

The results of finite element analysis show that the state of stress is strongly affected by the condition of the chain installed in the hook.

FEA results are in accordance with the Fractographic analysis, in that the change of load condition from tension to bending severely affects the failure of parts.

3D Model created in CATIA 3D Model imported in ANSYS

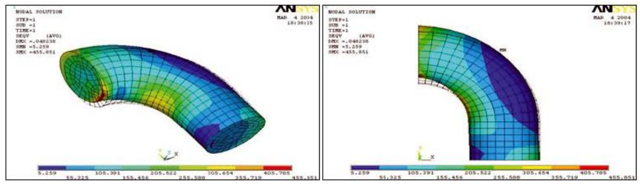

Fig -3: Stress distribution (Tension 5 ton) for crane chain model

Using the ANSYS FEA software the stress distribution was analyzed when the bending load was applied to the chain. Fig.- 3 shows the results of the ANSYS analysis when tension is applied under bending load.

KrishnaKumar K. et. al. (2015), ISSN: 0974-4290 [3] had conducted a review on the most of the chain that is under tension which causes failure of chain assembly which is a major trouble for the industrial sector. This study described the universal failure modes of chain in various engineering applications. The existing studies in the field are examined to ascertain the trends of research in the field and to identify unsolved problems. The distinction of roller chain from the leaf and conveyor chains were highlighted and the novel perspectives that are necessary for the analysis of the chain plate and bearing pin of the roller chains in particular are recommended. Chains are operating under tensile cyclic load condition. The failure of a chain assembly is the most important problem in industry applications which causes failures that are of unacceptable material selection, heat treatment causing other uncertainties in the manufacturing process. They are used to transport goods in production lines or assembly lines, such as pallets, automobiles or drill rig applications. It is occasionally used in dusty environments, soiled with water, foreign particles, chemicals or other contaminants. The typical use will result in wearing down of the components of the chain which can lead to unexpected failure and expensive production downtime.

Mr. Nitin G. Barge (2017) ISSN: 2278-0181, et. al. [4] had studied the improvement of breaking load, reducing the percentage elongation and failure mode, increases the strength of drag chain conveyor system. They found that the maximum stress is 500 N/mm2 for drag chain and for modified drag chain it is 486.49 N/mm2 by FEA. From these two values, it is cleared that stresses are reduced by 13.51 N/mm2 in modified drag chain by FEA. Also, load carrying capacity is less in old drag chain, then by improving in manufacturing processes, mechanical properties and heat treatment processes, can increase the strength and load carrying capacity of new drag chain by keeping the area and material same.

Apply finite element analysis method for both old and new drag chain link assemblies. Von misses stress and displacement has been obtained for different force magnitudes. From the calculations it is shown that percentage error is reduced in new drag chain link assembly as compare to the old chain link assembly. The finite element analysis gives maximum load carrying capacity of old chain is 87 KN and for new chain the maximum load carrying capacity increased up to the 100 KN.

3. METHODOLOGY

The guillotine damper design and the chain drive mechanism are studied in detail at industry SUDE Engineering Corporation, Pune. As shown in Fig.1, the blade is operated by means of chain drive. There are two major issues with the chain drive, which industry was facing.

- Elongation of chain causes chain slips over the pulley.
- The uncertain breakage of chain.

The elongation of chain causes improper drive operation, slippage of chain over pulley and partial opening of the damper due to which pressure drop in the duct line. This happened as chain remained under the influence of a mixture of various excessive loads. Furthermore, the residual stress is also generated in the welding zone of the chain because the temperature gradient and thermal stress were formed by irregular heating during the welding process. The elongation of chain affects the link location in pulley and hence the chain slips over the pulley as shown in Fig.-4 and sudden dropping of the blade causes a severe accident.

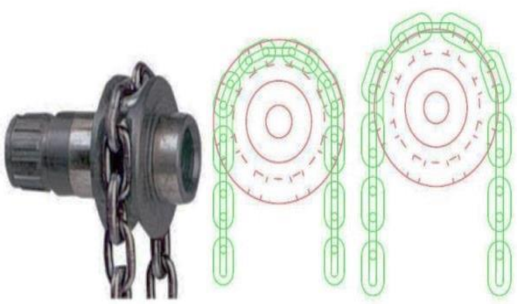

Fig -4: Engaged chain & pulley

Due to unpredicted loads such as friction loads, fluid pressure the uncertain breakage of chain occurs. When the chain gets elongated and it rolls over the pulley during lifting, the chain links don't get inserted properly into the pulley grooves. This causes the chain links to develop bending stress instead of tension.

From literature review, it was clear that by changing the chain drive mechanism the issue of chain failure of guillotine damper may be solved. Various parameters affecting elongation and breakage of the chain during operation are studied. Also analysis for different loads acting over the chain is calculated.

Over-stress was considered as the root cause of failure of the previous failed link chain. By numerical method the calculations are made to find the total pull on chain and with respective to total pull, replaced previous link chain by proper roller chain (M2416). The total pull on roller chain is compared with total breaking load which is much higher. Calculated total elongation numerically and compared result with standard elongation limit of chain (Table-1). Total elongation of chain was within limit.

Table 1: Elongation limit of chain

Number of teeth of large sprocket	Regular Chain (%)	Roller Chain (%)
40 or less	2.0	1.0
41~60	1.5	1.0
61~80	1.2	1.0
81~100	1.0	1.0
101 or more	0.8	0.8

Hence by analytic method, the problem of the uncertain breakage of chain and chain elongation is eliminated. Results are validated by FEA method.

4. FEA METHOD

FEA method may be adopted for analysis and validation. A model of damper and roller chain assembly can be prepared in CATIA as shown in Fig.-5.

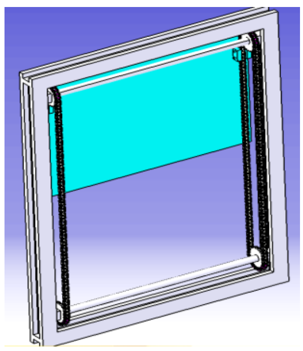

Fig -5: Model in CATIA

Further that model can be exported in to ANSYS for further analysis and can be tested for stress and elongation in chain.

5. SUMMARY

Available literature regarding guillotine damper, different drives, various applications of chain drive, chain drive design parameters, etc. are studied. Gained the knowledge of chain drive design. New design for chain drive with improved calculations is done. The chain finalized is roller chainM 2416 A. Total pull obtained is 10582.73 N which is less than maximum breaking load of M 2416 chain.Hence the design is safe. Then chain length calculations are made to get total chain length. After that chain elongation calculations are made to find the total elongation in chain and compared with standard elongation limit of chain (Table -1). Total elongation of chain is within limit.

Hence the problem of the uncertain breakage of chain and chain elongation is eliminated.

6. CONCLUSION

To eliminate the problem elongation and breaking of chain, by considering the various factors calculations are made to find out the total load on chain and total elongation of roller chain numerically. Total pull obtained is 10582.73 N which is less than maximum breaking load and chain elongation is within limit. Analysis and validation can be made further by FEA method.

We can conclude by comparing both results in terms of achieving the objective. By making certain changes in the design of chain, the defect of elongation and breaking of chain in guillotine damper could be eliminated. Further FEA method may be adopted for analysis and validation to predict new roller chain would be suitable to overcome the chain issue.

7. ACKNOWLEDGEMENT

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