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Stress Analysis of Bell Crank Lever in Sewing Machine

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Abstract

Thread take up lever is the type of bell crank lever which is important part of sewing machine. The take-up lever is a metal finger with a thread guide that moves up and down, pulling thread from the spool and feeding it through the machine. The needle bar and take-up lever mechanism is one of the most important mechanisms used in sewing machines. It is nearly in all classical sewing machines, this mechanism provides sewing by allowing movement of the needle and pulling of the thread for stitch formation. Knowledge of the interactions between a sewing machine's mechanisms and the sewing thread in the stitch formation process should help us to understand thread loadings in the sewing process. The aim of this work is to analyze the forces in the take-up lever and selecting most feasible shape of thread take up lever.

Keywords: *Thread take-up lever, structural analysis, ANSYS, bending stress*

1. Introduction

The sewing machines are taking large loads during working conditions. So the parts of the machine should strong and durable to bear such large amount of loads. Knowledge of the mechanisms' kinematics in the sewing machine and interaction with the thread in the characteristic parts of the stitch formation process is important in order to obtain the best possible insight into the stitch formation process.

Classical sewing machines are mostly used for domestic purpose. The needle bar and thread take-up mechanism used in classical sewing machines consists of cam mechanism. The sewing process occurs in the synchronized motions of these and other mechanisms in the machine. The function of the thread take-up lever in the stitch formation process is to en-sure appropriate thread feeding. In some parts of the stitch formation process, more thread is available than is needed for loop forming. During this process large amount of cyclic force exerted on the thread-take up lever which can leads to bending or breaking of lever. To avoid the failure of lever it is necessary to estimate the forces applying on lever.

2. Literature Review

Author worked on stress analysis of bell crank lever [2]. Bell Crank Lever is important components from safety point of view as they are subjected to large amount of stresses. They performed Finite Element Analysis (FEA) on various models of varying fillet radius, optimization for volume and reduction of materials form bell crank lever. They found that maximum stress is occurred at fillet. So by increasing the fillet radius stresses are reduced in bell crank lever. The work on modification in the classical needle bars and thread take-up lever mechanism is also done [3]. This study deals with the design of a new modified thread take-up lever mechanism and that can be used as an alternative to the classical mechanism.

3. Thread Take-Up Lever

The thread take-up lever is a metallic lever with a thread guide that moves up and down, pulling thread from the spool and feeding it through the machine. The thread take up lever is made up of hot rolled carbon steel sheets and strips. Its minimum hardness is 350 HV around the hole for the sewing thread and bearing surfaces.

3.1Functions of Thread Take-up Lever

1. Provides needle with upper thread
2. Supplies necessary amount of thread so that hook can scoop upper thread and so that the upper thread can pass through inner hook
3. It lifts upper thread quickly when upper thread passes through inner hook
4. It feeds out upper thread to be consumed for stitches together with feed dog
5. It also performs thread-tightening

Fig. 1 Thread Take-Up Lever

4. Modeling & FEA Analysis

In this paper the stresses are reduced by optimizing the volume of thread take up lever. Here three different volumes are proposed with original one. For this analysis, 3D models are prepared by using CATIA V5 software. The material properties of thread take up lever are given in below table. These materials are applied after importing the CAD model in ANSYS.

Table 1: Material properties for thread take up lever

Sr. No.	*Material Properties*	*Low Carbon Steel*
1	Density in g/cm3	7.87
2	Poisson's Ratio	0.29
3	Young's Modulus in GPa	205
4	Yield Strength in MPa	370
5	Ultimate Tensile Strength in MPa	440

4.1Meshing

After importing and applying properties to the model next step is meshing. This is important step in analysis. Because final results are depends on mesh type and mesh size. As number of elements increases accuracy in results also increases. So it is required to select particular size of meshing. Here tetrahedron elements are used to mesh the models.

Fig. 2 shows mesh model for thread take up lever with 2mm thickness. Similar model will be mesh for lever with 3mm thickness. Fig. 3 shows mesh model for lever with 4 holes in it.

Table 2: No. of Elements and Nodes for different shapes

Part No.	*Shape*	*No. of Elements*	*No. of Nodes*
1	Original (2mm Thickness)	26088	41208
2	With 4holes (2mm Thickness)	25802	40974
3	Original (3mm Thickness)	35291	54273
4	With 4holes (3mm Thickness)	34973	54043

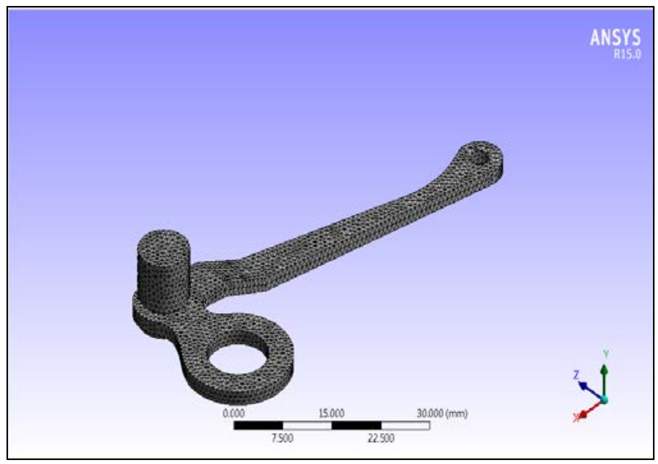

Fig. 2 Mesh model for original shape with 2mm thickness

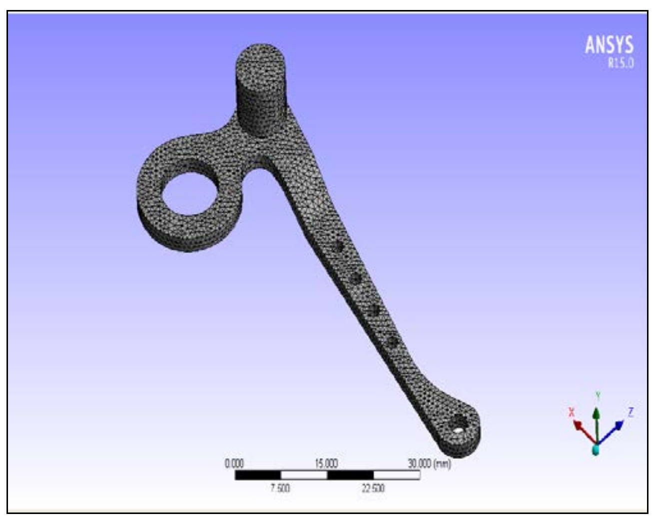

Fig. 3 Mesh model for original shape with 4 holes

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4.2 Loadings & Boundary Conditions

After meshing the model it is needed to apply boundary conditions such as loading and constraints. For getting the accurate result it is required to apply correct load and constraints. Loads and constraints are applied as shown in Fig.4. The loads applied to the model are taken at their maximum values. Here only static conditions of the loads are taken for analysis.

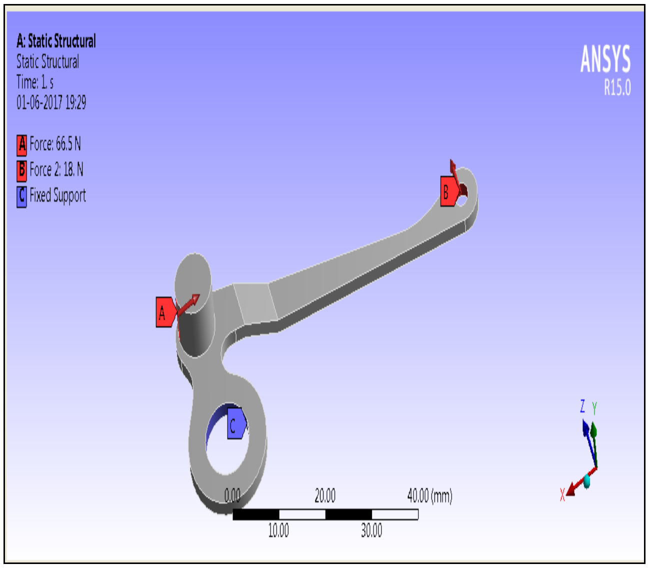

Fig. 4 Loads and constraints applied to the model

4.3 Results of Finite Element Analysis

In this analysis loads are applied at hole and roller. As shown in Fig.4, 66.5N load is applied at point A and 18N load is applied at point B. There is fixed constraint at point C. The values of loads are taken from the calculations. The equivalent or von-Mises stresses for different shapes of lever are shown in the figures from Fig.5 to Fig. 8. Also Table No. 3 shows the maximum stress values.

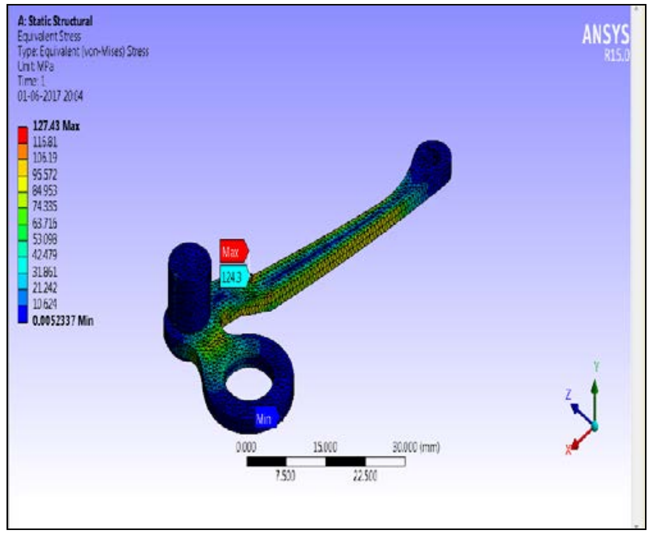

Fig. 5 Equivalent Stress in the Part No.1

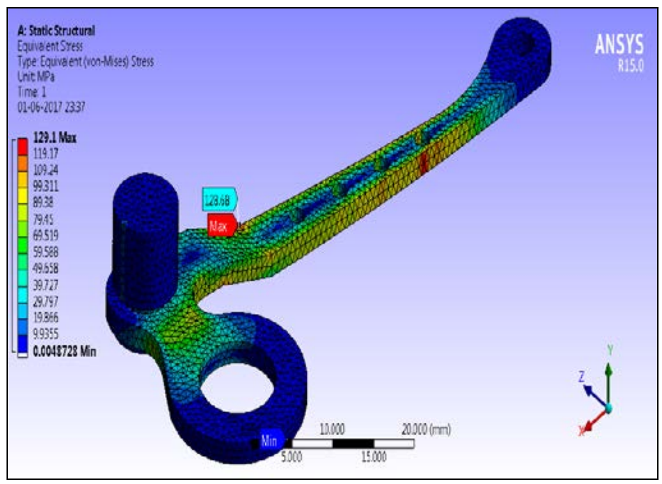

Fig. 6 Equivalent Stress in the Part No.2

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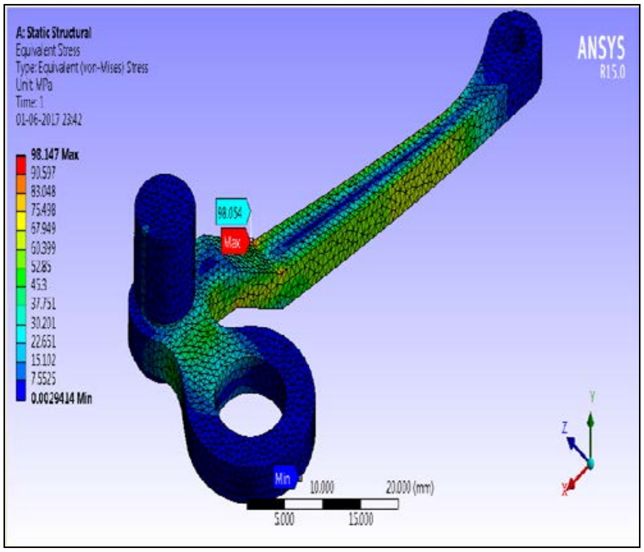

Fig. 7 Equivalent Stress in the Part No.3

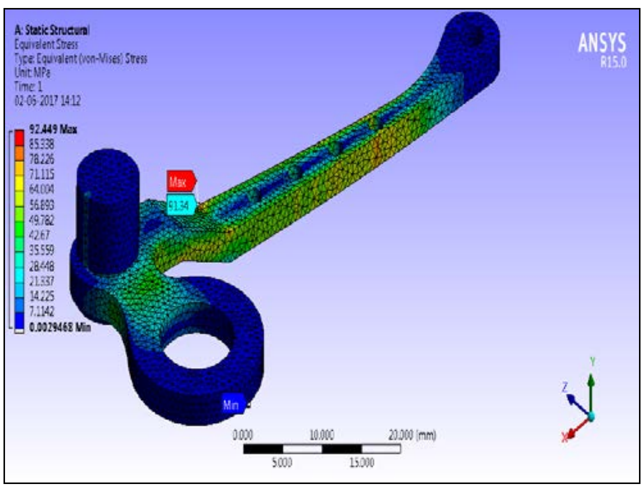

Fig. 8 Equivalent Stress in the Part No.4

Table 3: No. of Elements and Nodes for different shapes

Part No.	***Shape***	***Max. Stress in MPa***
1	Original (2mm Thickness)	127.43
2	With 4holes(2mm Thickness)	129.1
3	Original(3mm Thickness)	98.15
4	With 4holes(3mm Thickness)	92.5

5. Results & Discussion

After performing analysis on thread take-up lever, results are obtained for stresses generated in the lever. From figures it is shown that maximum stress is occurred at the position where lever has slight bend. The comparison between the stresses occurred in these levers is shown by graph below.

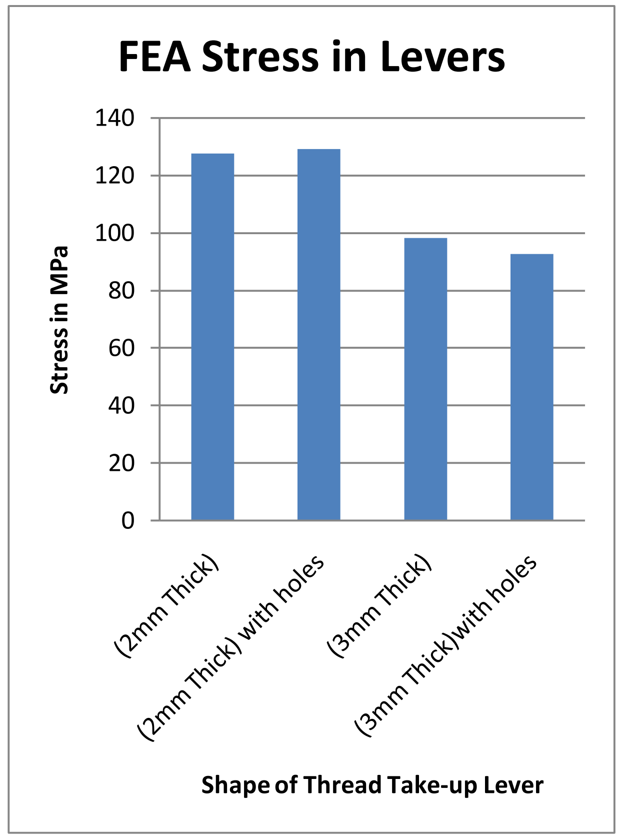

Fig. 9 FEA Stress in Different Levers

6. Conclusion

From the above results it is conclude that the maximum stress is occurred at the position where part is bent. Also from table no. 3, it is shown that maximum stress is occurred in second lever. So by changing and reducing the volume of lever stress can be reduced.

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