Dimensional Optimization of Helical Springs Used in Tractor Seat by FEA and Experimental Analysis

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Abstract - *Over the 12 months lots of paintings has been executed and remains persevering with with first rate attempt to lessen the fee and enhancing the overall performance of compression spring and additionally look at the evaluation of failure in spring The purpose of this challenge is to look at present layout of helical spring and production the spring and perform the strain evaluation of helical anxiety spring for Tractor seat .To decreased stresses the time of dynamic loading circumstance, implemented on helical spring. Also capable of maintain at one-of-a-kind load circumstance. At one-of-a-kind load circumstance and strain we've test the failure evaluation of spring. In trendy we are able to look at fatigue lifestyles evaluation of spring via way of means of the use of experimental evaluation .additionally look at the impact of various the variety of turns of the spring in investigated for helical compression spring, the suspension of spring needs to be changed with the intention to lessen the strain and adventure must be snug i.e. jerk unfastened adventure. Due to damping the helical spring receives split and which reasons the extreme accident.so powerful layout of helical spring wished for tractor seat to get consolation and to face up to vibration.*

***Key Words*: Helical compression spring, finite element analysis, fatigue life analysis, experimental analysis.**

1. INTRODUCTION

Most of the issue utilized in heavy automobile motors is subjected to excessive pressure loading and they're designed to resist the structural in addition to fatigue failure evaluation. The Tractor seat failure has been out to be because of fatigue failure, so designers and engineers are involved approximately the very excessive cycle fatigue. Failure of any mechanical issue is rely on the loading condition, cloth, issue layout and its production. To enhance the existence of the issue the cloth used could be very excessive power steels and widespread production system is observed which offers the fatigue failure of mechanical issue is relies upon on loading situations. Most of the tractor seat are failed due fatigue pressure appearing on due to recitative load due vibration of automobile. Helical springs are extensively used in lots of engineering programs because of their importance. Helical compression springs are used extensively all around the world. It has specific sort of programs in specific vicinity Springs are utilized in mechanical system with transferring parts, to soak up hundreds, which can be continuously, or abrupt varying. The absorption of the hundreds takes region withinside the shape of elastic energy. Coil springs are product of rods which might be coiled withinside the shape of a helix. The layout parameters of a coil spring are the rod diameter, spring diameter and the range of coil turns in keeping with unit length. Compression springs can be cylindrical, conical, tapered, concaveor convex in shape. Vehicle suspension machine is produced from springs which have fundamental position in strength switch, automobile movement and driving. There has been loads studies has been performed to locate optimized answer for helical spring relying at the application. The Jinee Lee has proposed a Pseudo spectral technique which become carried out to the loose vibration evaluation of cylindrical helical springs. The displacements and the rotations are approximated with the aid of using the collection expansions of Chebyshev polynomials and the governing equation become collocated [1]. A.M. Yu , Y. Hao has finished analytical observe at the loose vibration evaluation of cylindrical helical springs with noncircular cross-sections. They have formulated express analytical expressions of the vibrating mode shapes of cylindrical helical springs with noncircular cross-sections and the quit situations clamped–clamped and clamped–loose, the usage of the symbolic computing package deal MATHEMATICA [2]. L.E. Becker et al. linearized disturbance equations governing the resonant frequencies of a helical spring subjected to a static axial compressive load are solved numerically the usage of the switch matrix technique for clamped ends and round cross-segment to supply frequency layout charts [3]. The scope of K.MIchalczyk paintings consists of the dedication of the pressure amplitudes withinside the spring for the given parameters of elastomeric coating, on the consecutive resonance frequencies [4]. Mohamed Taktak has proposed a numerical technique to version the dynamic conduct of an isotropic helical spring [5]. The analytical and numerical fashions describing wave propagation, of slow excitations in time has been investigated with the aid of using AiminYu,et al.[6]. Suraj Kumar et al have purposed air spring that is to limition the vibration at a appropriate stage as in keeping with requirements. Anis Hamza et al has studied the vibrations of a coil, excited axially, in helical compression springs which includes tamping rammers are discussed. He has evolved a mathematical components which become made from a machine of 4 partial differential equations of first-order hyperbolic type, because the unknown variables are angular and axial deformations and velocities. The numerical decision become carried out with the aid of using the conservative finite distinction scheme of

Lax–Wendroff. Youl Zhu et al. [7] has Shown that a selection of things might also additionally motive fatigue failure of helical compression springs in engineering programs. In this paper, we performed Analytical Stress and fatigue evaluation, FEA, Experimental evaluation of tractor seat spring. We have proposed new association of spring on a tractor seat so one can enhance the overall performance of the spring.

I. MATERIAL

Springs are resilient structures designed to undergo large deflections within their elastic range. It follows that the materials used in springs must have an extensive elastic range. Some materials are well known as spring materials. Although they are not specifically designed alloys, they do have the elastic range required. In steels, the medium-and high-carbon grades are suitable for springs. Beryllium copper and phosphor bronze are used when a copper-base alloy is required. The high-nickel alloys are used when high strength must be maintained in an elevated-temperature environment. The selection of material is always a cost-benefit decision. Some factors to be considered are costs, availability, formability, fatigue strength, corrosion resistance, stress relaxation, and electric conductivity. The right selection is usually a compromise among these factors.

A. Commonly Used Spring Materials

One of the important considerations in spring design is the choice of the spring material. Some of the common spring materials are given below

Hard-drawn wire.

This is cold drawn, cheapest spring steel. Normally used for low stress and static load. The material is not suitable at subzero temperatures or at temperatures above 1200 C.

Oil-tempered wire.

It is a cold drawn, quenched, tempered, and general purpose spring steel. It is not suitable for fatigue or sudden loads, at subzero temperatures and at temperatures above 1800C.

Chrome Vanadium.

This alloy spring steel is used for high stress conditions and at high temperature up to 2200C. It is good for fatigue resistance and long endurance for shock and impact loads.

Chrome Silicon.

This material can be used for highly stressed springs. It offers excellent service for long life, shock loading and for temperature up to 250^0 C.

Music wire.

This spring material is most widely used for small springs. It is the toughest and has highest tensile strength and can withstand repeated loading at high stresses. It cannot be used at subzero temperatures or at temperatures above 120^0 C.

Stainless steel.

Widely used alloy spring materials.

Phosphor Bronze / Spring Brass.

It has good corrosion resistance and electrical conductivity. it is commonly used for contacts in electrical switches. Spring brass can be used at subzero temperatures. On the basis of this particular study we have selected material as 55 Si 2 Mn 90

TABLE I
Material Configuration

% C	% Si	% Mn
0.5-0.6	1.5-2	0.8-1.0

II. FINITE ELEMENT FORMULATION

Two CAD models has prepared for this particular research depend on the position of helical spring by using Pro-E Platform. The Models are prepared in such way that, it will take all real boundary conditions. Fig. 1 shows the CAD Model

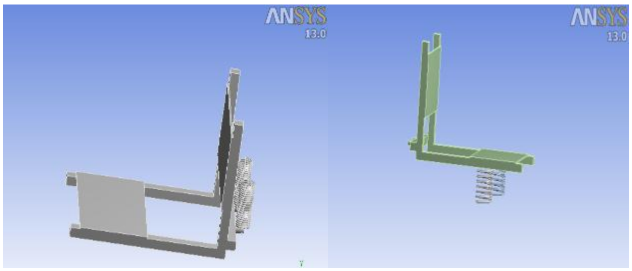

Fig 1 CAD Model of Tractor Seat

a) Helical Tension

b) Helical Compression

IV. FATIGUE MODEL

Fatigue life is defined as the number of stress cycles of specified character that a specimen sustains before the first evidence of failure. In case of Tractor seat road irregularities and engine will cause a vibration which ultimately will give the fatigue in the helical spring. Here for this research we have considered a vibration to be in completely reversed manner. So, for the fatigue life calculation we have to consider the fully reversed cycle.

Mean stress value (σ) = 0

Stress amplitude (σa) = 200 MPa

Endurance limit of mechanical a component (Se)

Se = Ka × Kb × Kc × Kd × Ke × Se'

Where,

Ka = Surface finish factor: - The surface finish factor is depends on modes of surface finish operation. Due to complex geometry of Tractor seat, polishing is the best way for finishing of crankcase. For polishing operation value of surface finish factor is one.

Kb = Size factor: - The size factor depends upon the size of cross-section of the component. As the size of the component increases, the surface area also increases, resulting in a greater number of surface defects. Ford> 50, its value is 0.75.

Kc = reliability factor: - The reliability factor depends on the reliability that is considered in the design of component. The reliability of the fatigue test is 50 %. At 50 % reliability the value of reliability factor is one.

Kd = Temperature factor: - Temperature factor depends on the temperature of component. Due to increase in temperature endurance strength of component decreases. Its value for temperature 550 ºC is 0.67.

Ke = Modified factor for stress concentration = 1

Se' = Endurance limit = 0.45×Sut

Sut = 2×Syt

Se = 0.750 ×1 ×1 × 0.67× 1 ×2 Se‟

Fatigue strength (Sf) = Nf×σa

From S-N diagram as shown in Fig 2

CF/FB = AE/EB.

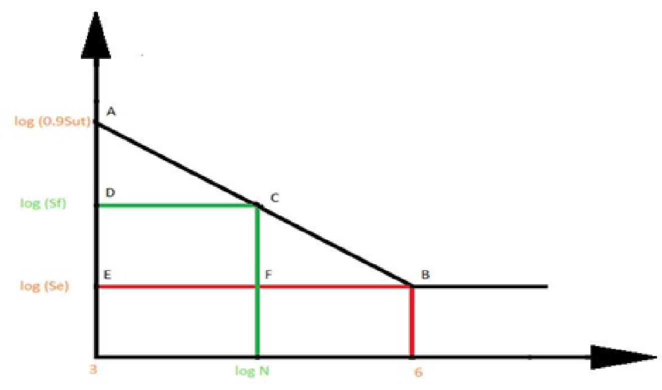

Fig. 2 S- N Diagram

V. EXPERIMENTAL METHODOLOGY

To find the problem of failure in tractor seat helical tension springs and try to replace it by helical compression springs using stress and fatigue analysis, the experimental setup made is shown in figure 3

Fig.3 Experimental Setup

a) Helical Tension

b) Helical Compression

A. Experimental procedure for tension spring

Experimental setup is prepared for calculating the fatigue life of spring. The setup is prepared by using MS channel structure and a seat of tractor is mounted. The seat is accelerated by using electric motor of 5hp. A crank is used of length 40mm for total stroke of 80mm, tension spring are placed at the back of seat .The seat is manufactured according the design of actual seat of tractor which is of MS. Two springs are placed at the back of seat the speed of output shaft is maintained as 500 rpm using rheostat at power input to electric motor.

Two tension springs are mounted on the model and machine is accelerated for duration up to spring is getting fractured and from obtaining time the numbers of cycles are counted.

B. Experimental procedure for compression spring

Experimental setup is prepared for calculating the fatigue life of spring. The setup is prepared by using MS channel structure and a seat of tractor is mounted. The seat is accelerated by using electric motor of 5hp. A crank is used of length 40mm for total stroke of 80mm, compression spring are placed at the bottom of seat. The seat is manufactured according the design of actual seat of tractor which is of MS. Two springs are placed at the bottom of seat. the speed of output shaft is maintained as 500 rpm using rheostat at power input to electric motor.

In these setup two compression spring of diameter 8mm and 5mm are mounted at the bottom of seat. Machine is accelerated till the spring get fracture and number of cycles is calculated. Similarly same procedure is done for 5mm spring and number of cycles is calculated.

VI. RESULTS AND DISCUSSION

A. Stress analysis for three springs

Table II
Analytical stress of springs for variable load

LOAD	Analytical stress Compression spring 8 mm (Mpa)	Analytical stress Compression spring 5 mm (Mpa)	Analytical stress Tension spring 4 mm (Mpa)
100	35.27963144	144.1468	169.175196
150	52.91944716	216.2202	253.762794
200	70.55926287	288.2936	338.350392
250	88.19907859	360.367	422.93799
300	105.8388943	432.4404	507.525588
350	123.47871	504.5138	592.113186
400	141.1185257	576.5871	676.700783
450	158.7583415	648.6605	761.288381
500	176.3981572	720.7339	845.875979
550	194.0379729	792.8073	930.463577

Table II shows analytical stress values for three springs for various loading. And that can be used for further comparison. It was found that the stress produced in compression spring of diameter 8mm is lesser than other two springs

Table III
FEA stress of Three Springs for Variable Loads

LOAD	FEA STRESS Compression spring 8mm (Mpa)	FEA STRESS Compression spring 5mm (Mpa)	FEA STRESS Tension spring4mm (Mpa)
100	94.8810	268.020	205.8862276
150	97.397712	287.1218124	274.5149722
200	100.530283	334.975445	343.1437129
250	112.66285	382.8290845	411.7724551
300	120.79542	430.6827097	480.4012043
350	140.92799	478.5363478	549.0299445
400	161.06057	526.3899825	617.6586907
450	181.19314	574.2436247	686.2874337
500	201.32571	622.0972639	754.9161855
550	221.45828	669.9508899	823.5449103

Table III shows FEA stress values for three springs for various loading. And that can be used for further comparison. It was found that the stress produced in compression spring of diameter 8mm is lesser than other two springs

B. Fatigue life *analysis for three springs*

Table IV shows the difference in life cycle for three springs and values difference in Analytical, Experimental, and FEA Analysis. It was found that life cycles of spring with diameter 8mm having better life than other two springs

Table IV
Analytical, Experimental, FEA Analysis

Spring	Diameter	Fatigue life	
		Analytical	Experimental
Tension	4mm	189971.53 Cycles	196000 cycles
compression	5mm	244962.72 Cycles.	250000 cycles
compression	8mm	270582.68 Cycles.	272500 cycles

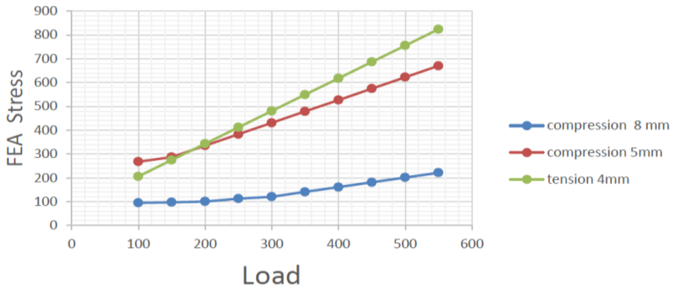

Fig 4 Comparison of FEA for Three springs

The fig. 4 shows that comparison of the FEA stress values for three springs. And it is found that stress produced in the compression spring of diameter 8mm is too lesser than other two springs.

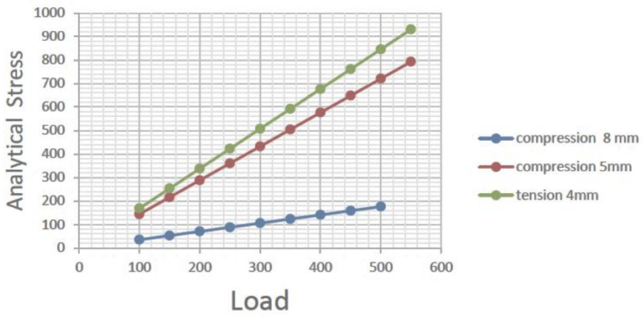

Fig 5 Comparison of Analytical for Three springs

The fig 5 shows that comparison of the Analytical stress values for three springs. And it is found that stress produced in the compression spring of diameter 8mm is too lesser than other two springs.

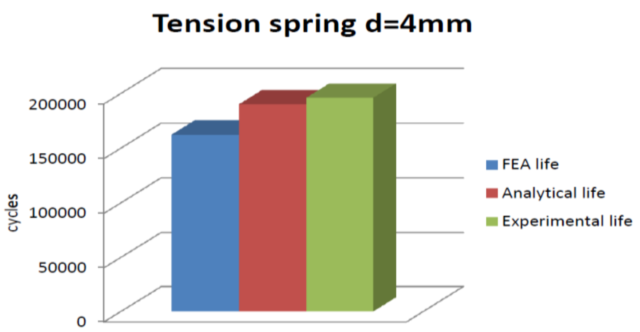

Fig 6 Comparison of fatigue life for tension spring

The fig 6 shows that Comparison of fatigue life for tension spring of diameter 4mm, experimentally it is higher than other two analysis but it is no too much variation.

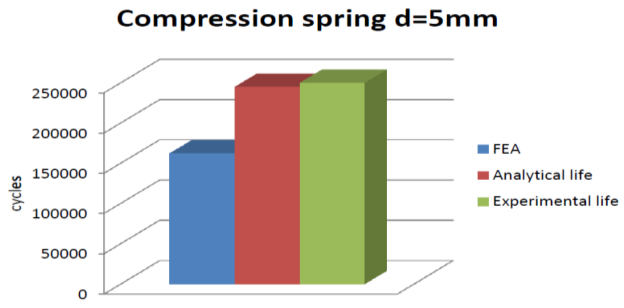

Fig 7 Comparison of fatigue life for compression spring d=5mm

The fig.7 show that Comparison of fatigue life for compression spring of diameter 5mm, experimentally it is higher than other two analysis and FEA value shows too lesser as compare to other two values

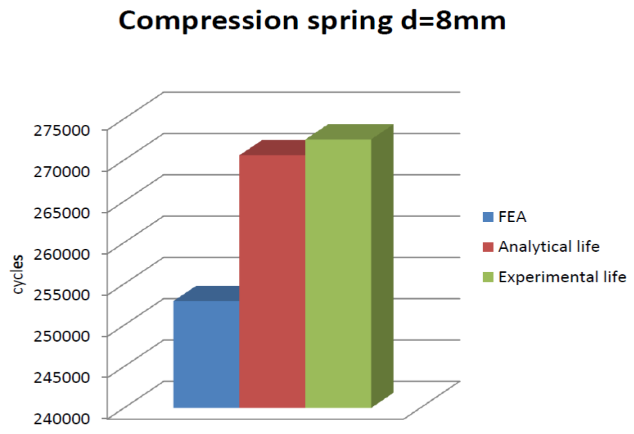

Fig 8Comparison of fatigue life for compression spring d=8mm

The fig.8 show that Comparison of fatigue life for compression spring of diameter 5mm, experimentally it is higher than other two analysis and FEA value shows too lesser as compare to other two values

VII. CONCLUSION

Fatigue Failure analysis of the both models shows the higher life cycle in a compression spring helical model than tension helical spring also von misses stress of helical tension is higher than compression model The tractor seat helical compression spring will last longer than the helical tension spring and also the stresses obtained in helical tension spring are much higher than the compression spring model

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