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EXPERIMENTAL INVESTIGATION AND ANALYSIS OF CONCENTRIC SPRING FOR PREVENTING DIE SET COMPONENT FAILURE

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Abstract - *This paper discuss about the basic fundamentals and working principle of the die set mechanisms and the problems and remedies occurring during functioning of the system. The main cause of failure of the system is due to the failure of the spring mechanism which is set to achieve restoring of the lower die after each stroke by punch. A typical die and punch set used for blanking operation is highly dependent upon the spring system utilized in it. The helical compression spring is used for the easy restoration of the system during functioning. To prevent this failure and to avoid the bottlenecks a strong restoring mechanism is required which will sustain under these varying loading conditions. The concentric springs carries the greater loads and mostly implemented over the varying load conditions. Those spring increases the performance of the die set mechanisms. FEA of the new developed spring is performed to ensure the proper working and deformation of the spring which provides the best suitable results.*

***Key Words*: Die set component, concentric spring, FEA**

1.INTRODUCTION

Punch holder is fixed to the ram of the press and punch is fastened to the punch holder which is aligned with the opening in the die block. It uses guide pins to take the punch out of the hole. Die shoe clipped to the bolster plate.

[A] Die holder used for holding the die to sustain it against heavy loads applied from the ram

[B] Die main component of the set which is used for forming the material

[C] Guide Post Guide post guides the punch holder for its appropriate and correct movement

[D] Punch holder holds the punch rigidly and provides support while punching

[E] Punch used to exert the force / pressure on work piece

[F] Bed provides foundations to all the sub-assemblies and those are mounted on the bed which is rigid to sustain heavy loads and prevent vibrations.

[G] **Springs** restores the lower die at predetermine place to obtain the accuracy of the parts

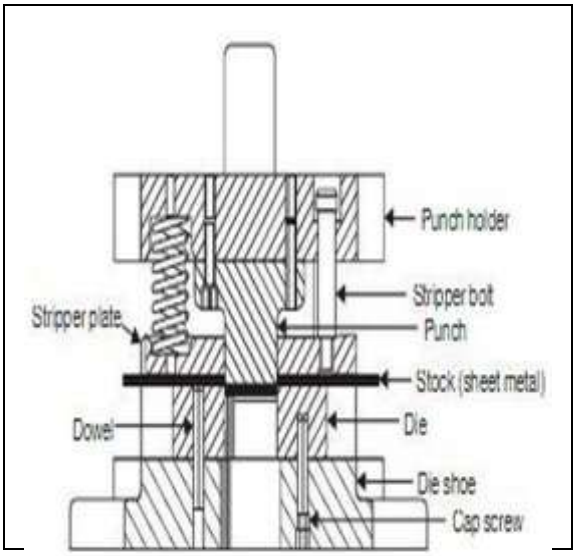


Fig -1: Die Set Components

Wide-ranging design and uninterrupted upgrading creates conformance to the desires of the customers and the methodology which will substantially reduce the loss occurring in the company arises due to rejection or damages. Quality of design is a critical process, typically hinged on a number of factors which can be either cost or performance related.

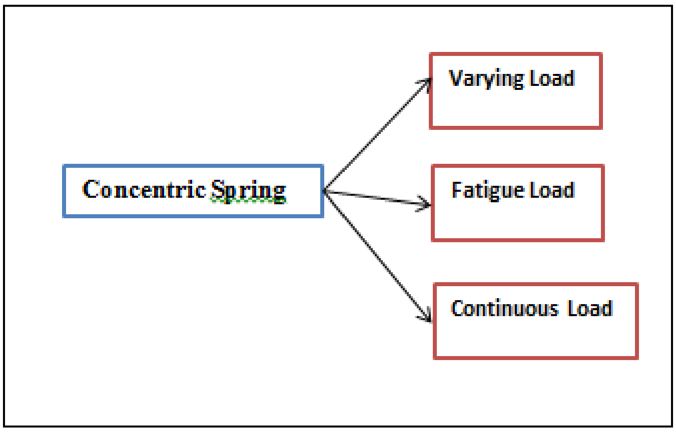
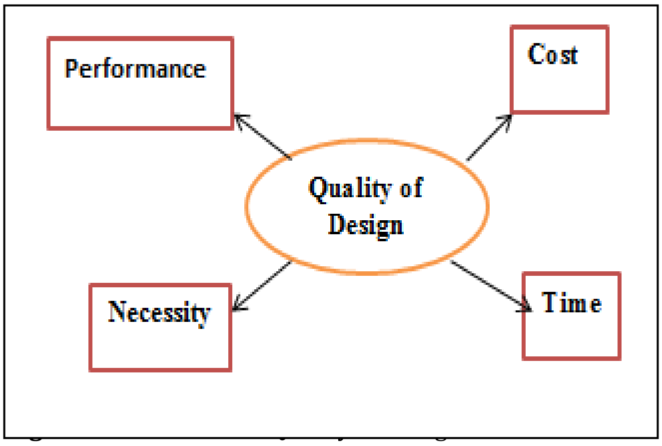


Fig -2 : Applications of Concentric Spring

Design of Concentric spring for preventing the failure of the die set component to reduce the breakdown time as well as to reduce the downtime of production line is the essential task and difficult to tackle. Also material selection for concentric or composite spring on shop floor applications is the tiresome job to tackle with greater effectiveness. Even experts fails to decide which material will provide desired attributes.



As the material changes, the objective parameters of the end products vary. The present global changes in manufacturing sector demand low cost and high quality products/services in order to retain the existing customers as well as to attract new customers. Cost reduction and quality are the main factors for the customers' satisfaction, which cannot be achieved with a little effort as they require sound design, various analysis, evaluation, selection and optimization of process, equipment, material, system, etc. A sound design resemblance to quality assurance, conformance of design, level of performance, reliability. A good design results in the reduction in the maintenance cost and assures zero breakdowns.

2. LITERATURE REVIEW

Vizcaya L. Del Llano et al. [1] had made an attempt to study multiaxial fatigue and failure analysis of helical compression springs. The critical plane approaches, Fatemi–Socie and Wang–Brown, and the Coffin–Manson method based on shear deformation, were used to predict fatigue lives of the springs under constant amplitude loading. Jeffrey Jooteck et al.[2] used to design composite multi-leaf spring for the two materials, E-glass fiber/epoxy and E-glass fiber/vinyl ester, which are of great interest to the transportation industry. Main consideration was given to the effects of material composition and its fiber orientation on the static and fatigue behaviours of leaf spring. The design constraints were bending stresses, deflection and fatigue life. Compared tothe steel leaf spring, the designed composite spring has much lower bending stresses and deflections and higher fatigue life cycles. Pawar B. Harshad et al.[3] carried out analysis for shear stress and deformation produced in the new spring at the loading condition was less than existing design so new design is safe. The stress reduction for new design is 13% than the existing. Relative error of maximum shear stress was 7 to 9 % with reference to the applied load compared with the calculated values by using simple numerical formulae which were found in the text books. From above analysis it has been observed that the stiffness of the suspension spring is increased which in turn increases load carrying capacity of the system.

Berger C. et al.[4] studied The aim should be to elaborate results about and insights concerning the level of the fatigue range in the stress cycle regime up to 10^9cycles, about the mechanisms causing failures and about possible remedies or measures of improvement. Author also investigated on that field deal with specimens under tensile or rotating bending load. Ansari Arif et al.[5] carried out static stress analysis using finite element method has been done in order to find out the detailed stress distribution and deformation of the spring. The comparative study has been carried out in between the theoretical values to the analytical values. Kumar Pavan et al.[6] work is carried out on modeling and analysis of primary suspension spring (60SiMnA) is to replace the earlier conventional steel helical spring (Chrome Vanadium). The work is to reduce the overall stress and deflections of the helical spring by using the new material. Pattar Sangmesh et al.[7] The force can be a linear push or pull, or it can be radial, acting similarly to a rubber band around a roll of drawings. static analysis of compression spring is carried out to identified maximum load carrying capacity of spring with its permissible deflection. Karthikeyan S.S. et al.[8] implemented composite materials in helical coil suspension system. Previously used the conventional steel for helical coil. For required stiffness, the design of such springs is very bulky and costly. Ladislav Kosec et al. [9] investigated motor coil spring and found out Rupture of the spring results from the corrosion induced fatigue of steel. The main reason that this has occurred was damaged corrosion protection layer (paint) on the surface of the spring, where corrosion attack has started. Simultaneous activity of corrosion and cycling loads caused failure of the spring. Pavani P. N. L.[10] Studied wave spring, Analysis on wave springs has been done by structural mechanics approach and results were validated compared with the coil spring of the shock absorber. Suresh kumar M. et al.[11] focused on tensile behaviour, fatigue resistance, chipping resistance, and base part resistance, a hybrid laminated spring is constructed for the purpose.

Tondiv M. T. [12] proposed an equation for the maximum tensile stress from loading of a helical spring, and a method is presented to calculate the likely fatigue crack origin. It is demonstrated that for high-stressed springs, fatigue design should be based on the range of the maximum principal tensile stress. Das Animesh et al. [13] studied spring material and its quality can normally be taken into consideration and consequently, material selection plays an important role during designing of a spring for a particular application. it is exceptionally crucial to select the most suitable material with the desired properties for enhanced durability, low operational and manufacturing cost, and better performance of the spring. Yong-Huang Lin et al. [14] proposed a dynamic decision making model which takes the TOPSIS technique as main structure, integrating the concepts of grey number and Minkowski distance function into it to deal with the uncertain information and aggregate the multi-period evaluations. Rao R. Venkata [15] studied that 'material suitability index' is proposed that evaluates and ranks the materials for a given engineering component. The index is obtained from a material selection factors function, obtained from the material selection factors graph.

3. METHODOLOGY

Many of the researchers had worked on the systematic design and material selection parameters of die set and their component. But none of the study has been carried out to resolve lower die restoring issue. The springs which causes major failure and results breakdown still very less focus given on the problem.

Fig -4: Die Set Components

Die set component used during blanking operation undergoes huge compressive force and it need to be obtained original position swiftly. Failure of restoring mechanism results into huge loss to the industry in terms of labour and downtime. Industry requires such a solution to the problem which will provide them proper and reliable resto

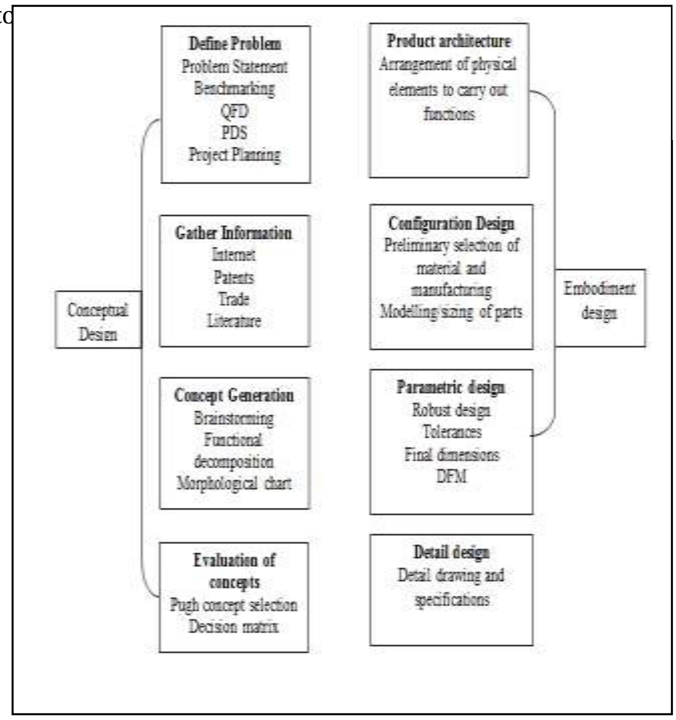
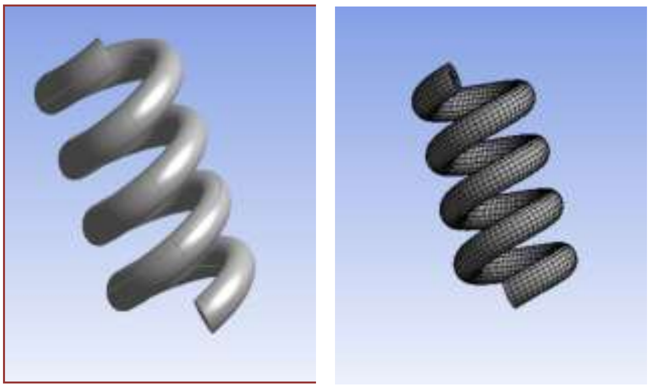
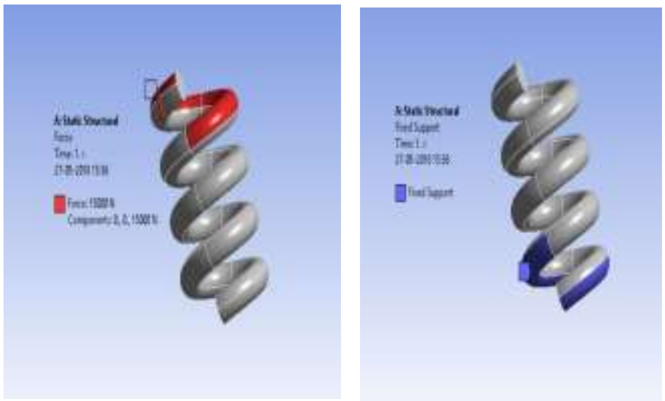


Fig -5: Design Methodology

3.1 FEA of Existing Spring

Basic concept in FEA is that the body or structure may be divided into smaller elements of finite dimensions called "Finite Elements". The original body or the structure is then considered as an assemblage of these elements connected at a finite number of joints called "Nodes" or "Nodal Points". Simple functions are chosen to approximate the displacements over each finite element.





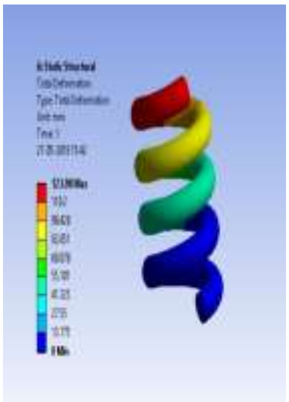


Fig - 8: Deformation of Existing Spring

[A] Design of Concentric Spring

[a] Outer Spring and Inner Spring

Material: Spring Steel **(A 286 Alloy)**
Rockwell hardness: C35-42
E = 200000 MPa, G = 71.7 X 10^3MPa
n_1= 8, n_2 = 8, d1= 5. 8 mm, d_2 = 5 mm

[1] Calculation for Maximum Deflection:
The deflection in the spring can be calculated as follows,

$$\delta = \frac{8\,W1D1^3 n1}{G\ d1^4}$$

$$\delta = \frac{8\ X\ 15000\ X20^3 X\ 8}{71.7\ X\ 10^3 X\ 5.8^4}$$

$$\delta = 94.65\ mm$$

[2] Calculations for Spring Index

Spring index can be calculated as,

$$\text{Spring Index (C)} = \frac{D2}{d2}$$

$$C1 = \frac{20}{5.8} \quad C2 = \frac{16}{5}$$

$$C1 = 3.44\ \ C2 = 3.28$$

[3] Calculations for Wahl's Stress Factor

$$K1 = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$
$$K1 = 1.4846$$

$$K2 = 1.5160$$

[4] Calculations for Max shear stress

$$\sigma 1 = \frac{8\,W1D1}{\pi d1^3} XK1$$

$$\sigma 1 = 5816.11\ Mpa \quad \sigma 2 = 7606.1\ Mpa$$

3.2 FEA of New Spring

Finite element analysis of the concentric spring is carried out prior to manufacturing which indicates the deformation and thermal stresses acting on the perforated pipe and welding points. FEA of the concentric spring is as shown below

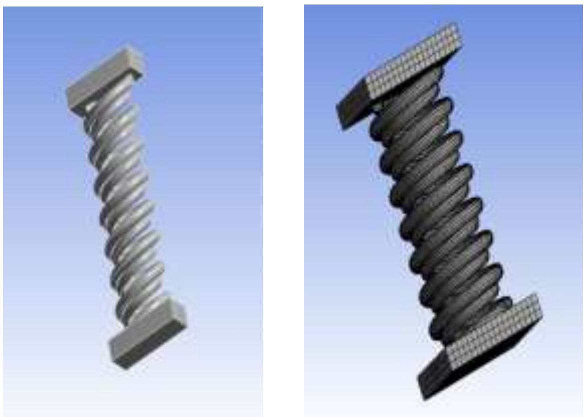


Fig -9: Geometry and Meshing

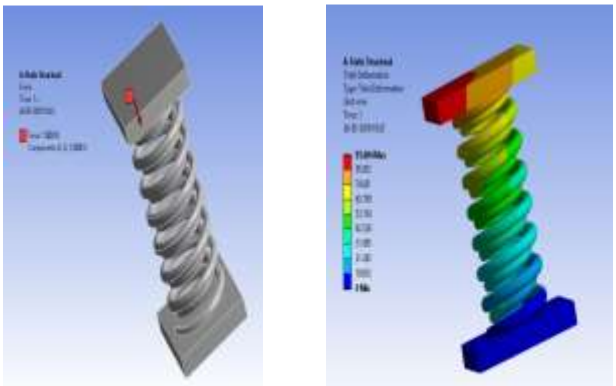


Fig -10: Load and Deformation

3.3 Experimentation

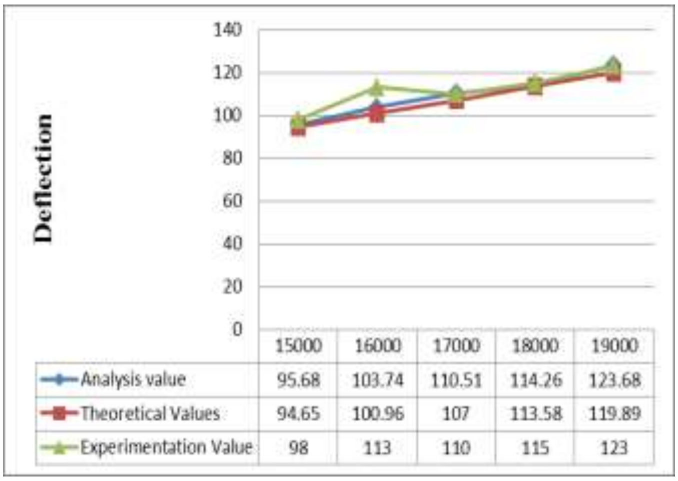
Fig -11: Wire Coiling Machine

Fig -12: Spring Testing Machine

TABLE I Observation Values

Sr. No.	Load (N)	Analysis value	Theoretical Values	Experimentation Value
1	15000	95.68	94.65	98
2	16000	103.74	100.96	113
3	17000	110.51	107	110
4	18000	114.26	113.58	115
5	19000	123.68	119.89	123

4. RESULTS



5. CONCLUSIONS

Study reveals the important facts regarding the reasons behind failure of the die set mechanism. Design and development of the concentric spring for the same application is crucial for application and requires greater attention for the same.

While designing the new spring these design parameters will be the immense important for efficient working of the process.

[1] Spring index plays an important role for its proper functioning

[2] The various causes of spring failure can be identified and eliminated with its proper study

[3] The max allowable deflection for 15000 N load is 100 mm which is easily achieved through this concentric spring whereas the earlier deflection was 125 mm for the same load

[4] The spring rate achieved on helical compression spring was 119 which is much lower than the spring rate obtained through the concentric spring i.e. 158

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