Scientific Journal of Impact Factor (SJIF): 4.14
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 3, Issue 9, September -2016

PREDICTION OF FATIGUE LIFE OF COLD FORGED PUNCH FOR FASTENER MANUFACTURING BY FEA

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Abstract-*Mechanical fasteners are becoming key part of every assembly in all manufacturing industry. The fasteners provide ease of disassembly & reassembly, ability to join similar or different materials in a wide variety of sizes, shapes & joint designs. They are having low manufacturing cost, readily available in variety of mass produced sizes, installation doesn't adversely affect base materials, no surface preparation or cleaning is required. Effectiveness of mechanical fasteners depends upon material of fastener, fastener design including load bearing area of head, hole preparation & installation procedure. Effective use of fasteners achieve uniform load transfer, minimum of stress concentration & uniformity of installation torque or interference fit. These are most widely used because they are easy to install, remove or replace. Most standard varieties are interchangeable. Selection of specific fastener or fastening method depends primarily on materials to be joined, function of joint, strength & reliability requirements, weight limitations, dimensions of components, environmental conditions.[8]*

Keywords: Cold Forging, Cyclic loads. Dies, Fatigue life, FEA, Punches, Stress Analysis.

1 .INTRODUCTION

This research will focus on the development and improvement of an innovated and integrated approach consists of an integrated CAD, FE analysis and analytical system to efficient determine the potential fatigue area and to predict punch fatigue life in cold forging operation for fastener. The punch and die material behaviors of AISI D2 were used in simulation and stress life approach. Number of cold heading punch life cycle has been calculated. In the work piece deformation analysis, the work piece was modeled as a deformable body in order to determine the forging load of interaction between punch and deforming material, while the punch, bottom die and ejector pin were considered as a rigid body. On the other hand, for the die stress analysis, the punch of the die set was modeled as elastic body meanwhile the work piece, bottom die and ejector pin were considered as rigid bodies to estimate the punch elastic deformation and the dimensional accuracy of forged component. The elastic deformation characteristic and stress concentration on heading punch were investigated to predict the number of fatigue life on the punch.

Mechanical fasteners are becoming key part of every assembly in all manufacturing industry. The fasteners provide ease of disassembly & reassembly, ability to join similar or different materials in a wide variety of sizes, shapes & joint designs. They are having low manufacturing cost, readily available in variety of mass produced sizes, installation doesn't adversely affect base materials, no surface preparation or cleaning is required. Effectiveness of mechanical fasteners depends upon material of fastener, fastener design including load bearing area of head, hole preparation & installation procedure. Effective use of fasteners achieves uniform load transfer, minimum of stress concentration & uniformity of installation torque or interference fit. These are most widely used because they are easy to install, remove or replace. Most standard varieties are interchangeable. Selection of specific fastener or fastening method depends primarily on materials to be joined, function of joint, strength & reliability requirements, weight limitations, dimensions of components, environmental conditions. Mechanical fasteners are manufactured by cold working process. It is fundamental process because it is economical, quicker & easier to handle as no extra arrangements for heating and handling are necessary. Mechanical properties normally get improved during process due to strain hardening. Also control of grain flow directions adds to the strength characteristics of the product**.**

1.1 Problem Statement-

During cold working metal is pressed under high pressure into high strength die in which large strains are occurring on work piece. The punch undergoes high cyclic loading .It has to resist heat abrasion & pressure. It has to withstand severe strains. Thus tools for cold working mainly fail due to cyclic fatigue .Tool costs can reach a significant portion of production costs about 30% So methods to improve tool life are of high interest In competitive environment, tool maker should produce punches at low cost but without degrading its quality .In this paper fatigue life of punch is improved by using suitable punch material (AISID2).

1.2 Objective-

The main objective is to predict fatigue life of cold forged punch used for fastener manufacturing.

1.3 Scope-

Here we are going to calculate fatigue life of cold forged punch analytically . Validate these results by using ANSYS14 software.

1.4 Methodology-

Here we are going to calculate fatigue life of cold forged punch analytically . Validate these results by using ANSYS14 software.

1.4.1 Punch-

Punch service life is defined as maximum number of products produced before it fails. Punches will fracture during extrusion & upsetting process.Metallurgical investigation of fractured extrusion punches shows brittle mode of failure. Impact strength increases with decreasing hardness. [1] The punch should be strong enough to withstand stripping forces , should not deflect and not rotate as a result of cutting action .Deflection of punches may be avoided by making shank diameter of punch larger than cutting diameter. Punches are usually held in a steel punch plate of punch holder which is again clamped to the lower end of ram.

1.4.2 Punch Design-

The following characteristics should be considered while designing punches:

i) Punches should not defect during use
ii) Punches should be of proper hardness
iii) They should be strong enough to withstand forces
i) They should not rotate as a result of cutting action.

Punch holder –It is used to mount punch either directly or through a back plate & retainer.

1.4.3 Punch material- AISID2 [2]

AISI : American Iron and Steel Institute D2 : For deep drawing quality (D1- For drawing quality and D3- For extra deep drawing quality).Type D2 is most widely used steel in United States for cold work tooling. It is air hardening steel. It contains very large chromium carbides which promotes abrasion resistance and excellent wear resistant characteristics. It has an outstanding record for freedom from cracking & minimal size change in hardening.[8]

Table1. Chemical composition of AISID2 steel (weight %) :

Elements	C	Si	Mn	Mo	Cr	Ni	V	Co	Fe
Weight %	1.5	0.3	0.3	1.0	15	0.3	0.8	1.0	79.8

Mechanical & Thermal properties of AISID2 tool steel at room temperature :

Density 7700Kg/m^3
Poisson's ratio 0.27-0.3
Elastic modulus 1.9-2.1GPa
Tensile strength 1736MPa
0.2% offset yield strength 1532MPa
Hardness (HRC) 57
Thermal expansion (at 20-100) $10.4 * 10^{-6}$

Raw material is available in rolled coils. These rolled coils are having high hardness (200-220 BHN). For softening, these coils are given special heat treatment called spherodised annealing (hardness-150 BHN Max.). Work piece is coated with a coating of MoS_2 (Molybdenum disulphide) to avoid friction between punch, die and work piece in order to increase life of die and punch. Steps involved in fastener manufacturing by cold forging – It involves progressive forgings. Sheering, forming (1^{st} and 2^{nd} or 3^{rd} Forming).

While designing a punch following factors should be considered

i) Easier fitting & removal of punch
ii) Alignment of punch & die
iii) Adequate provision of screws to overcome stripping force
iv) Prevention of rotation of punch.

The punch dimensions should be checked for strength & deflection. [9]
Punch length-
The maximum allowable punch length (Lm) is calculated using following formula:
$Lm = \pi D /8[(E*D)/ (fs*t)]^{1/2}$
Where,
D=Diameter of punched hole
Fs=shear stress
t=material thickness
E=modulus of elasticity of punch material
Where D/t=1.1 or higher
Punch material should have sufficient compressive strength.
Punch Holder: Thickness varies between 25 to 75 mm.
Punch Plate: Thickness of punch plate =1.5*D
Both punch holder & punch plate are made of cast iron.

2 . LITERATURE REVIEW

Raja V, Sornakumar T published paper on punch life improvement in cold forging of
Nut. They focused on methodology to improve the punch life in cold forging of nut. Production cost is one of the major concerns in cold forging industry. Punches will fracture during extrusion and upsetting
process. The metallurgical investigation of fractured extrusion punches shows brittle mode of failure. The impact properties of punch materials need to evaluate to control the brittle fracture. It is important to note down that the impact strength increases with
decreasing hardness. Hence by changing tempering temperature it is possible to change the hardness of the punch material. The aim of this paper was to improve the life of 3^{rd} station punches without increasing the punch production cost so much. There have been several literatures referenced to
explore the importance of impact loading in cold forging tool materials.[1]
Sudharshan H.K, Hemanth.R presented paper on study of split punch and die of the sheet metal blanking process for length component. They presented a study of Split Punch and Die of Sheet Metal Blanking Process for Length Component. The Component with 740mm length is considered and Analysis of Punch and Die was carried out for study. The Split Punch and Die techniques introduced is being studied in this paper and it is the most applicable technique for the lengthy components. Sheet metal parts are widely used in products of high complexity and precision such as vehicles, aircraft and other automobile related products. Therefore, the press process has been identified as one of the most important manufacturing processes. During Blanking Process the force acting is more between the punch and die, failure or damage may occurs as reaches some production, so need to replace the punch and die as damages occurs. For small components punch and die can easily replaceable, easy maintenance, easy handling, less time consuming and low cost. As we consider lengthy components punch and die the manufacturing, heat treatment, maintenance, handlings need more time and cost is also very high. By integrating the split method of punch and die will be highly beneficial also helps to reduce the cost and time for heat treatment, easy replaceable of damaged parts, easy maintenance, easy handling, good life and durability can be achieved.[2].
Dr D Ramegowda, Madhusudhana. M, had designed blanking punch and die for cam head washer component using finite element
Analysis. The analysis of punch and die performed using the computer aided engineering software has been successfully executed for the evaluation of maximum transverse deflection and stresses. The results taken by this analysis will be very useful to the designers and thereby saving lot of time and avoiding costly tryouts. Cam head washer was used as component(cold rolled carbon steel sheet designation: IS: 513 grade D) [3].

Dr D Ramegowda, Madhusudhana. M presented paper on design of blanking punch and die for cam head washer component using finite element analysis .They designed blanking punch and die for cam head washer component using Finite element analysis. Design analysis of various types of punches with special attention to their cutting profiles, using the finite-element technique.

Results obtained by the finite-element analysis of the punches enable the drawing of specific conclusions with regard to the selection of punches in practice for minimum distortion of the punch and reduced stress on the punch.[4]

A. R. Ab –Kadir , A. R. Othmanb , A. B. Abdullahb , Mohd Riduan Ibrahim, Mohd Suyerdi

Om and Mohd Hairizal Osman conducted to analyze the potential fatigue area in term of stress distribution, punch elastic deformation and forging load and calculated the number of life cycles of the punch by using the integrated system combined a finite element analysis (DEFORMTM F3 version 6.0) and stress-life approach are presented. The fatigue life analysis was utilized by taking into account the modification factors and to improve punch performance where case studies are performed with the modification in corner radius of punch design. There are four punches with different corner of radius sizes were modeled; sharp edge, 1.0 mm, 2.0 mm and 3.0 mm. The number of life cycles of the punch has be successfully predicted and improved, as discussed in the result discussion of the cold forging of a fastener, through changes in punch design (corner radius). The sizes of corner radius of punch were optimized to obtain the maximum number of fatigue life. Corner radius 3.0 mm was found to be the optimum punch to obtain maximum number of fatigue life with minimum stress concentration while enhancing punch performance. [5]

Khaleed Hussain M.T. Samad conducted a study on cold forging die design using different techniques. It is a review of the existing die design techniques which are used in forging process to enhance the die design and to optimize die design process which will improve the performance of die. In cold forging the die will under go high loads, hence it is essential to know Fatigue behavior and Fatigue Failure of the die when it has been under go cyclic loading. The study end up with future challenges of the die design and its processes, the approaches adopted to develop an optimum system that can fulfill the customer demand. [6]

Dr NWM Bishop, MSC Frimley and Alan Caserio . MSC Costa Mesa conducted finite element based fatigue analysis. This paper will deal with the issues associated with how fatigue techniques can be incorporated into the FE environment. Modern examples of FE based fatigue design will be included.[7]

Akgermann et al had given empirical guidelines for preform design of H-section. From the customer's point of view this entails some additional machining but in fact this is more than offset by the consistency of the forging and the increased die life Depending on the geometry of the component, the die-parting line separating the top and bottom impressions.[8] Chamouard had given a more general approach to perform design based on the natural metal flow theory . According to this theory ,metal when allowed to flow freely, tends to flow along a logarithmic curve in the direction of forging .He thus developed guidelines for the use of such curves in performs for joining the web and nb portions of the forgings .His work has been used in slightly modified form by many researchers .[9]

Hendrik Muntinga presented an approach for improving cold & warm forming process quality & economical efficiency by means of computer simulation. He studied damage problems in cold forging against increasing number of cycles. He applied ductile damage model for prediction of die life subjected to low cycle fatigue.[10]

M. Meidert and C. Walter predicted of fatigue life of cold forging tools by fe simulation and comparison of applicability of different damage models like Smith-Watson-Topper (SWT) damage model, Bergmann damage model, H¨ansel damage model, Modified H¨ansel damage model. He carried out simulations using the commercial Finite Element (FE) program systems DEFORM[5] und ANSYS [6] available at the Krupp-Presta company.[11]

E.Paul DeGARMO, J T BLACK,RONALD A KOSHER ,Materials & Processes in Manufacturing, Eighth Edition.[12]

G.R. Nagpal ,Metal Forming Processes , Second Edition.[13]

3. FATIGUE TESTING MACHINE

3.1 Experimental Set Up-This testing machine will determine the strength of materials under the action of fatigue load. Specimens are subjected to repeated varying forces or fluctuating loading of specific magnitude while the cycles or stress reversals are counted to destruction. The first test is made at a stretch that is somewhat under the ultimate strength of the material. The second test is made at a stress that is less that than that used in the first. The process is continued, and results are plotted. The fatigue-testing machine is of the rotating beam type. The specimen functions as a single beam symmetrically loaded at two points. When rotated one-half revolution the stress in the fibres originally above the neutral axis of the specimen are reversed from compression to tension for equal intensity. Upon completing the revolution, the stresses are again reversed, so that during one complete revolution the test specimen passes through a complete cycle flexural stress. The fatigue testing machine consists of the following components:[7]

A. AHP electric motor, B. Bearing and its housing assembly
C. Weight hanger assembly D. Dead weight
E. Bearing spindling F. Digital counter
G. Magnetic cyclic pick up (dynamo)
H. Variable speed control I. Switch, J. Specimen
K. Drill chunks, L. The metal desk

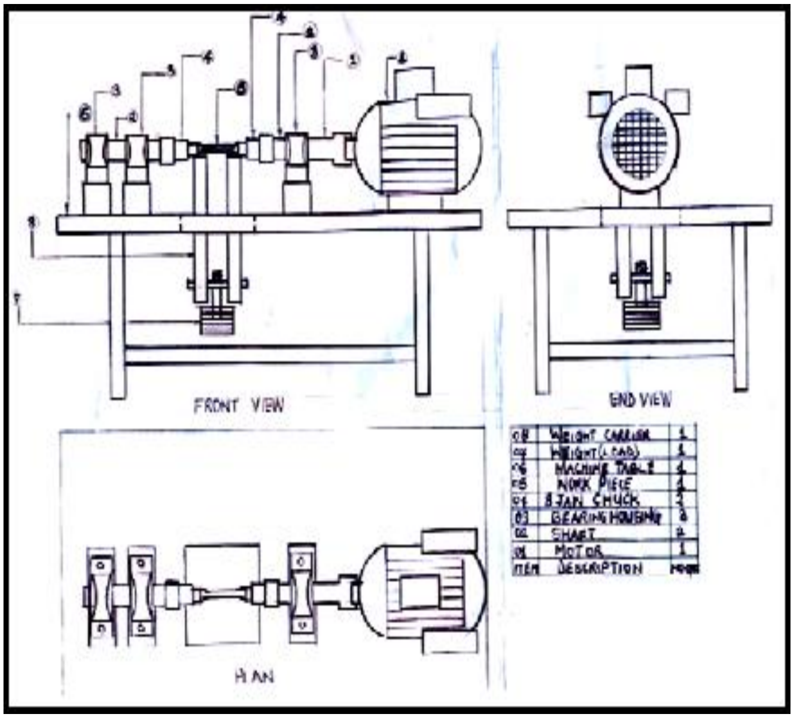

Fig.1: The isometric views of the fatigue-testing machine [3]

3.2 Setting Up The Machine:

The base should first of all be set leveled so that the weight will hang perpendicularly to the axis of the specimen. Wires in conduct from the power supply are run to the connecting block in the base of the machine and soldered to the lugs provided. The machine is equipped to operate from an AC power source at 120volts, 60 cycles, and single phase. Motor and relay equipment to operate from a power source of different rating can be provided on special order. With mild steel legs, the machine is set on five rubber tires. The weight hanger is of such length that it will clear the desk since it is mounted on the legs. A shock absorber in the hanger prevents the slight vibration of the housing from being impacted to the weight. The base is provided with holes so it can be bolted down if desired.

Assemble the housing with a sample of specimen provided in accordance with the direction given below, and start the machine to see if there is any misalignment. This will be indicated by noise and vibration. Examine the housing wind for oil. It should stand about midway of the windows when the machine is idle. Adjust the speed to 1,400 RPM by means of a rheostat in the base of the machine. The machine should now be ready for a test.

3.3 Speed:

The normal speed is 1,400RPM. The speed depends on the voltage. If the voltage of the supply line exceeds the proper amount of sliding rheostat in the base of the machine should be adjusted so that the speed cannot exceed 1,400RPM under ordinary conditions. Speeds in excess of the normal will cause no damage unless continued to long. In adjusting the speed take care that the contraction of the rheostat makes firm contact with the exposed potion of the winding. If it desired to run at speed below 1,400 rpm, or gradually increase the speed from zero, a variable resistor can be placed in the motor lead wires by utilizing the plug type connector. This will be necessary only in exceptional cases where the slight starting torque exerted on the specimen may be objectionable. The inertia of the motor armature is such in comparison with that of the remote half of the spindle that there is sufficient delay in starting for most purposes.

When fatigue stress is induced on a material due to the action of force reversing and fluctuating, a failure known as fatigue failure takes place. The study and test conducted so far shows that fatigue failure cannot be predicted accurately since material failure under fatigue are affected not by just reversal loading alone but also the number of revolution (cycle per minute) and fluctuating stress and other factors such as temperature, atmospheric condition, both internal and external defect on material subjected under fatigue stress. Such defect includes notch, inclusion, stress concentration and non-homogeneity.

Modelling of Punch:

3.4 Calculations:
Allowable shear stress,
fs=ultimate tensile strength/(2*factor of safety
$Fs= 1736/(2*8)=108.5 N/mm^2$
3.4.1 Shear Force-
The force required to penetrate the stock material with the punch is the cutting force. The formula for determining cutting forces takes into account the thickness of the work material, the perimeter of the cut edge, and the shear strength of the stock material. The cutting force is calculated below
Cutting/Shear force = (L x t x fs)=(ΩDtfs)
= Ω*15*3*108.5
=15338.83N
= 15.338 KN
Where,
L= perimeter of cut edge =ΩD
t = thickness of the work material
fs = shear strength of the stock material
3.4.2 Clearance **-**
Clearance is defined as the intentional space between the punch cutting edge and die cutting edge. Clearance is expressed as the amount of clearance per side.
Cutting Clearance = c x t x (√fs /10)
= 0.04 x 3x (√108.5/10) **=** 0.124 mm/side
Where
c = Constant = 0.04 for hard steel component.
t = thickness of the work material
fs = shear strength of the stock material
3.4.3 Maximum allowable punch length**-**
$Lm=\Omega D/8(E/fs*D/t)^{1/2}$
$=\Omega*15/8(209/108.5*15/3)^{1/2}$
=3.231 mm

4. FATIGUE THEORY

The **fatigue limit** has historically been a prime consideration for long-life fatigue design.
For a given material the fatigue limit has an enormous range depending on: surface finish, size, type of loading, temperature ,corrosive ,and other aggressive environments, mean stresses ,residual stresses, and stress concentrations. Fatigue limit based on a nominal alternating stress, Sa: Can range from essentially 1 to 70 percent of the ultimate tensile strength. Example of a case where the fatigue limit may be approximately 1 percent of Suis a high strength steel with a sharp notch subjected to a high mean tensile stress in a very corrosive atmosphere An example of a case when the fatigue limit might approach 70 percent of Suis a medium strength steel in an inert atmosphere containing appreciable compressive residual stresses.

4.1 Mean Stress effects On S-N Behavior:
The mean stress, Sm, can have substantial influence on fatigue behavior.
In general, tensile mean stresses are detrimental and compressive mean stresses are beneficial.

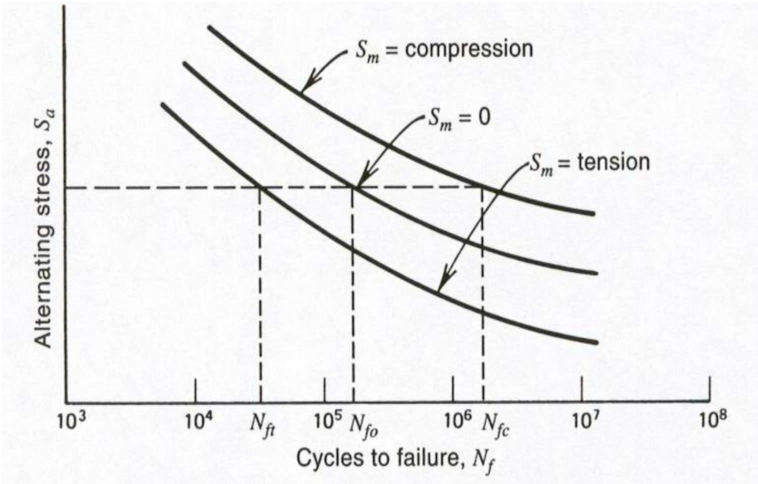

Fig 2 S-N behavior

Fig. 3 Constant Amplitude Loading
The reference fatigue condition for S-N
Behavior is usually fully reversed R= -1 bending or axial loading using small un notched specimens. In addition to mean stress many other factors also affect the reference fatigue condition.

4.2 Constant Amplitude Loading-
Minimum stress, **Smin**
Maximum stress, **Smax**
Stress range, ΔS   Alternating stress, **Sa**
Mean stress, **Sm**
Stress ratio, **R**
Fatigue Loading:
Sa= Δs/2= (Smax-Smin) /2
Sm= (Smax+Smin) /2
Smax =Sm+Sa
Smin=Sm-Sa
R=Smin/Smax
A=Sa/Sm
Stresses can be replaced with load, moment, torque ,strain ,deflection or stress intensity factors.
R= -1 and R= 0 are two common reference test conditions used for obtaining fatigue properties.
R= -1 is called the fully reversed condition since Smin= -Smax.
R = 0, where Smin = 0, is called pulsating tension.
One cycle is the smallest segment of the stress versus time history which is repeated periodically.
Under variable amplitude loading, the definition of one cycle is not clear and hence reversals of stress are often considered .In constant amplitude loading, one cycle equals two reversals.

4.3 ASTM Standard Practices Related to Fatigue Testing of Metals:
i)E466 Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials.
ii) E467Verification of Constant Amplitude Dynamic Forces in an Axial Fatigue Testing System.
iii) E468Presentation of Constant Amplitude Fatigue Test Results for Metallic Materials.
iv) E606Strain-Controlled Fatigue Testing.
v) E647Measurement of Fatigue Crack Growth Rates.
vi) E739 Statistical Analysis of Linear or Lineralized Stress-Life (S-N) and Strain-Life (Ɛ-N) Fatigue Data.[6]

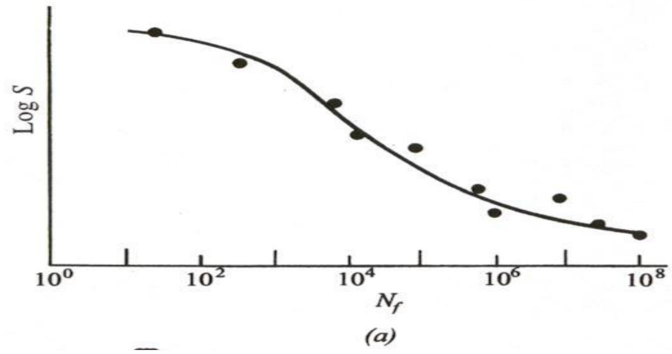

Fig.4 Stress-Life Curves

Understanding of the fatigue mechanism is essential for considering various technical conditions which affect fatigue life and fatigue crack growth, such as the material surface quality, residual stress, and environmental influence. This knowledge is essential for the analysis of fatigue properties of an engineering structure. Fatigue prediction methods can only be evaluated if fatigue is understood as a crack initiation process followed by a crack growth period. The fatigue life is usually split into a *crack initiation period* and *a crack growth period.* The initiation period is supposed to include some micro crack growth, but the fatigue cracks are still too small to be visible by the unaided eye. In the second period, the crack is growing until complete failure. It is technically significant to consider the crack initiation and crack growth periods separately because several practical conditions have a large influence on the crack initiation period, but a limited influence or no influence at all on the crack growth period.

4.5 Various steps in the fatigue life are indicated in Figure 5. The important point is that the fatigue life until failure consists of two periods: the *crack initiation period* and the *crack growth period.* Differentiating between the two periods is of great importance because several surface conditions do affect the initiation period, but have a negligible influence on the crack growth period.

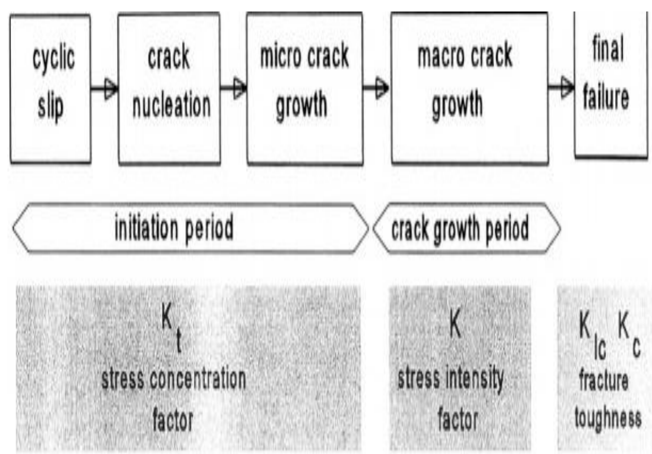

Fig 5 Different Phases of Fatigue Life & Various Factors.

4.5.1 Crack initiation:

Fatigue crack initiation and crack growth are a consequence of cyclic slip in slip bands. It implies cyclic plastic deformation as a result of moving dislocations. Fatigue occurs at stress below the yield stress. At such a low stress level, plastic deformation is limited to a small number of grains of the material. This micro-plasticity can occur more easily in grains at the material surface because the surrounding material is present at one side only. As a consequence, plastic deformation in surface grains is less constrained than in subsurface grains; so it can occur at a lower stress level. In the crack initiation period fatigue is a material surface phenomenon.

4.5.2 Crack growth:

As long as the size of the micro crack is still in the order of a single grain, the micro crack
is obviously present in an elastically anisotropic material with a crystalline structure and a number of different slip systems. The micro crack contributes to an inhomogeneous stress distribution on a micro level, with a stress concentration at the tip of the micro crack. As a result, more than one slip system may be activated. Moreover, if the crack is growing into the material in some adjacent grains, the constraint on slip displacements will increase due to the presence of the neighboring grains. Similarly, it will become increasingly difficult to accommodate the slip displacements by a single slip system only, i.e. on parallel crystallographic planes. It should occur on slip planes in different directions. The micro crack growth direction will then deviate from the initial slip band orientation. In general, there is a tendency to grow perpendicular to the loading direction. Crack growth resistance, when the crack penetrates into the material, depends on the material as a bulk property. It is no longer a surface phenomenon.

5.SIMULATION PROCESS

5.1 Analysis Data:

Force: 15340 N
Punch length: 3.231 mm
D= 15mm
Unit area A= 3.14* 15* 1 = 47.1 sq. mm
Take punch load = 1.5 * actual force = 23010 N
Hence, pressure = 23010 / 47.1 = 488.53 N / sq.mm
Density = 7700Kg/m^3
Poisson's ratio= 0.27- 0.3
Elastic modulus = 1.9 - 2.1GPa
Ultimate tensile strength = 1736MPa
Take FOS = 8
Allowable tensile strength = 1736/8 = 217 M Pa
Thermal expansion (at 20-100) 10.4 *10^{-6} / deg. C

5.2 Structural Analysis:

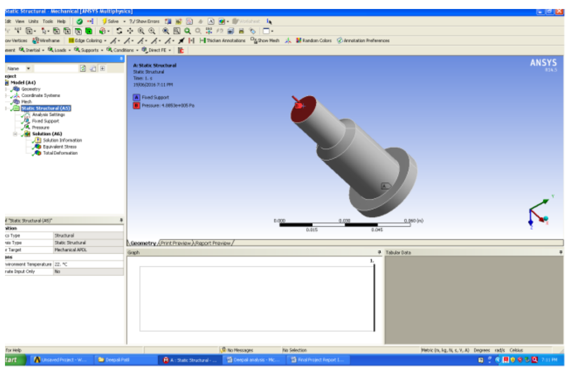

Fig.6 Structural Analysis

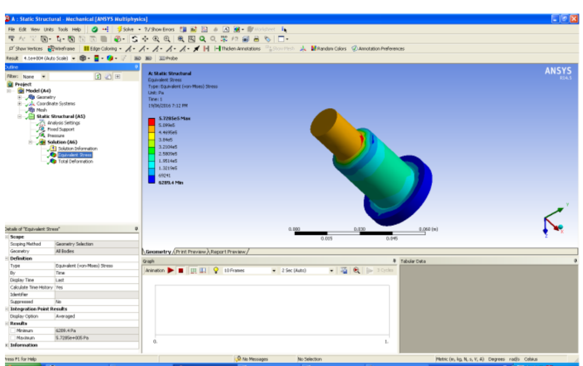

Fig.7 Stresses Induced

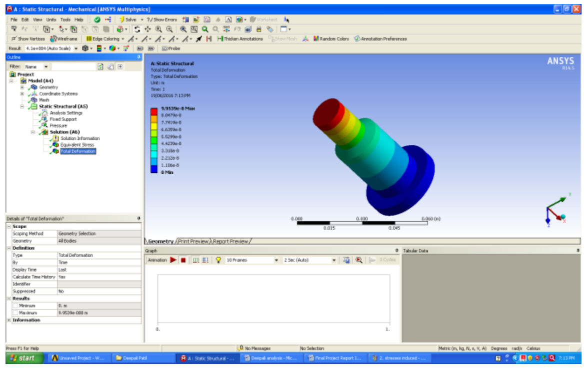

Fig.8 Structural Deformation

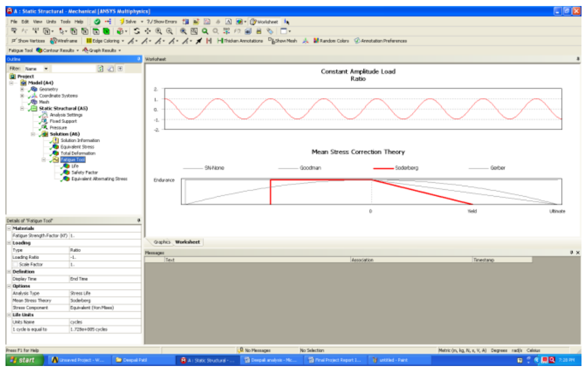

Fig.9 Fatigue Analysis

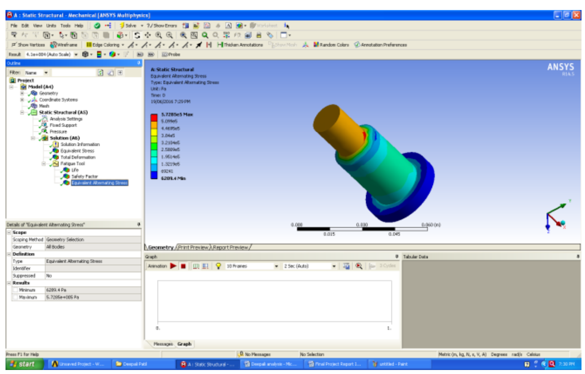

Fig.10 Fatigue Analysis (Alternate stress)

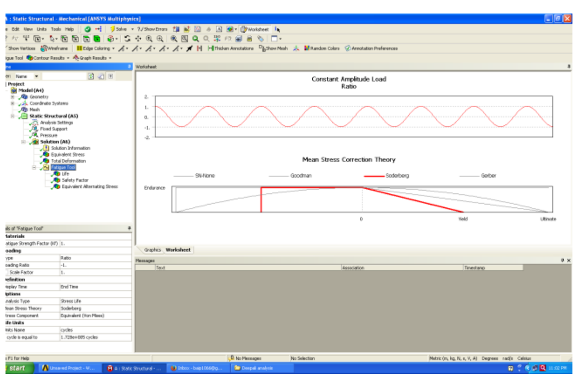

Fig.11 Goodman Diagram

Simulation Results:
For both static & alternating loads both pressure & deformation are equal.

6. FINITE ELEMENT ANALYSIS

Finite Element Analysis is a simulation technique which evaluates the behavior of components, equipment's and structures for various loading conditions including applied forces, pressure and temperature. Finite element analysis is a computerized method for predicting how a real object will react to forces, heat, vibration, etc. by mesh of simpler interlocking structures, the simpler structures or finite elements being amenable to mathematical analysis. The analysis of whole structure is obtained by simultaneously analysis the individual finite elements, having due regard to their individual positions within the mesh and being totally dependent upon the assistance of an automatic computer. Numerical modeling of metal forming processes has now gained the industrial stage, and it became possible to simulate metal deformation and to calculate stress and strain states for complex processes.
Nowadays, the finite element method (FEM) has proven its efficiency and usefulness simulating steady and non-steady metal forming processes. When the modeling approaches are deterministic requiring the introduction of several input data such as geometry,mesh,non-linear material behavior laws, loading cases, friction laws, thermal laws, then the computation of process evolution and final results is called a direct problem.[3]
The various steps involved in the finite element analysis are: (i) Select suitable field variables and the elements.
(ii) Discritise the continua.
(iii) Select interpolation functions.
(iv) Find the element properties.
(v) Assemble element properties to get global properties.
(vi) Impose the boundary conditions.
(vii) Solve the system equations to get the nodal unknowns.
(viii) Make the additional calculations to get the required values.

7 SUMMERY

The study and test conducted so far shows that fatigue failure cannot be predicted accurately . Since material failure under fatigue are affected not by just reversal loading alone but also the number of revolution (cycle per minute). Fluctuating stress and other factors such as temperature, atmospheric condition. Both internal and external defect on material subjected under fatigue stress. Such defect includes notch, inclusion, stress concentration and non-homogeneity.

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