Analysis and Optimization of Wire Drawing Process

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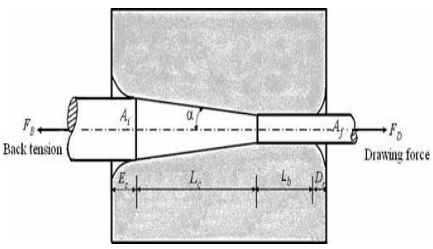
***Abstract*—The finite element method is a numerical analysis tool for analyzing complex problems. We have taken the problem of understanding wire drawing process from Avitzur's theory 'Wire Drawing through Conical Dies of small cone angles'. This theory was used to obtain the drawing load. Wire is drawn through dies with Land and With Land & Fillet. We find that the provision of die land and fillet at entry made the flow smooth and die safe i.e., operate low stresses and low heat generation due to friction and contact pressure. Hence least wire drawing defects and die life increased. Loads were applying to the finite element model treating the problem to be axisymmetric. The problem to be solving by using ANSYS a popular FEA software package.**

Keywords*—FEA, ANSYS, wire drawing, ,With Land and With Land & Fillet dies.

INTRODUCTION TO WIRE DRAWING

Wire is one of the most important products required by man. Endless lengths of wire are used in the form of conductors in communication and power transmission. Enormous quantities of wire are used for fencing, cables for bridges and hoists. The products require correct dimension, surface finish and mechanical properties. Sizes vary from fraction of an inch to thousands of an inch. Wires are produced by the process of wire drawing.



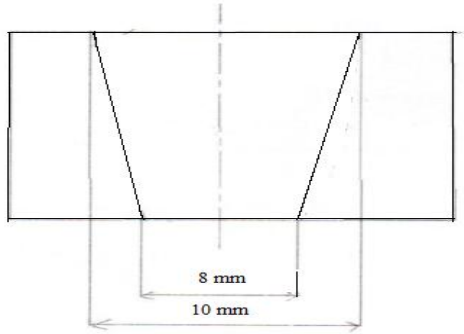
Fig(1) : Wire drawing through die

INTRODUCTION TO ANSYS

ANSYS° is general purpose finite element analysis software developed. Supported and marketed by ANSYS°. Inc., formerly Swanson Analysis Systems, Inc., founded in 1970 by Dr. John . ANSYS simulation solutions are used by several Fortune 500 companies to produce a wide range of products including aircraft and automobile engines, spacecraft, computer chips, buildings, office furniture and medical devices.

PROBLEM DEFINITION

A Wire drawing die of length 8mm is required to reduce a wire from 10mm to 8mm dia. outer dia of the die being 18 mm. Die materials Tungsten carbide, Wire material AISI. 4340 steel



Fig(2) : Plain die

TABLE I
MATERIAL PROPERTIES

Properties	Die Material (Tungsten carbide)	Wire Material (AISI No 4340)
Density, ρ	15630 Kg/m^3	7850Kg/m^3
Young's Modulus	5.5×10^5 Mpa	2.1×10^5 Mpa
Thermal Conductivity, K	84.02 W/mK	44.5W/mK
Specific Heat. C_p	292 J/KgK	460 J/KgK
Passion's Ratio, υ	0.22	0.3

LOAD CALCULATION

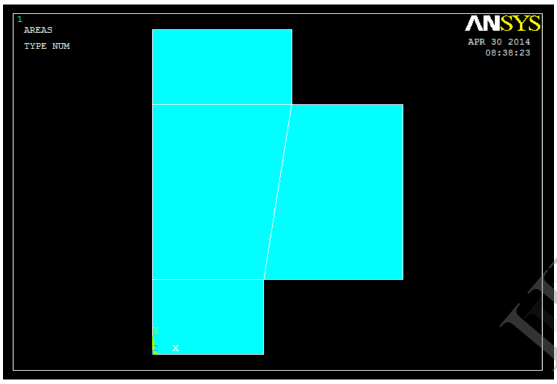
B= μ / tan α = 0.1 / tan 7.125 =0.8
Where μ = coefficient of friction (taken 0.1 - cold drawing)
Tan α = 1 / 8
Draw stress $\sigma_{xa}=\sigma_{xo}\,[(1+B)\,\{1-(D_a/D_b)^{2B}\}/B]$
$=744[(1+0.8)\{1-(4/5)^{2*0.8}\}/0.8]$
$= 502.16$ Mpa

σ_{xa} = Draw stress
σ_{xo} = Yield strength of wire (744 Mpa)σαμ
D_a = Exit diameter of die
D_b = Entrance diameter of die

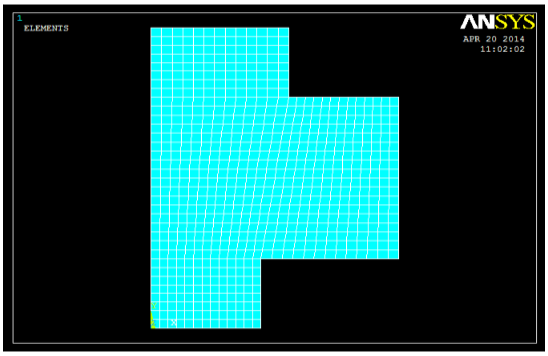
% of Reduction $= \{1-(D_a / D_b)\} \times 100$
$= \{1-(8/10)\}\times 100$
= 20%

WIRE DRAWING THROUGH PLAIN DIE

(A) Modelling



(B) ANSYS Meshed Models



ANSYS SOLUTION, RESULTS AND DISCUSSIONS

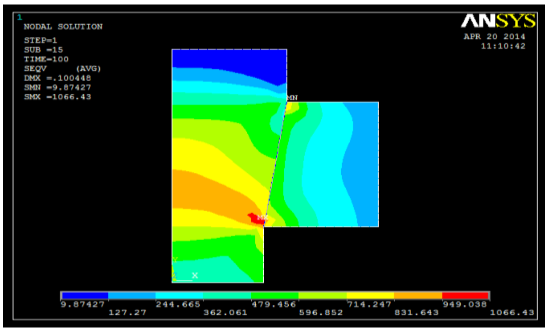


Fig (5): Von Misses Stress:

The maximum stress induced at the exit of the die. In wire stress is very large than that is necessary to cause uniform yielding.

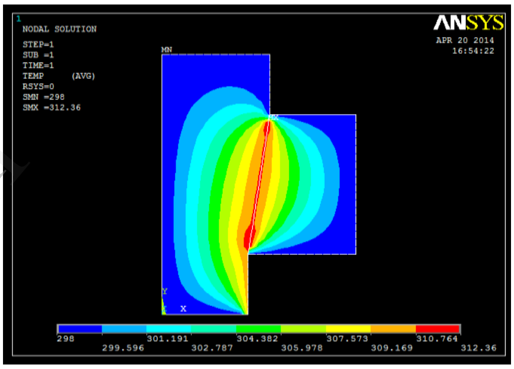


Fig (6): Nodal temperature by Generation Due To Friction

Maximum heat generated over the contact length between wire and die due to friction and contact pressure. Peak temperature (312.36k) generated at entrance and exit of the die.

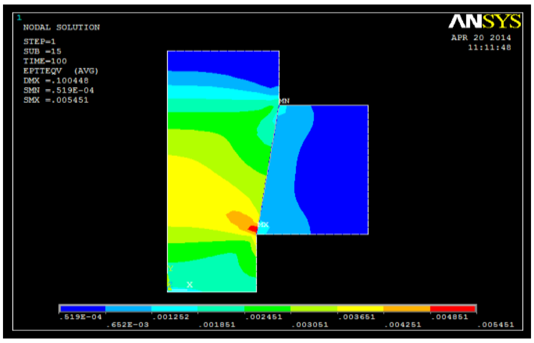


Fig (7): Total Thermal and Mechanical Strain

Maximum total thermal and mechanical strain was observed at exit of the die. That is strain occurs very low and negligible.

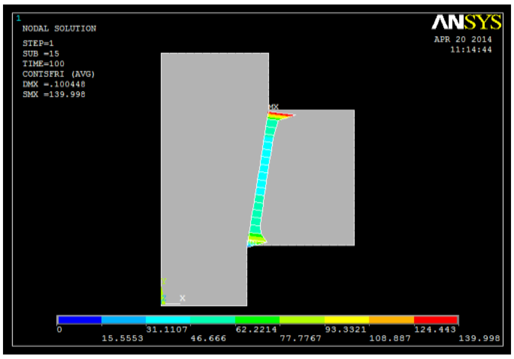


Fig (8): Contact Friction Stress

Maximum contact friction stresses was observed at exit and entry portion of the die. Minimum contact friction stresses observed between exit and entry portion of the die. Therefore peak contact friction stresses (139.998 Mpa) was observed at entry portion of the die.

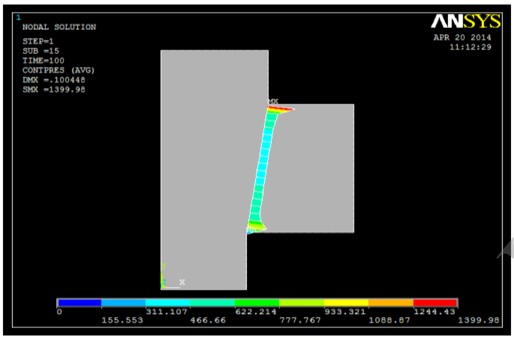


Fig (9): Contact Pressure:

Peak contact pressure (1399.98 Mpa) was observed at entrance of the die. Maximum contact pressure was observed at exit and entry portion of the die. Minimum contact pressure observed between exit and entry portion of the die

Peak contact pressure was observed at entrance of the die. It has reached maximum value at entrance and exite of the die. Therefore die defects likely occur.

It is there felt to create fillet at entrance portion of the die and land at exit portion of the die.

Contact Friction Stress:

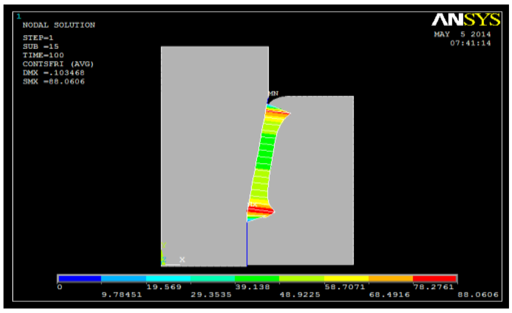


Fig (10): Contact Friction Stress after creating die land and fillet

contact friction stresses was found to gradually increase from entry unlike what has happened without filter maximum contact friction stresses was observed at exit portion of the die. Minimum contact friction stresses observed between exit and entry portion of the die. Peak contact friction stresses was observed at exit portion of the die.

Therefore maximum contact friction stresses was decreased by creating fillet at entrance and land at exit portion of the die.

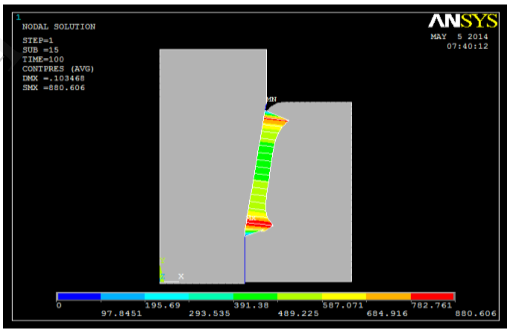


Fig (11): Contact pressure after creating die land and fillet

Contact pressure was found to gradually increase from entry unlike what has happened without filter .Peak contact pressure (880.606 Mpa) was observed at exit of the die. Maximum contact pressure was observed at exit and entry portion of the die. Minimum contact pressure observed between exit and entry portion of the die

Therefore maximum contact pressure was decreased (up to 500 Mpa) by creating fillet at entrance and land at exit portion of the die.

CONCLUSIONS

Theory of wire drawing was sufficiently studied. Performing the analysis of both wire drawing process and enabled us to understand what is the drawing load required to carry out the drawing process fruitfully ie., with no wire defects and safe die.. Both these ideas led to further improvements i.e., incorporation of die land and filleting at the entry. The use of the powerful tool ANSYS Analysis has helped to observe the stresses in the wire suitable for yielding.

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