OPTIMIZATION OF BLOCKER DESIGN OF CONNECTING ROD

BY
KAMALESH SINGH
OUTLINE OF THE PRESENTATION

- JOB ANALYSIS
- PRODUCT DESIGN
- FORGING DRAWING DEVELOPMENT
- FLASH AND GUTTER DESIGN
- EQUIPMENT SELECTION
- DIE BLOCK DESIGN
- SIMULATION
- RESULT
JOB ANALYSIS

- CONNECTING ROD IS USED TO CONNECT PISTON AND CRANKSHAFT
- THE COMPONENT HAS TO BE MANUFACTURED USING PRESS BECAUSE OF FOLLOWING REASONS:
  - GREATER ACCURACY
  - HIGHER INTRICACY
  - LOWER TOLERANCE LIMIT
  - WEIGHT CONSTRAINT (WEIGHT OF COMPONENT IS 7KG)
  - FUTURE ORDERS
- FORGED COMPONENTS WEAR MORE LOAD PERPENDICULAR TO THE FIBERS RATHER THAN PARALLEL TO IT, WHICH HELPS US TO DETERMINE THE PARTING LINE
PRODUCT DESIGN

- PRODUCT DESIGN INCLUDES DESIGN OF FORGING DRAWING AND SELECTION OF PROPER PARTING LINE
- THE COMPONENT DRAWING IS CONVERTED INTO FORGING DRAWING BY ADDING ALLOWANCES TO EACH DIMENSION, WHICH ARE:
  - **MACHINING ALLOWANCES:** 1.5MM TO 2 MM MACHINING ALLOWANCE AT ALL LOCATIONS ACCORDING TO THE DIMENSIONS. HIGHER THE DIMENSION, HIGHER WILL BE THE MACHINING ALLOWANCE.
  - **FILLET EDGE RADII:** SHARP EDGES AND CORNERS LEAD TO THE PREMATURE FAILURE OF THE DIE. SOME CHANGES HAVE BEEN MADE IN THE COMPONENT DRAWING BY PROVIDING FILLET AND CORNER RADII, WHICH ARE 2, 3, 4, 8 AND 10MM AS PER REQUIREMENT.
PRODUCT DESIGN cont..

• **DRAFT ANGLES:** DRAFT ANGLES ARE USED FOR EASY RELEASE OF FORGINGS FROM THE DIE WHICH ARE 5° TO 7° AS PER REQUIREMENT IN OUR CASE.

• **STRAIGHT OR UNEVEN ALLOWANCE:** THE STRAIGHTNESS OR UNEVEN ALLOWANCE IS ADDED IN STRAIGHT DIMENSIONS SO AS TO COMPENSATE FOR BENDING & VARIATION OF STRAIGHTNESS DURING OPERATIONS, IT IS CONSIDERED TO BE 1.0 & 2.0 MM ON STEPPED PORTION. ALONG WITH THESE ALLOWANCES SOME SHAPE IS MODIFIED TO PROVIDE EASY FORGING.

• **PARTING LINE SELECTION:** CONSIDERING ALL THE POINTS AND USING PAST EXPERIENCE OF DESIGNERS, PARTING LINE IS SELECTED AS *STRAIGHT* ALONG CENTRAL LINE.
FORGING DRAWING DEVELOPMENT

- FORGING DRAWING IS DEVELOPED BY TAKING INTO CONSIDERATION THE PARTING SURFACE, THE ALLOWANCES, RECOMMENDED FILLET AND CORNER RADII.

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<tr>
<th>Description</th>
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<td>VOLUME OF FLASH</td>
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FORGING DRAWING DATA
FORGING DESIGN WITHOUT FLASH AND GUTTER
FLASH AND GUTTER DESIGN

- FLASH IS THE EXCESS METAL THAT IS EXTRUDED FROM THE FINISHER IMPRESSION DURING FORGING. IT HAS THE FOLLOWING FUNCTIONS:
  - ACTS AS A CUSHION FROM IMPACT BLOWS.
  - ACTS AS A PRESSURE RELEASE VALVE FOR THE INCOMPRESSIBLE WORK METAL.
  - ACTS AS A RESTRICTION TO THE OUTWARD FLOW OF METAL SO THAT REMOTE CORNERS AND DEEPER CAVITIES CAN BE FILLED UP.
- CARE MUST BE TAKEN WHILE DECIDING THE FLASH THICKNESS.
- LOWER THE FLASH THICKNESS, HIGHER ENERGY IS REQUIRED TO FILL THE DIE. HIGHER THE THICKNESS, THE FILLING OF DIE MAY BE INADEQUATE.
FLASH AND GUTTER DESIGN CONT.

CALCULATIONS:

FLASH THICKNESS ($t_f$) = 0.015 $\times$ $\sqrt{A}$ (FOR ANY SHAPE OF FORGING OTHER THAN ROUND AND SQUARE)

$A$ - AREA OF FORGING AT PARTING LINE

$t_f = 0.015 \times \sqrt{24100.1741} = 2.3$ MM

ACTUAL FLASH THICKNESS WILL INCLUDE BACKLASH OF MACHINE I.E. OF PRESS

ACTUAL FLASH THICKNESS = FLASH THICKNESS THEORETICAL + BACKLASH OF MACHINE
FORGING DESIGN WITH FLASH AND GUTTER

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DIMENSIONS FOR FLASH AND GUTTER
DESIGN OF PREFORM IMPRESSION

STEPS OF PREFORM IMPRESSION DESIGN:

- THE PLAN AND THE SIDE VIEW OF FORGING ARE LAID OUT TO HALF SCALE.
- THE FLASH OUTLINE FOR 10MM FLASH WIDTH IS LAID OUT.
- FORGING IS DIVIDED IN 47 DIVISIONS BASED ON THE GEOMETRIC SHAPE.
- SECTION OF LINE CUT BY THE SECTIONAL VIEW OF FORGING IS ‘a’ AND THE SECTION CUT BY THE PLAN VIEW IS ‘b’.
- THE HORIZONTAL LINES ARE DRAWN THROUGH LARGER AND SMALLER CROSS SECTION AREAS OF EACH ELEMENT FOUND AS ABOVE.
- THE AREAS OF THE ABOVE CROSS SECTIONS ARE CALCULATED AND TO EACH SUCH FLASH AREA, CROSS SECTIONAL AREA OF FLASH IS ADDED.
- FROM THESE AREAS, THE EQUIVALENT DIAMETERS ARE CALCULATED BY:

\[ D = \sqrt{\frac{4A_t}{\pi}} \]

WHERE: D-EQUIVALENT DIAMETER, A_t -TOTAL AREA (FLASH AREA + SECTIONAL AREA)
DESIGN OF PREFORM IMPRESSION CONT..

• THE DIMENSIONS ‘D’ ARE PLOTTED SYMMETRICALLY ABOUT A REFERENCE LINE USING POINTS.

• THESE POINTS ARE FINALLY CONNECTED WITH A SMOOTH CURVE.

• THE PROFILE FORMED BY THE CONNECTION OF THE POINTS, GIVES THE PREFORM CONTOUR.

• A PREFORM IMPRESSION HAVING THIS AS AN APPROXIMATE CONTOUR CAN PROVIDE SMOOTH FLOW OF METAL FROM BLANK IN TO PREFORM AND FINALLY FINISHER IMPRESSION.

• ON THE BASIS OF PREFORM PROFILE, THE PREFORM DIES ARE MADE.
PREFORM CONTOUR WITH SECTIONAL AND PLAN VIEW OF COMPONENT
### CALCULATION OF EQUIVALENT DIAMETER ‘D’ AT VARIOUS SECTIONS (ALL DIMENSIONS ARE IN MM)

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<th>SECTION</th>
<th>a</th>
<th>b</th>
<th>$A_f$</th>
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<th>$D=\sqrt{4\times A/\pi}$</th>
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PREFORM DIE BLOCK DESIGN

- The die dimensions are depending on the dimensions of impression.
- While calculating the dimensions of the die block, it should be ensured that the distance between outer periphery of the impression and the die edge should not be less than 1.5 times the maximum depth of the impression.
- For this particular case it is taken as 2.5 times to take care the 4-5 times of re-sinking of the die.

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<th>Dimension of the die (mm)</th>
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PREFORM TOP AND BOTTOM DIES
BILLET DIMENSION CALCULATION

- The billet volume is taken as the approximate volume of the preform which is equal to 1267840 mm$^3$.
- For calculating the dimensions of billet, the preform volume is converted into three parts based on its volume distribution.
- The volume distribution for billet is in accordance with the preform.

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<th>LENGTH (MM)</th>
<th>WIDTH (MM)</th>
<th>HEIGHT (MM)</th>
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<td>PORTION III</td>
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Various dimensions of billet
BILLET MODEL WITH DIMENSIONS

DIMENSIONS (IN MM):

PORTION 1:
- LENGTH: 90
- WIDTH: 84
- HEIGHT: 110

PORTION 2:
- LENGTH: 36
- WIDTH: 40
- HEIGHT: 45

PORTION 3:
- LENGTH: 60
- WIDTH: 60
- HEIGHT: 75
EQUIPMENT SELECTION

• EQUIPMENT SELECTION TOTALLY DEPENDS ON THE FORGING LOAD CALCULATIONS.

• THE LOAD CALCULATION FOR PRESS IS:

  • FOR CIRCULAR FORGING

    \[ P_{kg} = 8 \times (1 - 0.001 D) \times (1.1 + 20/D)^2 \times \sigma \times S \]

    WHERE: \( D \) = PLAN PROJECTED DIAMETER OF FORGING FOR CIRCULAR SHAPE INCLUDING FLASH LAND (IN MM)

    \( S = (\pi/4)D^2 \) (PLAN PROJECTED AREA OF CIRCULAR PIECE INCLUDING FLASH LAND AT DIE PARTING PLANE IN MM)

    \( \sigma = \) TENSILE STRENGTH AT FORGING TEMPERATURE (6-7 KG/MM²) FOR LOW ALLOY STEELS.

    \( P_{kg} = \) REQUISITE PRESSURE FOR FORGING A CIRCULAR PIECE IN KG.
EQUIPMENT SELECTION CONT..

• FOR NON-CIRCULAR FORGING

\[ P_1 = P \times [1 + 0.1 \times \sqrt{\frac{2}{b}}] \]

WHERE: \( P = 8 \times (1 - 0.001 \times D_{\text{red.}}) \times (1.1 + 20/D_{\text{red.}})^2 \times S_1 \times \sigma \)

\( D_{\text{red.}} = \text{REDUCED DIAMETER OF NON-CIRCULAR FORGING INCLUDING FLASH LAND (MM)} = 1.13 \sqrt{S_1} \)

\( S_1 = \text{PLAN PROJECTED AREA OF NON-CIRCULAR FORGING INCLUDING FLASH LAND (MM}^2) \)

\( \sigma = \text{TENSILE STRENGTH AT FORGING TEMPERATURE (6-7 KG/MM}^2) \)

\( b = \text{AVERAGE WIDTH OF FORGING INCLUDING FLASH LAND} = S_1/L_{\text{max}} \)

\( L_{\text{max}} = \text{MAXIMUM LENGTH OF FORGING AT PARTING PLANE INCLUDING FLASH LAND (IN MM)} \)

\( P_1 = \text{REQUISITE PRESSURE FOR FORGING A CIRCULAR PIECE IN KG}. \)
CALCULATION

THE CONNECTING ROD IS OF NON CIRCULAR FORGING TYPE, THUS THE CAPACITY WILL BE CALCULATED ON THE BASIS OF NON-CIRCULAR FORGING CAPACITY CALCULATION:

AR. OF FORGING (WITH FLASH) = 33112.2077 MM²

σ = 6.5 KG / MM²

D_{red.} = 1.13\sqrt{S_1} = 1.13 \times \sqrt{33112.2077} = 205.62 MM = 206 MM (APPROX)

L_{max} = 359.6 MM

b = S_1 / L_{max} = 33112.2077 / 359.6 = 92.08 MM = 92 MM (APPROX)

P = 8 \times (1 - 0.001 \times D_{red.}) \times (1.1 + 20/D_{red.})^2 \times S_1 \times σ

= 8 \times (1 - 0.001 \times 206) \times (1.1 + 20 / 206)^2 \times 33112.2077 \times 6.5

= 1959119.562 KG = 1959 TONES.

P_1 = P \times [1 + 0.1 \times \sqrt{(2/b)}] = 1959 [ 1 + 0.1 \sqrt{(2/92)} ]

= 1967.88 TONES = 1968 TONES
FINISHER DESIGN

• FOLLOWING ARE THE IMPORTANT CONSIDERATIONS WHILE DESIGNING FINISHER:
  
  • **DIE WORN OUT ALLOWANCES:** THESE ARE THE ALLOWANCES ADDED TO PROFILE SO AS TO COMPENSATE FOR INCREASE OR DECREASE OF DIMENSIONS DUE TO CONTINUOUS RUN. THEY ARE NEGATIVE FOR INTERNAL PORTIONS AND POSITIVE FOR EXTERNAL PORTION. THE VALUE OF THESE ALLOWANCES IS DECIDED FROM TOLERANCE FOR THAT PARTICULAR DIMENSION ACCORDING TO THE STANDARD CHART.
  
  • **SHRINKAGE ALLOWANCES:** THESE ALLOWANCES ARE ADDED TO THE SINKING DRAWING WHICH TAKES CARE OF SOLID SHRINKAGE IN METAL (HERE STEEL). STEEL WHEN HEATED TO AUSTENITIC TEMPERATURE EXPANDS AND ON COOLING CONTRACTS, WHICH CAUSES THE REDUCTION IN SIZE OF THE COMPONENT AFTER COOLING.
FINISHER DESIGN STEPS

- The dimensions of the forging drawing are multiplied by the shrinkage factor. For steel it is (1.5% shrinkage) 1.015.
- At some critical sections die wear allowances are added.
- The flash and gutter are along the parting line and flash is laid upset in central portion.
- The flash thickness is shifted completely to top die along with gutter.
- The fillet corner radii are maintained same as that forging drawing.
- The die shrinkage tolerance is given of ± 0.1mm.
- Resting and locating surfaces are mentioned clearly.
- The surface roughness is mentioned generally for impression and flash land is VVVV and other surfaces up to VV.
- Deep impression is kept in bottom die for easy stock location.
- For finisher die sinking drawing, the internal flash & gutter are added to reduce press load.
FINISHER DIE BLOCK DESIGN

• FOLLOWING STEPS ARE CONSIDERED WHILE DESIGNING FINISHER BLOCK FOR PRESS:
  • EJECTOR PIN SET UP ASSEMBLY IS TAKEN IN TO CONSIDERATION AS PER THEORY.
  • THE DIE BLOCK DIMENSIONS ARE DEPENDING UPON MAXIMUM LENGTH, WIDTH AND DEPTH OF THE IMPRESSION.
  • ONE MORE FACTOR IS TAKEN INTO ACCOUNT WHILE DESIGNING THE FINISHER BLOCK, WHICH IS AVAILABILITY OF EJECTOR PIN SETUP.
  • THE DISTANCE BETWEEN OUTER PERIPHERY OF THE IMPRESSION AND THE DIE EDGE SHOULD NOT BE LESS THAN 1.5 TIMES THE MAXIMUM DEPTH OF THE IMPRESSION. IN THIS CASE IT IS TAKEN AS 2.5 TIMES TO TAKE CARE THE 4-5 TIMES OF RE-SINKING OF THE DIE.

<table>
<thead>
<tr>
<th>DIMENSION OF THE IMPRESSION (MM)</th>
<th>DIMENSION OF THE DIE (MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>440</td>
<td>1100</td>
</tr>
<tr>
<td>223.8</td>
<td>560</td>
</tr>
<tr>
<td>31.5</td>
<td>78.75</td>
</tr>
</tbody>
</table>

DIE BLOCK DIMENSION FOR FINISHER
FINISHER DIE BLOCKS

FINISHER TOP & BOTTOM Dies
BLOCKER DESIGN

- Blocker Impression immediately precedes the Finisher Impression and serves to refine the shape of metal prior to forging to its final shape in the Finisher.
- Usually Blocker imparts or gives the final overall shape to the forging.
- **Benefits of Blocker Design:**
  - To promote metal flow in the Finisher.
  - To serve as a gathering operation.
  - To reduce wear on the Finisher cavity to prolong the Die Life of Finisher.
  - To produce close tolerance forging.
- It is always better to make Blocker Impression slightly narrower and deeper than the Finisher Impression with a volume that is equal to or slightly greater than that of the Finisher (not more than 2 - 3%).
BLOCKER DESIGN STEPS

- Choke is provided surrounding the profile on bottom die.
- The choke helps to restrict the metal to flow excessively in unwanted direction thus provide complete filling of the die cavity.
- The choke dimensions are decided keeping in view the increase in load due to choke.

BLOCKER DIE BLOCK DESIGN

- The size and shape of the blocker die is same as finisher die, the only difference here is due to the choke provided in bottom die.
- The top view without choke and with flash and gutter impression should be superimposed along with the choke layout that gives the plan of bottom die.
- Other considerations are same as that of finisher die block.
<table>
<thead>
<tr>
<th>DIMENSION OF THE IMPRESSION (MM)</th>
<th>DIMENSION OF THE DIE (MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>337.6</td>
<td>844</td>
</tr>
<tr>
<td>123.8</td>
<td>309.5</td>
</tr>
<tr>
<td>32.5</td>
<td>81.25</td>
</tr>
</tbody>
</table>

DIE BLOCK DIMENSION FOR BLOCKER

BLOCKER DIE BLOCKS
DIE MANUFACTURING

THE DIE MANUFACTURING CONSISTS FOLLOWING STEPS:

- DIE MODELING.
- TOOL PATH GENERATION.
- COMPILING PROGRAM AND CREATING G AND M CODED PROGRAM FOR CNC MACHINE.
- DIE BLOCK LOADING.
- TOOL REPLACEMENT.
- DIE SINKING.
- DIE CHECKING.

THE PROCEDURE FOLLOWED TO PRODUCE DIFFERENT DIES ARE:

- FOR FINISHER AND BLOCKER- TOP AND BOTTOM DIES, THE IMPRESSION IS SUNK IN DIES USING CNC MILLING MACHINE.
DIE MANUFACTURING CONT..

- For trimming, the trimming plate profile is produced by EDM with copper electrode. The profile of electrode is same as that of the trim profile. This electrode is manufactured on wire cut EDM using the CAD profile.
- Once the impression is obtained, the edges are ground to 5 mm, which are then welded and grounded.
- The trim punch is manufactured by sinking the finisher impression on top of finisher in a die block. The extra material than impression is removed by using EDM. The electrode used is graphite.
- Similar is the case for piercing die and punch.
- The stripper plate is made of die steel and profile is shaped using wire cut EDM.
- The average time for sinking each die is three hours.
SIMULATION

• THE SIMULATIONS HAS BEEN CARRIED OUT USING THE SOFTWARE PACKAGE DEFORM-3D V 3.2.

• THE GEOMETRIES OF THE BILLET AND DIES ARE GENERATED IN AUTOCAD AND IMPORTED INTO DEFORM 3D.

• BILLET IS CONSIDERED VISCO-PLASTIC WHILE DIE IS CONSIDERED RIGID, AND IN MATERIAL MODELS, ELASTIC DEFORMATIONS ARE NEGLECTED.

• FLOW STRESS IS TAKEN AS A FUNCTION OF TEMPERATURE, STRAIN AND STRAIN RATE.

• FOR ANALYSIS, THE BILLET IS DIVIDED INTO 5000 ELEMENTS.

• LOW C STEEL (AISI 1045) IS SELECTED AS BILLET MATERIAL AND H-13 TOOL STEEL IS SELECTED AS MATERIAL FOR DIE.
# DIE AND BILLET MATERIAL PROPERTIES

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>AISI 1045 (900-1200°C)</th>
<th>H-13 TOOL STEEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>DENSITY (kg/m³)</td>
<td>7800</td>
<td>7760</td>
</tr>
<tr>
<td>COEFFICIENT OF THERMAL EXPANSION (mm/mm°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.1 x 10⁻⁶ for 100°C</td>
<td>11.5 x 10⁻⁶ for 100°C</td>
<td></td>
</tr>
<tr>
<td>12.1 x 10⁻⁶ for 200°C</td>
<td>12.0 x 10⁻⁶ for 200°C</td>
<td></td>
</tr>
<tr>
<td>13.5 x 10⁻⁶ for 400°C</td>
<td>12.5 x 10⁻⁶ for 400°C</td>
<td></td>
</tr>
<tr>
<td>13.9 x 10⁻⁶ for 500°C</td>
<td>12.8 x 10⁻⁶ for 500°C</td>
<td></td>
</tr>
<tr>
<td>HEAT CAPACITY (N/mm² °C)</td>
<td>3.7</td>
<td>5.6</td>
</tr>
<tr>
<td>THERMAL CONDUCTIVITY (N/sec °C)</td>
<td>36.5</td>
<td>25</td>
</tr>
<tr>
<td>HEAT TRANSFER COEFFICIENT BETWEEN WORK PIECE AND DIE (N/s mm °C)</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>CONVECTION COEFFICIENT (N/s mm °C)</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>EMISSIVITY</td>
<td>0.6</td>
<td>0.15</td>
</tr>
</tbody>
</table>
PARAMETERS AND BOUNDARY CONDITIONS

- Initial die and billet temperatures are selected as 200°C and 1100°C respectively.
- Environment temperature selected is 20°C.
- The friction factor at the billet – die interfaces is assumed as 0.4.
- The shear type friction conditions with slave – master relationship between work piece and tooling interfaces are imposed as a part of boundary conditions.
- Heat exchanged between the work-piece and tooling and tooling between the tooling and ambient surrounding is incorporated in the FEM calculation.
- It is assumed that ninety percent of the input mechanical energy is converted into heat.
RESULT AND DISCUSSION

PREFORM FILLING AND ITS ANALYSIS

DIE ASSEMBLY FOR PREFORM
DIE FILLING FOR PREFORM
EFFECTIVE STRESS ANALYSIS FOR PREFORM
EFFECTIVE STRAIN RATE ANALYSIS FOR PREFORM
EFFECTIVE STRAIN ANALYSIS FOR PREFORM

Title: DEFORM SIMULATION
Database: connecting_red_new.DB

Object 1
△ = 0.0728
□ = 3.1289

Strain (Effective) (mm/mm)

Point:
A = 0.0220
B = 0.4133
C = 0.7537
D = 1.0042
E = 1.4147
F = 1.7751
G = 2.1150
H = 2.4569
I = 2.7986
J = 3.1389
METAL FLOW VELOCITY DURING FILLING OF PREFORM
BLOCKER FILLING AND ITS ANALYSIS

DIE BLOCK ASSEMBLY FOR BLOCKER

OPERATION 1 Step 60
DIE FILLING FOR BLOCKER
EFFECTIVE STRESS ANALYSIS FOR BLOCKER

Title: DEFORM SIMULATION
Database: connecting_red_new-DU

OITAREPO 1 Step 142 Stress [Effective] (MPa)

Effective stress analysis for blocker.
EFFECTIVE STRAIN ANALYSIS FOR BLOCKER
EFFECTIVE STRAIN RATE ANALYSIS FOR BLOCKER
METAL FLOW VELOCITY DURING FILLING OF BLOCKER
LOAD-STROKE CURVE FOR BLOCKER

Z Load vs Stroke

Z Load (N)(x10E7)

Stroke (mm)(x10E1)

Op 0
FINISHER FILLING AND ITS ANALYSIS

DIE BLOCK ASSEMBLY FOR FINISHER
FILLING OF FINISHER
EFFECTIVE STRESS ANALYSIS FOR FINISHER
EFFECTIVE STRAIN ANALYSIS FOR FINISHER

Title: DEFORM SIMULATION

Database: connecting Rod_new.DBF

OPERATION 1 Step 200 Strain (Effective) (mm/mm)

Scale: 1.3993 - 0.3454

Object 1

6.3454 3.2993
EFFECTIVE STRAIN RATE ANALYSIS FOR FINISHER
METAL FILLING VELOCITY IN FINISHER

OPERATION 1 Step 200 Velocity ( ) (mm/sec)
TOP VIEW OF THE METAL FILLING VELOCITY FOR FINISHER
LOAD-STROKE CURVE FOR FINISHER
DISCUSSION

- Pref orm die is required to provide such a shape to the billet so that it should flow uniformly and smoothly.
- The blocker gets optimized due to the inclusion of the preform die.
- It's not necessary for the complete filling of the die in preform and blocker, but filling of finisher is must.
- In this case also the preform and blocker are under filled which can be seen in figure.
- The finisher die gets completely filled which can be seen in figure.
- The load required to fill the die is matching with the theoretical load calculation.
- There is the formation of approximately uniform flash in finisher.
CONCLUSION AND FUTURE SCOPE

• IN THE CONVENTIONAL METHOD OF FORGING DUE TO THE LACK OF PREFORM DIE, THE YIELD IS AROUND 60%. BUT IN THIS CASE, DUE TO THE INCLUSION OF PREFORM DIE OR WE CAN SAY ON OPTIMIZING THE BLOCKER THE YIELD GETS INCREASED TO 80%.

• THIS GREAT INCREASE IN THE YIELD RESULTS IN THE COST SAVING IN TERMS OF MATERIAL COST, POST PROCESSING COSTS ETC.

• THIS YIELD CAN BE FURTHER INCREASED ON DOING CLOSE ANALYSIS OVER EACH AND EVERY STEP.