6.1 UPSET FORGING MACHINE

The Electro discharge coating is done on the flat surface of the anvil. The coated surface is used for upsetting the valve head (after induction heating up to temperature 900°C). The validation test was conducted on the flat surface of anvil of upset forging machine used for upset forging of engine valve at Varroc Engineering Private Limited, Plant-7, L-4, Industrial area, Waluj, Aurangabad. Before the test, there was fast wear & tear of the flat surface of the anvil. But after the electro discharge coating, there is a drastic improvement in wear resistance & hardness of flat surface of the anvil, leading to increase in life of anvil. Fig. 6.1 shows induction upset forging machine.

Fig.6.1: Induction upset forging Machine
6.2 UPSET FORGING PROCESS

A high density of electric current at very low voltage is made to pass through a portion of the end of the bar stock, which is held against an anvil and clamped between two jaws, to generate sufficient heat to make the portion red hot and plastic. An upsetting force is applied axially on the rod against the anvil making the portion, which is in plastic stage to deform into a bulb shape and to gather the required volume.

Electric upsetting is a means of performing bar stock to create an enlarged diameter on a bar, which can then be forged with no further heating. It has applications to the production of parts that are conventionally produced by closed die forging in presses or hammers, and also the production of parts that are conventionally produced in mechanical upsetting machines. The cold bar stock is placed in the upset forging machine and clamped by the gripper jaws. A low-voltage, high-amperage, electric current is passed through the bar between the anvil and the gripper jaws. As the bar between the contacts heats (by resistance) and becomes plastic, the axial force applied by the hydraulic cylinder compresses the bar and enlarges it at the hot end, creating a ball against the anvil. As the ball becomes larger, the anvil retracts at a rate less than that of the upsetting cylinder. There is virtually no limit to the amount of material that can be gathered. The current is constantly applied, so the entire ball is at forging temperature, and since the resistance heating begins at the center of the bar, scale is minimized. The shaft of the upset is completely unaltered by upsetting process. Fig.6.2 shows upset forging process.

Fig.6.2: Upset forging Process
A high current is passed into one portion of the material to be upset. Electrical resistance causes the component to heat up. Once this portion of the material reaches plastic state, cold material is pushed into the hot area via hydraulic force. During open electrical upsetting, the bar material is positioned between the upsetting cylinder and the anvil plate or die. Two-part clamping jaws close around the bar and electrical current flows between the clamping jaws and anvil plate, heating the exposed portion of the component. The hydraulic cylinder exerts a controlled force on the cold end of the bar producing a shaped head. The machines incorporate many features that ensure optimum cycle time, excellent repeatability, quick set-up and reliable operation for all types and sizes of valves. Fig. 6.3 shows the engine valves after and before upsetting [125].

![Engine valves after and before upset forging](image)

**Fig 6.3: Engine valves after and before upset forging**

### 6.3 VALIDATION TEST

Validation test for application of the coating on Anvil of upsetting Machine is carried out at Varroc Engg.Pvt.Ltd., Waluj MIDC, Aurangabad. The Electro discharge coating is done on the flat surface of the anvil. The coated surface is used for upsetting the valve head (after induction heating up to temperature 900 °C). The Coating conditions were as follows.

| Table 6.1: Factors Level and responses for the Validation test |
|-----------------|-----------------|----------------|----------------|-----------------|-----------------|----------------|
| Current I_p, A  | Density of Electrode (f) g/cm^3 | Discharge Duration T_{on}, μs | Duty Factor τ  | Layer Hardness HV | Layer Thickness μm | Surface Roughness R_a, μm |
| 6               | 7.15            | 125            | 7             | 1666            | 70              | 2.85           |
| Parent Metal H11 | 366             |                |               |                 |                 |                |
Fig.6.4: Coating on Anvil of Upset forging  

Fig.6.5: Valve head forged with Anvil

Fig.6.4 shows the electro discharge coated surface of the Anvil and Fig.6.5 shows upset forged valve head in the above figures respectively. Fig.6.6 shows the electro discharge coated Anvil fitted to the position on the upset forging machine after upset forging of the valve head. Quantities of valves upset forged with the anvil of upset forging machine for its one position are observed as follows.

Fig.6.6: Coated Anvil surface after upset forging of the valve head
Table 6.2: Improvement in the quantities of the upset forged valves by Coated Anvil

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Quantities of the valves upset forged with Anvil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity before coating</td>
</tr>
<tr>
<td>1</td>
<td>60</td>
</tr>
</tbody>
</table>

Quantity of valves upset forged with the anvil without electro discharge coating on its surface are observed to 60 nos. and Quantity of the valves upset forged with the anvil of upsetting machine with the coating are observed to 122 nos. This shows considerable improvement in the quantity of upset forged valves if done with the anvils after electro discharge coating on its surface. This validates the industrial application of the coating process. The Validation Test Certificate is attached as Appendix-F.

6.4 REMARKS ON VALIDATION

Based on optimum results of electrode development, density of electrode material was selected 7.15 g/cm³ for validation test. At this density of electrode, coating rate is relatively higher which is resulted in higher layer thickness. Similarly with this density of electrode material layer hardness is also relatively higher with better surface finish.

The other parameters include Peak Current, discharge duration, duty factor used as 6 Amp, 125μs and 7 respectively as optimum conditions for obtaining coating on the test anvil surface. Overall improvement in the productivity by use of the developed coating on the anvil surface is attributed to coating performance with higher hot hardness.

It is interesting to note that the coating development itself takes place at high temperature electrical discharge pulses. Therefore the coating has sustained the higher temperature and fluctuations with in without any loss in terms of hardness. Repetitive use of anvil during upset forged valve manufacturing is certainly prone to surface deformation. In view of this, high layer thickness of 70-100 μm also found to be useful.