

# **The Study And Application Of Planetary Gear Net Forging Technology**

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## **Abstract**

In this paper presented the net forging technology of planetary gear after much experiment and analysis, technology of two forging processes after billet being one -time heated, and cold net forging was adopted to ensure the gear forming quality. In the process of die producing, electrical rod NC cutting technology was used .the test and application has proved the net forging gear has reached higher quality and met the requirement of design. The net forging gear technology had been put into production.

Keywords    Planetary Gear    Net Forging

## **1. Foreword**

At present, net forging planetary gears have been widely used in automobile production, but it is difficult to meet the requirements of min tolerance and high quality of this kind of part, especially to big gears.

In our corporation, a lot of cut gears are used in middle and heavy trucks. Cutting gear has lower efficiency, high cost, lower strength and the cost ratio of material is only 35-40%. Net forging gear has advantages of high intensity, long service life, high efficiency, little deformation after heat treatment and can save 20%material. So we did some researches on the nature science of planetary gear and differential side gear forming and developed a series technology and put it into production. Now I will take the net forging technology of planetary gear as example to introduce.

## **2. The analyses on the difficulty of net forging technology**

Technology of twice forging after one time heat or twice forging after two-time heat are often used in net forging gears production. It is very difficult to get min roughness and

tolerance. So it is difficult to produce high quality gears only rely on hot forging. We have attempted to adopt the technology of warm (or hot) forging and plus cold forging to produce net gear.

The planetary gear is shown in fig.1, the circumferential pitch and thickness of tooth require much little tolerance and the gear belongs to ISO 8 degree.

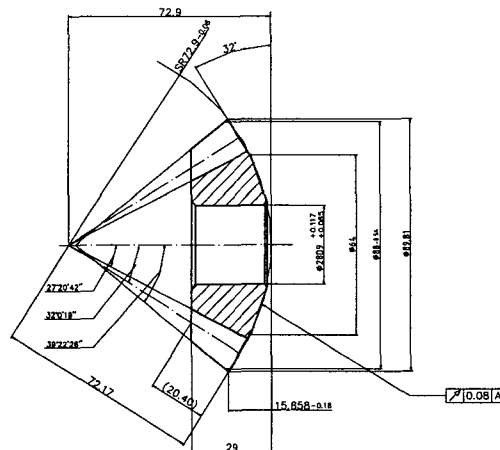


Fig.1 the gear part

Die is produced with electrical rod and the tolerance of die should meet 7degree, electrical rod must meet 5- 6 degree, the surface roughness must be Ra0.8-1.6, so it is very difficult to make electrical rod. At present, common gear shaping machining and gear milling machine are often used in electrical rod production. NC milling technology is the best method for the shape of tooth can be easily adjusted for compensation of uneven deformation caused by shrink of descending of temperature. So it is the key to develop the NC milling technology of electrical rod.

The cold forging gear force is very high, the spring-back of metal part also influence the gear tolerance.

Wear and tear of die can lead to the shape change of gear tooth.

The existence of oxide during hot forging can also influence the gear dimension

So, every circle must be controlled of electrical rod and die machining, billet heating, process of net forging, heat treatment and gear machining.

### 3 .The gear net forging process

Cutting off grinding rod to billet with band saw--- heating billet with intermediate frequency induction heating stove---- make billet with 250kg air hammer -----pre forging with 400t screw press -----final forging with 630ton screw press -----trimming with 160ton crank press ----remaining heat normalizing --- blowing with liquid sand----drilling-----phosphorus and soap treatment-----cold forging with 1000ton hydraulic press

The technology of warm (or hot) forging and plus cold forging eliminates the second heat oxide, surface can be controlled effectively and the gear quality can be improved.

Normalizing by using forging remaining heat can save much energy

Cold forging semi-product gear dilled at the center reduce the forging force, ensure the gear tolerance and improve the serve life of net cold forging die. The concrete process technology is shown below

According to machining remaining we designed the cold forging and hot forging blue print. The hot forging blue print is shown in Fig.2.

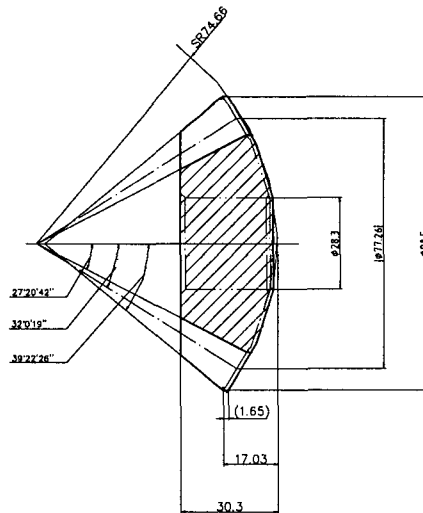


Fig.2.hot forging part

- 1). Part billet weight is 0.58kg,
- 2). The billet dimension is  $\phi 50 \times 54$  (mm)
- 3). The forging force  
Hot forging force  $P_1 = 358$  (ton)  
Cold forging force  $P = 659.2$  (ton)
- 4). Heating method: Intermediate frequency induction heating  
The pre-forging temperature is  $1050^\circ\text{C}$   
The final forging temperature is  $900^\circ\text{C}$ .
- 5). The method to remove oxide  
Rapid heating, blow oxide with air during upsetting billet to control metal oxide and nitrogen can be used in large production.
- 6). Equipments  
400ton, 630ton screw press and 1000ton hydraulic press was used
- 7). The lubrication and cold method of billet and die  
The billet and die were lubricated and made cold with graphite sprayed by compressed air
- 8). Cooling method and criterion  
Formed gear teeth should not be heated to high temperature, so during experiment cube was used to normalize the formed gear. the finish forging part was put into cube at  $780^\circ\text{C}$  after trimming. For large production protecting gas should be used during normalization

**4. Die design and production of die** The stress ferrule was adopted to ensure die life and gear dimension tolerance. The die structure is shown in Fig.3, the cavity of die was eroded by using electrical rod, and electrical rod was divided to wide and finish rod to reach

high efficiency and little tolerance. According to gear structure dimension, cold shrinking ratio and discharge clearance, electrical rod of pre-forging die, finish forging die and cold forging die were made. We developed the electrical rod mould by using modeling software and cutting rod with NC milling center. The electrical rod reaches 5-6 degree. The roughness is lower 2-3 degree and gets Ra0.62-0.68. The cold forging die had the main function of extrusion and little upsetting.

## 5. The experiment and result

Pre-forging temperature 1050°C

Pre-forging with 400ton screw press

Final forging with 630ton screw press

Cold forging with 1000ton hydraulic press

Test billet is shown in table 1, test result is shown in table 2.

Table 1

Specimen No.	1	2	3	4	5
Billet Dimension (mm)	50x52	45x64	45x64	45x64	45x64
Billet Weight (kg)	0.80	0.80	0.80	0.80	0.80

Table 2

Specimen No.	1	2	3	4	5
Accumulated Pith Variation (mm)	0.052	0.065	0.061	0.053	0.063
Allowable Pith Variation (mm)	<b>0.038</b>	0.016	0.043	0.028	0.044
Gear Shape	Good	Good	Good	Good	Good
Double gear joggle checking	Check out	Check out	Check out	Check out	Check out

This technology was also used in half gear net forging. The result show that the net forged half gear met the same tolerance degree as planetary gear.

At present, the net forging technology of planetary gear and differential side gear has been put into production, the production effect shows that the technique is reliable and the gear has stable quality.

## 6. Conclusion

- It was proved in experiment that the planetary gear produced with the technology of warm (hot) forging and plus cold forging gear drilled center hole is feasible. The tooth

tolerance and roughness can be improved and the technology can be used in production stably. Net forged gear has metal flow lines along the shape of the tooth, the influence of anisotropy can be removed and the strength and toughness can be improved.

- Die and electrical rod tolerance is important, the tolerance must be controlled in the area in reason. The tolerance should be in the area of 1/3 tolerance. Cold forging deformation should not be too small, or the spring back will not be controlled.
- And before cold forge, the billet should be drilled a hole.