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PRECISION FORGING OF BEVEL GEAR WITH STRAIGHT TEETH

I. COMPARISON OF RESULTS

BY

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Abstract. The precision forging concept has appeared due to problems arising from machined parts. These issues are: high material consumption, high processing time, damage due to microcracks, which appeared early on machined surfaces. The precision forging method solves a large part of these problems, by means of the small volume of material being removed by machining, and, due to redistribution of the material in the desired shape without the need for additional processing of active surfaces. After comparing the durability of machined and precision forged bevel gear with straight teeth, the result is that forged pieces have 27% more life.

Key words: Precision forging; bevel gear with straight teeth; durability.

1. Introduction

At this time bevel gears with straight teeth are achieved especially by machining, powder metallurgy and near-net forged. Each of these processes has problems that can be improved by precision forging. Precision forging is achieved through a complex technology, having a significant effect due to both

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savings of material and reducing the costs of machining, and, especially due to the increased durability of parts (bevel gears with straight teeth) and increased resistance to gear damage. Precision hot forging requires tools made of steel, with high damage resistance. Processing tools must be realized in high precision classes, to give the desired accuracy classes to pieces.

2. Precision Forging Process

2.1. Forging Process Preparation

2.1.1. *Conditions for the realisation of precision forging*. The necessary blanks for precision forging are debited on saws, or precision cutting machines from peeled bar. Cutting should ensure a constant volume. For a batch it is required to use material from the same heat. In order to ensure the uniformity of material deformation, materials with constant characteristics have to be used. The bars are peeled to ensure a constant volume to the blank, and to remove surface defects resulting from rolling. In some cases, the blanks are machined in order to reach a form that ensures uniform deformation.

Heating of blanks is made by induction (2500-8000 Hz) in a controlled atmosphere, with a thermal warming regime, which is rigorously checked. To avoid dross (decarburized coating), the heating process is made in a protective atmosphere. The heating system is coupled with a generator of exothermic atmosphere. The induction heating has to ensure high productivity in such a manner to cover the requirements of the forging press. The blanks heating temperature is 1050°C, while the system is providing uniform heating.

The precision forging process is achieved in 2 phases:

Phase 1. Rough forging. In this phase, 90-95% of the total degree of deformation will be achieved, and next conditions have to be followed: the die with teeth is the upper one; heating and maintaining working tools at 400-450°C; cleaning and lubrication of tool engraving after each forging; automatic supply press with heated blanks; active control of tools damage.

Phase 2. Finished forging. In this phase, 5-10% of the deformation degree is achieved, if the gears remain in the Class 9 of accuracy. For higher accuracy, classes (8-6) should perform a cold or a low hot calibration with a degree of deformation of 1-2% of the total degree of deformation. Rough forged parts are placed with their teeth in down die, for finished forging. The conditions for finished forging are the same as for the rough forging case, and, in addition, visual and dimensional control of pieces.

After finishing the forging process, the primary heat treatment is performed for normalizing (annealing). Treatment is achieved in electric furnaces with protective atmosphere at 850-890°C, for 4 h.

After the primary treatment, the deburring is achieved, then, the drilling gear (if applicable), and shaft machining. These operations are achieved on lathes. The most important aspects of this particular machining process are basing and fixing of the pieces on the lathe. Basing takes place on the flanks of teeth.

The final heat treatment is following the machining process and it is realized in a protective atmosphere, after the treatment pieces will achieve 54-60 HRC hardness. Parts could be cemented, with coat deep 1-1.2 mm (Turcilă, 2015a).

2.1.2. *Drawing of forged pieces*. After calculating the bevel gear dimensions and drawing the forged gear with straight teeth (Fig. 1), the next step is dies drawing. Planning for realization of dies engraving: rough machined; hot print/electro-erosion engraving; primary heat treatment (annealing); half-finishing of outer and inner surfaces; secondary heat treatment (quenched-tempered); finishing by means of electro-erosion; finishing of outer and inner surfaces (grinding); final control.

The most important part of dies engraving is represented by piercer achievement, which has to be realized with high class accuracy. The piercer is achieved from cooper, and it is assembled with a steel bush before the final machining.

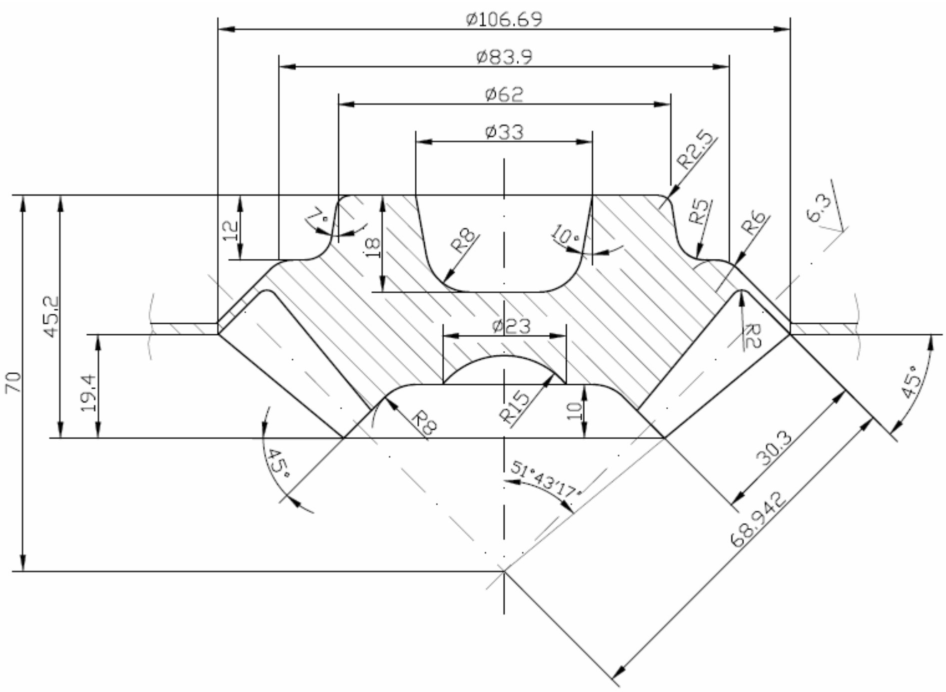

Fig. 1 – Forged bevel gear with straight teeth (Turcilă, 2015a).

2.2. Results of the Forging Process

After the forging process, the bevel gear with straight teeth was resulted, as shown in Fig. 2. The bevel gear with straight teeth has the 9 accuracy class.

Fig. 2 – Precision forged bevel gear with straight teeth (Turcilă, 2015b).

3. Comparing the Theoretical Process with the Practical Realisations

The resulted forged bevel gear (Fig. 4) has the same grain flow as the drawings depicted in (Fig. 3).

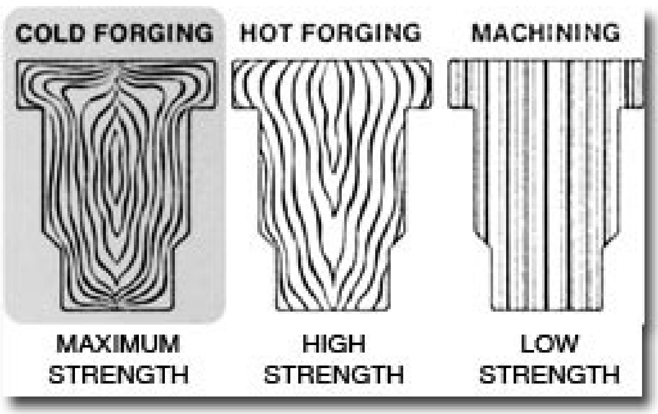

Fig. 3 – Grain flow (The Forging Industry Association, 2015).

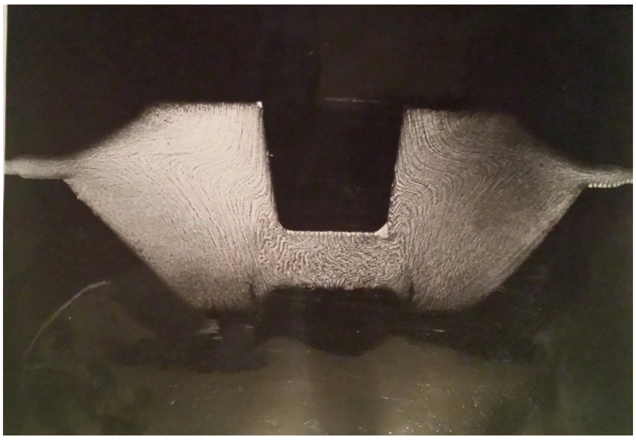

Fig. 4 − Forged bevel gear with straight teeth (Turcilă, 2015b).

The bending strength of the forged gears improves from 20% to 30% for the forged teeth, compared to cut teeth. It is believed that such strength improvements are related to the material grain flow, which is forced parallel to the root surfaces when the teeth are forged into a specific shape. Weaker gear teeth typically have a grain flow perpendicular to the root surfaces (International Journal, 2013).

The durability tests have shown that the forged bevel gears have 27% more life than machined parts.

4. Conclusions

1. The forged parts have a flow grain that cannot be found at machined parts.
2. The bevel gear with straight teeth can be obtained by means of precision forging, with 9 accuracy class. After a cold calibration process, the obtained accuracy class can be on 8-6 level.
3. The most important thing for finished surfaces obtained by precision forging is that blanks heat and all heat treatments are compulsory to be made in a protective atmosphere, in order to avoid the appearance of dross.
4. The bevel gear with straight teeth, obtained by means of precision forging, has 27% more life than the machined parts from the shown experiments.

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MATRIŢAREA DE PRECIZIE A ROŢILOR DINŢATE CONICE CU DINŢI DREPŢI

I. Compararea rezultatelor

(Rezumat)

Ideea matriţării de precizie a apărut pentru a elimina problemele cu care se confruntă procesul de prelucrare prin aşchiere. Aceste probleme sunt: volumul mare de material irosit, timpul mare de prelucrare, defectele de suprafaţă apărute din cauza microfisurilor rezultate în urma prelucrării. Matriţarea de precizie rezolvă o mare parte dintre aceste probleme datorită consumului mic de material îndepărtat prin aşchiere şi datorită redistribuirii materialului în forma dorită fără a fi nevoie de prelucrări suplimentare ale suprafeţelor active. După proiectarea pieselor şi a sculelor necesare (matriţe) s-au realizat roţile dinţate conice cu dinţi drepţi care nu necesită prelucrarea dinţilor. Aceste roţi dinţate au fibrajul dorit şi se încadrează în clasa 9 de precizie. După testarea acestor roţi dinţate concluzia este că au o durabilitate cu 27% mai mare decât roţile dinţate prelucrate prin aşchiere.