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SOME VIEWPOINTS OF MATERIALS FORMING TECHNOLOGY

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Metal forming can be regarded as a process during which materials are treated by "force" and "heating" under a certain external load and boundary condition (loading mode, rate of loading, constraint condition, geometry, contact friction condition, temperature field). As well as in former times and presently from time to time detect overview lecture and articles, which have for one's object draw up demand on modern forming technologies one's about new wave in the area like: shortening processes, flexibilization, integrating production processes, hollow structure technology and simulation and optimization. New metal forming technologies may be developed using new energy resources, new forming mediums and new loading methods for developing new products according to the needs of the automotive, electrical, electronic and aerospace industries. Some cases of these technologies will be presented inside of volume of this contribution.

Key words: forming, new technologies, rolling, forging

INTRODUCTION

Forming is such technological process at which happens to permanent plastic deformation form by effect largely outer forces without changes volume and without infringement cohesion. Shape changes and process control of forming depend upon features formed material, on conditions of contact with tools, on mechanism of plastic deformation (metallurgical and technological plasticity) and as well as on the used technology and on needs on final desired mechanical (toughness and plastic) qualities of the product. About it, that the forming is virtually oldest extant method of material processing to testify also term epochs; in light of technology was to be oldest smith's method, which is today, (what to the quantity), overruled by rolling. Passed 100 years was in both directions, as which to the technology, so to the used materials, guided gradual changes, that, by far not last, was fluent casting with the aim of achievement what smallest thickness so ironically downsizing room for forging [1].

Technical public, no exactly, but pragmatically, divides forming on „bulko or volume" (great changes in every way) and „surface" (with stamping and near operations).

In the area „volume" forming is that a afterwards forging, rolling, pushing, …. and series variants above mentioned primary objective manners (at random rolling strips, metal plate, tubing,...)

Costs, quality, production times and the environmental compatibility of processes and products all play a decisive competitive role in production engineering. They entail new challenges and opportunities for metal-forming production processes. Apart from daily endeavours to improve tolerances or to analyze costs and reduce them by means of continuous rationalization, trends are currently observable in metal-forming technology which in some cases lead to completely new methods for producing semi-finished and finished products and which all the above-mentioned criteria into account. Figure 1 summarizes a number of these trends, which will be described with the aid of specific examples below [2].

Constituent part hereof contribution is assumed from technical literature and built - up to the new unit.

We will deal only very shortly with the single parts of pie graph.

Shortening processes

A number of positive results can be achieved by process shortening, e.g. shorter production times, lower costs, lower energy consumption, fewer opportunities for waste. One example is steel strip production, hitherto realized on hot wide strip lines, which are now experiencing steadily greater competition from a new type of rolling mill.

Flexibilization

There are various reasons for increasing the flexibility of production engineering and hence of metal-forming technology. Flexible manufacturing centres, in which the most accurate possible semi-finished and finished products can be manufactured as quickly as pos-

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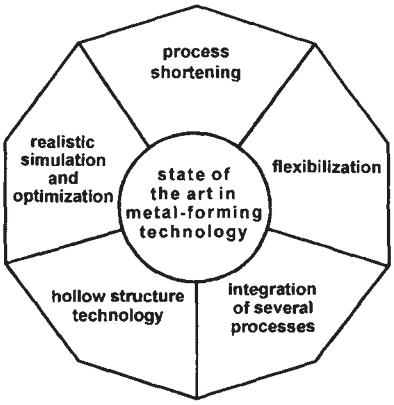

Figure 1 Development trends in metal-forming technology [2]

sible with optimum properties and without high tool and machine effort, are gaining in importance.

Integrating production processes

Completely new production systems can be created in this way, contributing to process shortening, but also to other objectives like cost saving, quality enhancement etc. A number of prospective new developments should also be noted briefly:

Local heating to extend process limits
Local heating immediately after forming
Forming and joining

Hollow structure technology

Systematic use of hollow structures is a feature of competition to achieve optimum lightweight structures in the metal components field. They can be used to combine the good recycling properties of, for example, steel, with significant new weight savings.

Simulation and optimization

The development of new products and processes demands intensive parallel analysis of all phenomena with the aid of numerical simulation. Numerical algorithmic optimization is also becoming increasingly relevant as a means of shortening the development process. Both simulation and optimization have made great strides in recent years, and performance is likely to improve still further as computer capacities increase. The state of the art in simulation and optimization is already impressive, and it is outlined in the multi-level overview [3-4].

PROCESSING MAP

In order to predict the instability of the material in the hot forming processes, processing maps based on two approaches available in the literature were obtained by carrying out hot compression tests for two different steels at various temperatures and strain rates and used inthe present investigation [5].

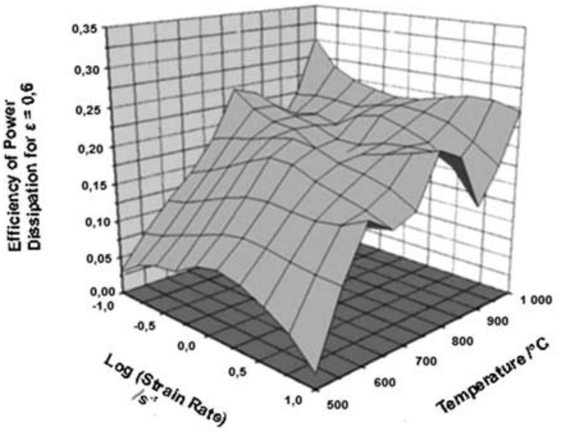

Figure 2 3D plot efficiency of power dissipation for steel A (low carbon steel) at ε = 0,6

The important engineering parameter in mechanical processing is commonly known as workability with which a material can be shaped by plastic flow without onset of fracture. Many researchers utilized workability as one of controlling parameters to reduce surface cracking in the hot rolling.

According to Prasad and Sasidhara [6], the processing map is an explicit representation of the response of the material in terms of microstructural mechanism to the imposed process parameters, consisting of superimposition of power dissipation and instability.

At hot working processing conditions, the instantaneous response of the workpiece to the applied strain rate to impose a given plastic strain at a constant temperature T and for a given strain rate sensitivity m, can be described as the

$$\sigma = C \cdot \dot{\varepsilon}^m \tag{1}$$

Thus, comparison with an ideal linear dissipator with $m = 1$ in which maximum possible dissipation leads to the definition of a dimensionless parameter, called efficiency of power dissipation as given by [6 – 8]

$$\eta = \frac{2m}{m+1} \tag{2}$$

This parameter may be plotted as a function of temperature and strain rate to obtain the power dissipation map, Figure 2.

According to the present results, the efficiency of power dissipation was lower at lower temperatures and leading to flow localization.

Hot profile extrusion of AA-6060 aluminum chips.

Analyses of energy consumption in manufacturing processes have shown that most of the energy is needed for the production of material such as aluminum or steel and not for further manufacturing steps like forming or

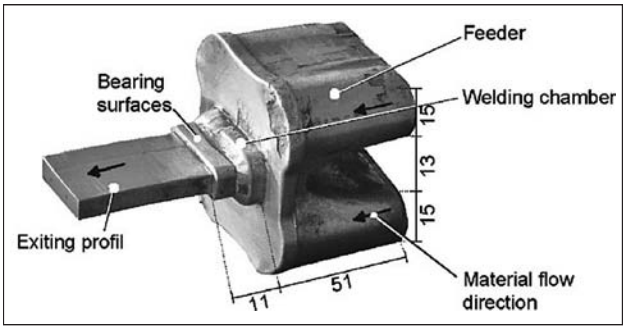

Figure 3 View on the material flow inside the die based on exemplary press rest of a casted billet [12]

cutting [9]. In proposed part of article the re-use of aluminum AA-6060 scrap based on milling and turning chips, by direct hot extrusion is presented, figure 3. To prevent further use of primary aluminum or melting of the chips the process aims at using compacted chips as billet material [10,11].

All procedure falls first from production aluminous scraps, follows compaction and then extrusion. For the analysis of the direct conversion process realized with extruded profiles produced from secondary aluminum, chips from three machining operations were used. To produce different shapes of chips, investigations on milling and turning operations have been carried out on conventional cast extrusion billets made of the aluminum wrought alloy AA-6060.

The turning chips were placed in an aluminum, 88mm long covering tube to prevent falling apart of the billet after compacting. In a compacting route of 4–7 steps, each one comprising the adding of chips in the free tube volume and compacting until 60 kN, these chips were compacted. A density increase from initially 0,7 g/cm3 to 2,7 g/cm3 was reached over the individual steps of the compacting route. The pre-compacted billets as well as conventionally cast billets were preheated before extrusion to an initial temperature of 500 °C. As process conditions, a container temperature of 450 °C and a constant ram speed of 1mm/s were used, Figure 3.

As it can be seen, there is hardly no reduction in mechanical strength when comparing yield point and stresses during plastic deformation. All specimens show a yield stress of approximately 60 MPa, independent of the billet production method. Comparing the hardening, i.e. at a level of true strain $e = 0{,}15$, the true stress of the extruded chips reaches up to 160 MPa while the extrudate of the cast billets reaches up to 178 MPa.

Even during further forming procedures, e.g. during the tensile tests, no reduction in the surface quality of a sample such as opening of pores was detected.

BLOW FORMING PROFILE OF SPHERICAL TITANIUM TANK

When manufacturing spherical titanium tank by superplastic blow forming, it is important to obtain uniform thickness distribution of the tank in terms of performance. Superplastic blow forming using diffusion bonded blank is one of the appropriate process to manufacture tanks for aerospace purpose [13].

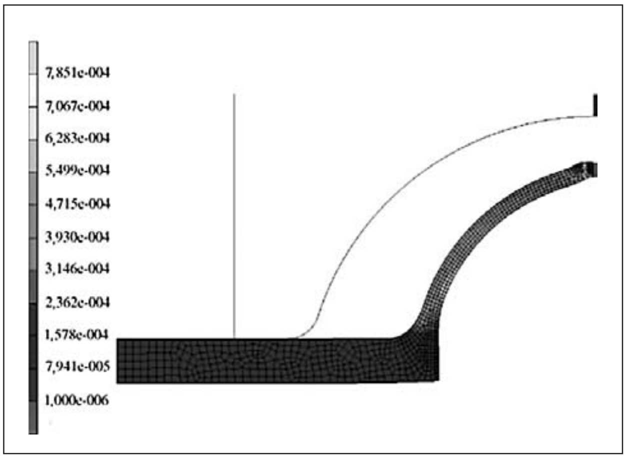

Figure 4 Equivalent strain rate distribution at t = 1 100 s and optimized blank

The analysis has been carried out for each case of using uniform blank, profiled one, and optimized blank without boss. Therefore, since the region near boss is a region where stress concentration occurred under internal pressure loading, more improved theoretical or empirical optimization should be followed to prevent from thinning near boss and to maximize the performance of the tank.

When superplastic blow forming method is applied for manufacturing spherical tank, it is well known that the proces variables should be carefully controlled to obtain uniform thickness coincident with the requirement.

Analysis results shows the equivalent strain rate distributions in deformed shape, Figure 4.

In case of uniform blank, the maximum equivalent strain rate occurred in knuckle zone and the gradient was observed in the deformed blank. On the other hand, optimized blank shows that it maintains uniform deformation in spite of higher strain rate than uniform blank.

Forming pressure drastically increased according to approaching the final shape in all cases. Case 1 predicted the longest forming time, about 3 500 s, while the optimized blank without boss showed the shortest duration (about 2 440 s). It is thought that there are two main reasons. Firstly, knuckle zone and diffusion bonded zone are the latest areas to be formed. It means that the material was trapped, thus it is difficult for the material corresponding to this zone to flow. This deformation mode induced the forming pressure to increase. Secondly, the increase of contact nodes causes the increase of pressure. In case of uniform blank, the maximum equivalent strain rate occurred in knuckle zone and the gradient was observed in the deformed blank. On the other hand, optimized blank shows that it maintains uniform deformation in spite of higher strain rate than uniform blank.

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Note: The responsible translator for English language is the lector from VBŠ-TU Ostrava, Czech Republic