Definition

There are several definitions for burrs, but they all describe the same phenomenon. Burrs are undesired but mainly unavoidable. A burr is a material accumulation, which is created on the surface during the manufacturing of a workpiece. It extends over the intended and actual workpiece surface and has a slightly higher volume in comparison with the workpiece (Beier 1999). Burrs are uncut material remaining on the workpiece after being machined.

Burrs occur at the workpiece surface in cutting as well as in shearing operations at the workpiece edges. Further, laser machining can lead to burrs as well. This essay focuses on burrs of machining and shearing processes.

Burrs are of great industrial relevance as they interfere with the workpiece performance and functionality. Ideally, workpieces would be free of burrs, but, as this is often not the case, burrs can only be reduced either by changing the machining parameters, tool path, or tool. Alternatively, the burrs will have to be removed by time-consuming and expensive deburring processes.

Theory and Application

History

Burrs are an economically very important issue in many machining operations. Therefore, a lot of research has been done in the last 50 years to understand, control, and minimize burr formation. The first published works on burrs cover burr formation in punching. Pekelharing (1964) was the first to describe burr formation mechanisms in metal cutting processes. He described the chip formation process and closely interlinked burr formation to chip formation. The first fundamental work describing an analytical model of burr formation, which enables to predict burr properties, was done by Gillespie et al., published in 1976 (Gillespie and Blotter 1976). After a basic understanding of the burr formation mechanisms was gained, research activities turned to the topic of deburring.

In 2009, CIRP published a keynote paper on burrs by Aurich et al. (2009). The paper gives a review of the topic of burrs in machining operations.

Burr Classification

There is no overall classification of burrs. However, classifications of burrs defining the edges of workpieces, for example, in drilling or milling, as well as an ISO standard, are available. CODEF (the Consortium on Deburring and Edge Finishing) classified five drilling burr types
Gillespie introduces four types of burrs: poisson burr, rollover burr, tear burr, and cutoff burr (Fig. 2) (Gillespie 1999). The ISO 13715 standard defines the edges of workpieces as sharp, free of burrs, rounded, chamfered, or with burr (Fig. 3) (ISO 13715). Nevertheless, many companies use an in-house classification, as an overall accepted burr classification is lacking (Aurich et al. 2009).

**Burr Formation**

A lot of research focuses on understanding burr formation and revealing the parameters influencing burr formation. Pekelharing is the first to publish results on the investigation of burr formation. He interlinks burr formation to chip formation, as the burr formation depends on the chip formation mechanism (Pekelharing 1964). Gillespie states six physical processes which form burrs. The processes (1) lateral flow, (2) bending of material, and (3) tearing of chips from the workpiece result in plastic deformation of workpiece material. The (4) redeposition of material occurs in recasting processes. The (5) fifth process regards the incomplete cutoff of material. The last process treats burrs produced in molding or shaping processes, when the material flows into cracks (Gillespie 1999). Hashimura et al. have issued a schema of burr formation (Hashimura et al. 1999). In his model, the burr formation mechanism is influenced by cutting conditions, tool and workpiece geometry, as well as by the mechanical properties of the workpiece material. Schäfer (1975), Beier (1999), and Thilow et al. (2008) did a lot of work on burr formation. They
all observed that a burr occurs at the tool entry or exit if the workpiece material evades the cutting process.

To gain a better understanding of the burr formation process and to be able to predict burr formation, the finite element method analysis can be applied. In Leopold et al. (2005), the state of research and future developments in modeling and simulation of burr formation are highlighted.

**Burr Measurement**

A large number of burr measuring and detecting methods are available. The choice of the measuring system depends on the burr values to be measured (e.g., burr height or thickness), the requested measuring accuracy, the application conditions (e.g., within the production process), or the research purpose. The measuring methods can be categorized into:

- Destructive methods
- Mechanical systems
- Optical systems
- Electrical measuring methods

Destructive methods are mainly chosen for research purposes, as the workpiece is destroyed afterward. With destructive methods, as, for example, the preparation of metallic cross sections, very detailed information about the burr can be obtained. It is possible to measure burr thickness and burr height, as well as the micro-hardness in the burr.

Mechanical, optical, and electrical systems are mainly used to detect burrs. The stylus method, a mechanical system, can measure burr height, but optical methods can also be applied for this purpose. Among the most important optical systems are microscopes, autofocus methods, laser triangulation, and camera systems. For automatic burr detection in a production process, an electrical measuring method, for example, an inductive sensor system, can be applied.

**Burr Control Strategies**

As burrs cannot always be avoided, there are several burr control strategies to (at least) reduce burr formation. Burrs can be significantly influenced by the choice of tool, tool geometry, tool material, and tool coating. The tool or tooling best applied depends on the machining situation and the workpiece material. Several investigations on this topic have been conducted. The application method of coolants, the coolant media, and the application location of coolants influence burr formation likewise significantly. A proper combination of cutting parameters can reduce burrs notably. Changing the workpiece material can lead to less burrs or a more preferable burr type. Further, a change of workpiece design or a change of the order of machining processes can help to avoid burrs. A helpful approach is a targeted tool path planning.

**Deburring**

There are several techniques for deburring, which is the process applied to remove burrs from workpieces. They range from simple hand deburring to elaborated surface finishing by NC-controlled robots (Aurich et al. 2009). Gillespie (1999) grouped the numerous deburring operations into the following four main categories:

- Mechanical deburring operations
- Thermal deburring operations
- Chemical deburring operations
- Electrical deburring operations

Mechanical deburring operations are very common, for example, abrasive flow machining, milling, or dry blasting. The burrs are removed or reduced by mechanical abrasion. In thermal deburring operations, the workpieces are heated at very high temperatures for a very short period of time. Thin material accumulations, for example, burrs, are removed. In chemical deburring, chemical substances are applied to remove the burrs. Further, electrical fields can be applied to reduce or remove burrs. The choice of the deburring operation depends on the workpiece material, burr dimensions, and burr position as well as process costs.
Cross-References

- Chip-forms, Chip Breakability and Chip Control
- Cutting, Fundamentals
- Drill Milling
- Drilling
- Grinding

References


