12th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

TECHNOLOGICAL SUITABILITY OF MACHINERY PARTS

Dr. Eng. Svetislav Lj. Marković, professor
Technical College Čačak
32000 Čačak, Svetog Save 65, E-mail: svetom@nadlanu.com
Serbia

ABSTRACT
The concept of form (shape) in industrial design includes final and overall outer appearance of a product which is manufactured in series. Form is an element of industrial design of a product and it is determined by material, methods of manufacturing, colour and very often by certain ornaments. All these elements contribute to aesthetic value of the product. The aim of industrial design as a creative branch is not to make the product look nice, but to meet the requirements such as: functionality, economity, psychological adaptability to men, creating and ensuring harmony between the product and the man, as its user. Ecological and aesthetic requirements are equally important.
Technological suitability of shaping is achieved through adjusting construction details to the need of simpliflying manufacturing procedure, taking into account not to impair the function, hardness, appearance or some other characteristic of a machinery part.
The shape of the machinery part must be adjusted to manufacturing technology, which means that it also depends on the technological level of the manufacturer. The aim of this paper is to establish the connection between the shape of the machinery part and manufacturing technologies.
Keywords: technological suitability, industrial design, machinery parts.

1. INTRODUCTION
The analysis of the above mentioned suitability consists of the analysis of the given machinery part, regarding the possibility of its manufacturing by a certain technological method. The analysis comprises three sections: geometry of the construction of the piece, material and possible sizes of the series [4].
At constructing machinery parts it is necessary to define the manufacturing procedure, in order to allow making calculations and defining final shape. The manufacturing procedure depends on various factors, among which the most important are:
- The shape of the part,
- The size of the part,
- Its responsibility,
- The mechanical characteristic of the material,
- The number of pieces,
- The demanded dimensional accuracy,
- The demanded surface coarseness,
- Aesthetic appearance,
- The price.

If the shape of the part is complex, then it will be manufactured by casting at large series, and series by welding at smaller series. In case the part is exposed to static and relatively steady load, it will be produced from grey cast iron, while when the load is smaller the material is silumin. When the load is dynamic, the material is cast steel or nodular cast iron. The parts of simpler shape in smaller series are manufactured by cutting, while in larger series the manufacturing procedure includes casting, pressing, forging, and similar processes. The larger parts are manufactured by welding, while the smaller ones demand some other procedure. As a rule, the responsible parts are manufactured by forging. The number of pieces (the size of the series) greatly influences the choice of the manufacturing procedure, since highly productive manufacturing procedures such as casting, forging, pressing and rolling must be used at large series. In case the high dimensional accuracy is needed, the part will be manufactured by cutting out of the rail, panel or some other ready-made items obtained by casting, forging... When there exists the demand for high quality surface coarseness, the part is manufactured by cutting, grinding and polishing. If the price is the key factor which determines the manufacturing procedure, the parts of complex shape in smaller series are produced by welding and in larger series by casting [1].

2. TECHNOLOGICAL SUITABILITY OF SHAPES

The form of a machinery part is technologically suitable if it is easy to get it produced in the process of manufacturing. Every manufacturing technology, in a more or less complex way, can produce a suitable shape of the machinery part which satisfies its function and other conditions. More acceptable is the shape which is obtained through a technologically simpler and cheaper process. The simplicity of shape regarding this aspect is achieved by adjusting construction details to the need of simplifying manufacturing procedure without impairing the function, toughness or some other similar condition. The adjustment of the construction details to the shape of the machinery part is realized only after the basic shape, material and manufacturing procedure have been established [5].

The basic technologies for producing machinery parts are casting, forging, welding and cutting. Each of them includes classical and new methods. Classical technologies are improved by methods (technologies) which allow procedure simplification, cutting down on expenses, reduction of scrap and raising the quality level. Besides the above mentioned basic (conventional) technologies, the special technologies, commonly called the non-conventional technologies, are also used. These technologies, which result from major scientific achievements and breakthroughs, are high technologies.

Machinery parts are outlined by flat, cylindrical, spherical, conical and other surfaces. They can be contact surfaces, which are in contact with other parts, and free surfaces which are not in direct contact with other parts. Contact surfaces must be more quality (more accurate and with less coarseness) in order to allow correct functioning, safety at work and longer working life. Free surfaces can be less accurate and coarser. The difference in surface quality and accuracy commands that the manufacturing of machinery parts be conducted in two phases. In the first, preceding phase, rough shaping is performed with the aim of gaining the basic shape of the machinery part. The surface coarseness is greater and the accuracy of the shape and dimensions is lower. In the final phase the shape accuracy of the contact surfaces, their position and coarseness are raised to the demanded level. The final phase is primarily performed through cutting procedures i.e. by scraping, milling, grinding, broaching. Casting is used for manufacturing machinery parts of complex shape, smaller toughness, greater overall dimensions, lower accuracy, while the series size depends on the type of the casting procedure. Forging is used for manufacturing machinery parts of great toughness, small shape complexity, smaller dimensions and large series. Welding is used for producing machinery parts of complex shape, great toughness, lower accuracy and in small series. In the preceding phase cutting is used for manufacturing machinery parts of simpler shape, greater toughness, and in small series (with some exceptions). In the final phase cutting is used as a finishing process for the contact surfaces regardless of the technology used in the preceding phase. Therefore accuracy, as a criterion for choosing the technology in the preceding phase, is not of significant importance.

3. SHAPES OF THE CAST MACHINERY PARTS

The shaping of machinery and device parts by casting has many advantages. They are primarily in the following [3]:

- variety of shapes,
- decrease in the expenditure of material,
- great productibility of various shapes...

The manufacturing productivity of the castings is directly related to the shape of the castings. Therefore the shaping is based upon: the demanded quality, the size of a series, disposable equipment and other factors.

In order to shape the castings regularly it is necessary to take into account: the complexity of the mould, the thickness of the walls, the ribs (reinforcement), the inner surfaces and openings, the concentration of materials, the manufacturing and positioning of the sprues and vents, the shrinkage of materials, assemblage and disassemblage, final and machine processing.
At shaping walls it is necessary to take into account their arrangement during casting (Figure 1). The big horizontal surfaces turned upwards during casting should be avoided, since there could be residual gases, slag and other non-metal impurities, which are formed within the mould and separated from the metal. Besides that, the schemes shown in Figure 1.b ensure localization of internal tension and remove the waste caused by cracks, due to their free distortion at cooling [1].

a)

b)

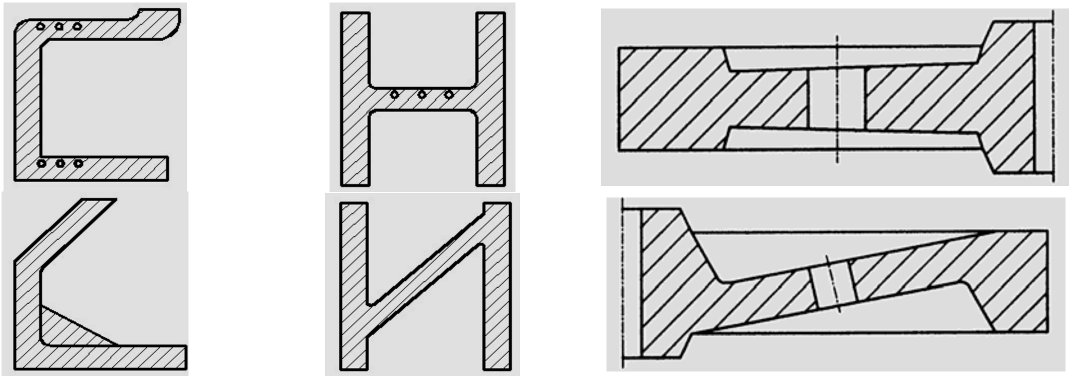

Figure 1. The schemes of cast constructions: a) incorrect, do not allow the gases and other impurities to flow up to the surface, b) correct

4. THE SHAPES OF THE FORGED MACHINERY PARTS

There are certain limitations that are necessary to adhere to at shaping forgings. They primarily include the following [2]:

- The forging inclinations (figure 2).
- The transits.
- The shaping of cranks and shafts, which have a rim (thickening) in the middle or at the end (figure 3).
- The narrowing in the longitudinal section of the forging, which limits the flow of the metal during forging in the direction opposite to that in which the puncher is moving (figure 4).
- The concavities at the end of the rim, positioned laterally on the gripping part of the mould.
- The thickness of the walls.

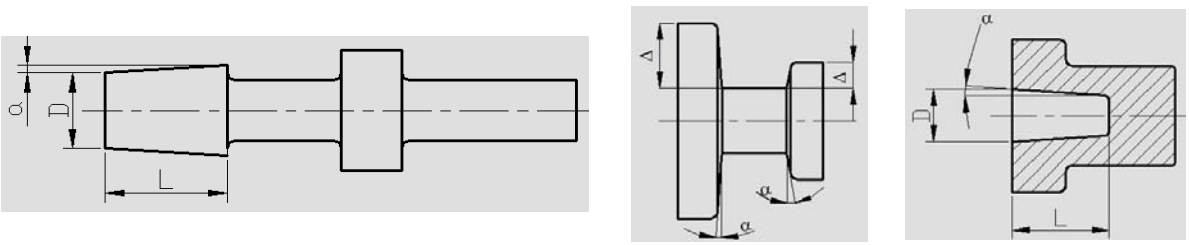

Figure 2. Forging inclinations

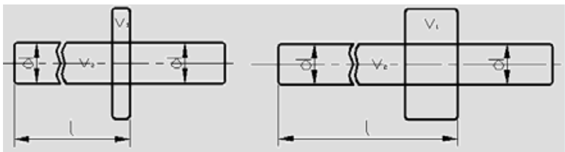

Figure 3. Shaping the shaft with a rim (thickening) correct (on the left) and incorrect (on the right)

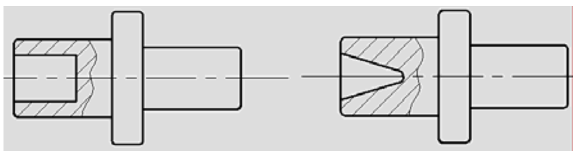

Figure 4. Shaping the forgings regarding the flow of the metal: correct (on the left) and incorrect (on the right)

5. THE SHAPES OF THE WELDED MACHINERY PARTS

The welded seams include butt seams (figure 5.a), angular seams (5.b) and overlapping seams (5.c). Butt seams are made from the welded parts which lie in the same plane- juxtaposed parts. At angular welded seams, the welded parts are at a certain angle to each other and the most often case is that one part is perpendicular to the other. Overlapping seams are made by overlapping the joined parts themselves or by overlapping the parts which are to be joined by additional overlapping sheet metal.

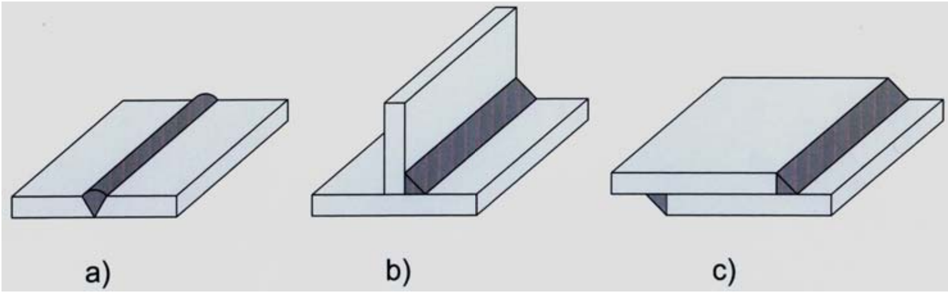

Figure 5. Welded seams: a) butt seams, b) angular seams, c) overlapping seams

6. THE SUITABILITY OF SHAPES FOR PROCESSING BY CUTTING

Cutting is applied for processing cylindrical and flat surfaces along with the surfaces of specific shape. The basic technological cutting operations are: scraping, milling, planing, drilling, grinding and broaching. The processing by scraping may be longitudinal (internal and external), cross-sectional, cutting in, cutting off, processing of helical surfaces. Milling is used for processing flat surfaces and surfaces of complex shape. Planing is used for processing greater flat surfaces and for grooving. Drilling is used for making and processing openings. Grinding is a procedure of finishing process and can be flat, cylindrical (external and internal) and special. Broaching is applied for making profiled opening as well as the parts of complex configuration in larger series [1].

The final phase implies processing of those surfaces of the machinery parts which are in contact with other parts and which must be provided with the accuracy of shape, position, length and the suitable coarseness. At processing (manufacturing) machinery parts in the preceding phase (by casting, forging, welding or cutting), these surfaces retain a layer of material of thickness suitable for finishing process.

7. CONCLUSION

The technology of casting is used for obtaining very complex configurations of the parts while the outer appearance is improved by expressive material, colour and the dimensions of the elements. Deformation processing is applied for manufacturing the parts the dimensions of which range from a part of a millimetre to several metres. The basic methods for processing sheet metal are: cutting off, slotting, punching, extruding, bending, deep drawing, embossing, combined processing... Rational application of deformation processing requires proper constructing of parts, i.e. shaping constructions suitable for this processing technology, since, for example, very complex configurations of the parts can be obtained by bending. Cold extruding allows manufacturing parts with the shape of a pot and the parts such as the shaft with the variable cross section. The shape of the metal parts subjected to heat treatment should be such as to prevent the occurrence of excessive residual stresses, distortions, deformities and cracks in the material. This is achieved by reducing the stress concentration in the critical sections of the parts as well as by reducing the lack of symmetry in parts.

8. REFERENCES

[1] Inžinjersko tehnički priručnik, knjiga 5, grupa autora, “Rad”, Beograd, 1976.
[2] Kuzmanović S.: Zbirka zadataka iz konstruisanja, oblikovanja i dizajna, Fakultet tehničkih nauka, Novi Sad, 2003.
[3] Marković S., Jovičić S., Tanasijević S., Josifović D.: The technologicality of shaping the castings, Proceedings the International symposium about desing in mechanical engineering „KOD 2008“, Novi Sad, 15÷16. april 2008.
[4] Ognjanović M.: Razvoj i dizajn mašina, Mašinski fakultet, Beograd, 2007.
[5] Charlotte & Peter Fiell: Design 20th Century, Taschen, Köln-London-Los Angeles-Madrid-Paris-Tokyo, 2006.