Sborník vědeckých prací Vysoké školy báňské - Technické univerzity Ostrava
číslo 1, rok 2008, ročník LIV, řada strojní
článek č. 1579

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PARTING AND SHAPING OF LIGHT-WALLED SECTIONS
DĚLENÍ A TVAROVÁNÍ TENKOSTĚNNÝCH PROFILŮ

Abstract

This article deals with various technologies of light-walled sections parting and shaping. Parting and shaping of sections made of various materials is a very common technological operation in the production process and thus it deserves more attention than it is being given. Technologists, who engage in this issue, are capable of suggesting several possible technologies for parting and shaping of light-walled sections. The projected and applied technology is however highly dependent on the required parameters and quantity of the final product. The crucial factor for choosing a technology is primarily the cost of purchase and also running costs are an important aspect.

Abstrakt

Tento příspěvek se zabývá možnostmi dělení a současně také tvarováním tenkostěnných profilů různými technologiemi. Dělení a tvarování profilů nejrůznějších materiálů je velmi častou technologickou operací při výrobě požadovaných výrobků a proto si zaslouží více pozornosti než je jí nyní věnováno. Technologové, kteří se této problematice věnují, dovedou navrhnout několik možných technologií jak dělit a tvarovat tenkostěnné profily. Navrhovaná a použitá technologie je však velmi závislá na požadovaných parametrech výrobků a na počtu požadovaných výrobků. Podmínkou pro rozhodování o použité technologii jsou především náklady na pořízení a rozhodujícím kritériem pro správně navrženou technologii patří také ekonomika provozu.

Keywords: parting, shaping, laser cutting, robots, manipulation

1 INTRODUCTION

The choice and application of a particular technology of parting or shaping of thin-walled sections affects the purchase costs and maintenance costs of the used tools, energy costs, material costs, labor costs etc. Other influences that affect the choice of a suitable technology are demands for number and qualification of workers who are required to operate and perform maintenance on the machines and other necessary devices for clamping, manipulation and transport. Characterization of alternative technological solutions follows.

Alternative technological solutions of thin-walled sections parting and shaping:

1. Forming (dinking).
2. Machining (cutting on saws, drilling, milling).
3. Laser cutting:
   - a special-purpose NC machine for shape cutting on pipes,
   - a fixed laser plus a robot manipulating with a pipe,
   - shape cutting by a robot with a built-in laser.

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2 PARTING AND SHAPING OF THIN-WALLED SECTION BY FORMING (DINKING)

For cutting and dinking of tubes and sections, there are universal machines developed in our country. One type of these machines is shown on figure 1; it is a non-deformational CNC dinking machine that allows a non-deformational dinking of thin-walled sections. This technique is one of the most effective techniques of dinking using CNC machinery. Actuation of the feed can be handled multiple ways; a Common way is by means of a servomotor or a stepper motor driving a ball screw or a rack. For more demanding applications dealing with sections of bigger lengths, a modern solution containing a linear actuator controlled by an NC control system is used. These machines provide a high productivity of labor, long-lasting reliability and safe and ecological operation.

Disadvantage of There machines is a limited durability of the tools, which is estimated at 10 000 cutting before the tool needs to be sharpened or completely replaced. Examples of various sections for non-deformational cutting are shown on Fig. 2.

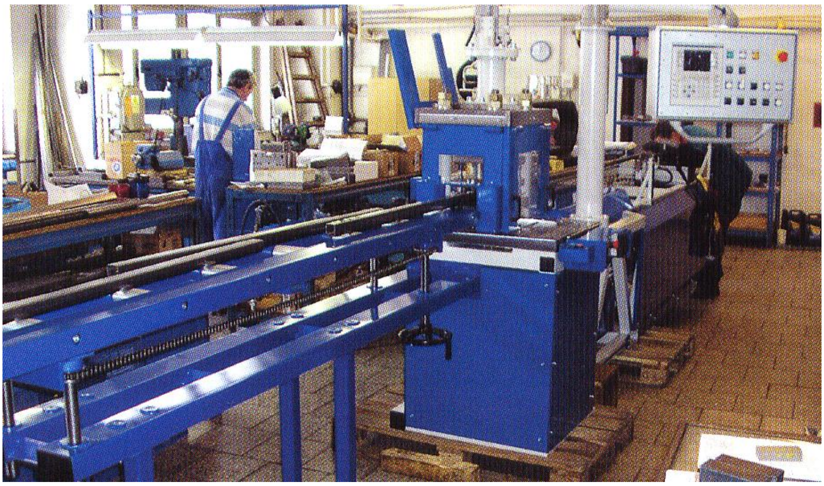

Fig. 1 Non-deformational CNC dinking machine

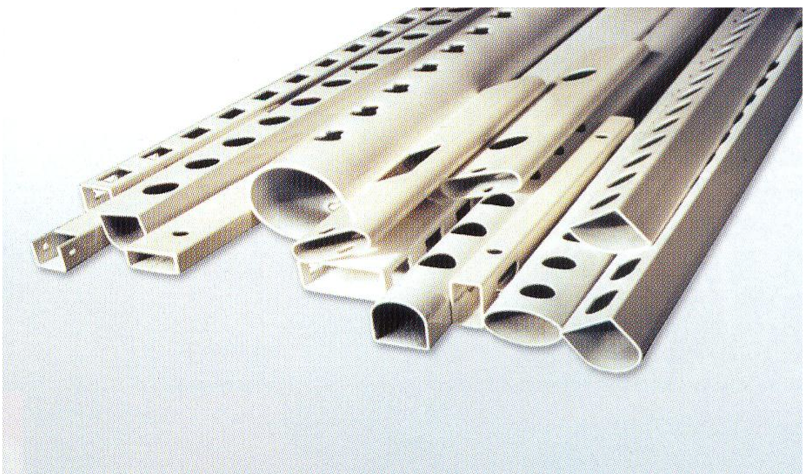

Fig. 2 Examples of sections for non-deformational cutting

In practise, however, there are more complicated shapes to be cut and thus more complex cutting tools are required. Arrangement of the tools and also design of the whole workplace depend on the complexity of the required shapes. Usually it is done by a consecutive forming in more successively situated cutting tools. These tools used to be designed to be placed on a crank press and precise fixation of the raw product during the operation used to be done manually. The cutting force was created by pressure on a wedge surface, which resulted in an extensive wear of the contact surfaces by friction.

Nowadays the cutting is done my means of hydraulic pistons, which offers higher forces together with more compact and efficient construction of the machine. Source of the power is an adequately dimensioned hydraulic generator and the individual cutting tools are controlled separately.

Durability of the tools is highly affected by choice of materials of the tools, their heat treating, surface cementation or nitridation, alignment of the movable and stationary parts of the tool and also continuous lubrication of the tools and their guide faces.

Manipulation and positioning of the raw product during the cutting operation can be handled by a robot or a purpose-built manipulator, which can allow also a consecutive cutting in one compound tool or a successive cutting with an accurate positioning between the operations.

3 MACHINING ON A MACHINE TOOL

To make a complete summary of possible technologies for making holes and various shapes on endings of thin-walled sections, it is necessary to mention also the technology of machining.

Most of the shapes and holes can be made by machining with a single mounting of the raw product, for example on an NC milling machine. This option decreases costs of development, construction and maintenance of the cutting tools, because all kinds of holes on endings of sections or tubes can be made by machining using standard mass-produced tools and an accurate final product can be achieved just by modifications of the control programme.

Manipulation with the raw product (in the form of tubes) between the single-purpose machines can be done by the means of a manipulator (robot). In small series or in a piece production, interstage manipulation can be also manual. Suggested solution can be also easily and cheaply accomplished and verified.

Alternatively, there is also a possible solution containing a machining tool carried on the arm of a robot, whilst the machined raw product is fixed in clamping jaws. This solution is mentioned as an example of options provided by robotization. Before choosing such option, it is important to make a calculation of rentability of the solution in correspondence with the proposed productivity.

4 LASER CUTTING

Each of the many methods of cutting has a specific area of optimal application, because they all have their disadvantages which prevent them from being used more universally. Thus, more and more new methods are introduced. The latest technologies include also laser cutting, where a focused laser ray with a great concentration of power is capable of cutting materials and alloys almost independently on their thermo-physical properties. A very narrow cut and a small thermally affected area are achieved. During the laser cutting, no mechanical influence on the processed material is produced and only very minimal deformations are caused. It is possible to cut with high precision, which holds true also for easily deformable materials or very brittle materials.

The high concentration of power in the laser ray brings a high productivity of labor and outstanding quality of the cut. The laser can be easily operated using a manipulator or an industrial robot, which allows very complicated planar and also spatial shapes to be cut. From the economic point of view, the production of workplaces with laser cutting technology is nowadays fully competitive in comparison with other methods of parting.

Special-purpose NC machine for shape cutting on thin-walled sections and tubes

Special-purpose NC machines are designed for parting and shaping of thin-walled sections and tubes of given dimensions. The most common raw products are sections and tubes in the length of 4000 to 6000 mm. Such devices are made by many companies, for instance AMADA, BLM and TRUMF.

An example of a CNC laser cutting machines is LT712D Laser Tube Cutting System by BLM Group Company (Italy). This machine is suitable for circular and square, both open and closed, shapes in the dimensions of 16 to 140 mm. The cutting process runs in an automatic loop. The machine can be controlled by CAD/CAM solutions and it can also operate in CIM systems. LT712D can be used to divide longer sections and tubes to required accurate lengths and also for shape-cutting, as shown on the following images.

Fig. 3 LT712D Laser Tube Cutting System

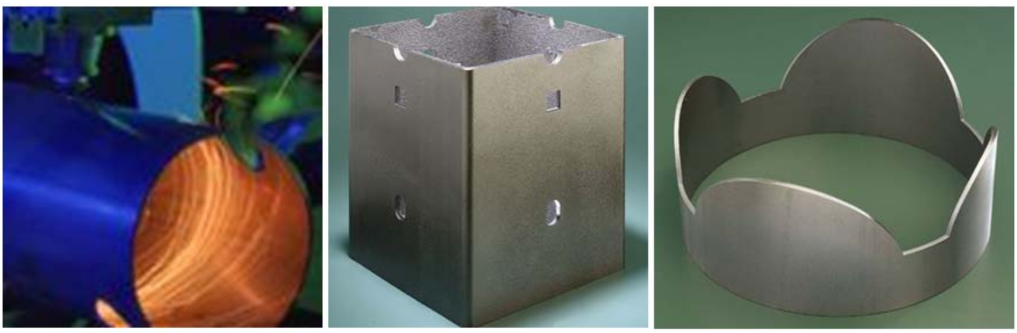

Fig. 4 Examples of shape cuts on ends of tubes and sections

Stationary laser and raw product manipulated by a robot

In the realm of robotized laser cutting, there is a possible solution (which is, however, not in use anywhere, as it seems) consisting of a stationary laser, while the raw product is precisely manipulated by a robot during the cutting operation. Schematic drawing of possible layout of such a workplace is shown on Figure 5. This solution is not preferred by designers of robotized workplaces. In our opinion, however, this is worth a discussion and it deserves much more attention.

A similar solution can be also applied for shaping and cutting using water jet or plasma cutters.

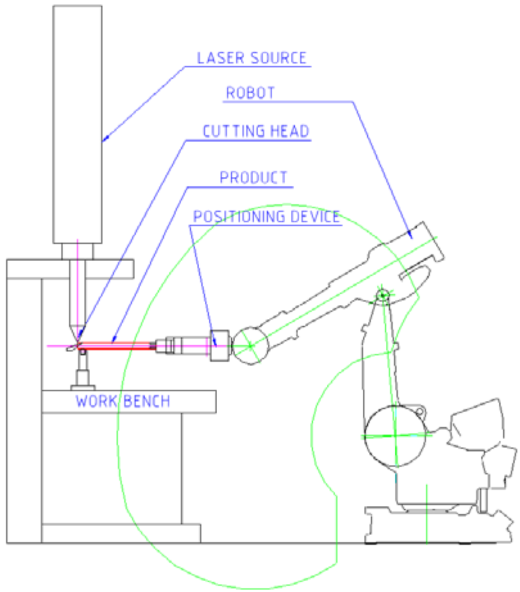

Fig. 5 Schematic layout of a workplace with a stationary laser and a robot manipulating the raw product

Robot carrying a laser cutting device

The progress in robotization brought also solutions where the laser is fixed on a robot arm. For the first time it was introduced by the REIS Company. The robot arm is carrying a source of the laser ray and the cutting head is located on the robot wrist, as shown on Figure 6. Very complex three-dimensional shapes can be cut this way. The only, although very important, disadvantage of this solution is the high cost of the device.

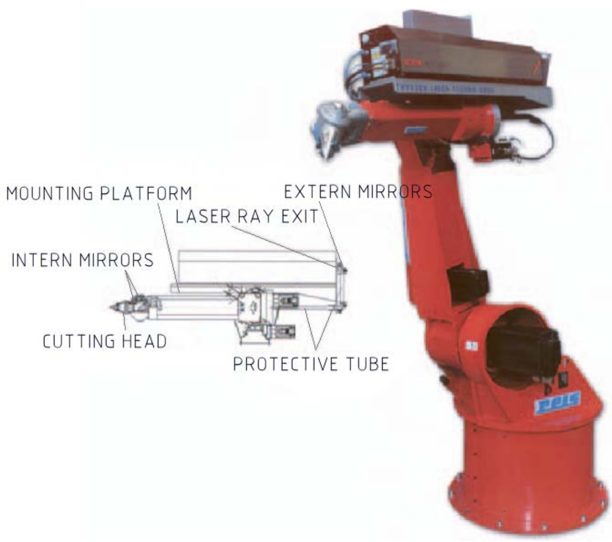

Fig. 6 Angular robot RV 16L with CO_2 – laser

Placing the laser source on the upper robot arm means a huge decrease of the number of necessary mirrors in the ray trajectory. A new laser TCF1 was developed by Trumpf Company especially for application on robots. This laser is diffusionaly cooled and weights only 250 kg, which is a very low weight for lasers of this class, while having a good power of 2 kW.

5 CONCLUSION

There are many possible technologies of thin-walled sections and tubes parting and shaping. Laser cutting is in many aspects one of the most progressive ones. Purchase and operational costs for laser devices are higher than for other solutions, but even so it is economically profitable. There is a significant cost saving for conventional tools. Laser cutting is most suitable for production of large amounts of products; while it doesn't have to be only mass production, but also a flexible production system using advantages of CIM (CAD/CAM). Thus, the initial high investment can have a short period of returnability.

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