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Visualisation of pipes welding process in technical subjects teaching

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Education and research trends

ABSTRACT

Purpose: This paper presents the application of the visualization technique for enriching the educational process. The visualization approach allows to present all difficult and even dangerous phases of a manufacturing process.
Design/methodology/approach: The computer visualization technique has been applied to elaborate the scenes presented in this paper. The process of modelling has been correlated with films captured in the steel mill.
Findings: The methodology of preparing and presenting the virtual manufacturing processes models is the main result obtained during these researches.
Research limitations/implications: The analyzed problem causes two main limitations of researches. Firstly the analysis of a visualization technique has been conducted basing on one specific manufacturing process. In this phase of researches it is important to formulate the general conclusions about this technique. Secondly, it has been chosen the process of pipes pressure welding with currents of high frequency. It allows to present both plastic forming and welding in one manufacturing process.
Practical implications: The first practical implication of these researches is the possibility for offering a wider scope of materials on the educational platforms prepared for the new university e-learning system. Secondly, it is possible to use these materials in consultations offered for industrial plants in the system of commercial cooperation of the university.
Originality/value: This work presents a complete analysis of the visualization process applied for the educational aims. It allows to analyze the problems considered with visualization process and includes some solutions in this area.
Keywords: Computer aided teaching; E-learning

1. Introduction

The conventional educational process of technical subjects requires very expensive laboratory education and cooperation with industrial plants to present the students specific manufacturing processes. Moreover not all processes and all phases could be presented to students because some of them are dangerous or must be conducted in special conditions. It is particularly important for students of materials and manufacturing sciences. So it is needed to change the conventional educational process with the virtual one.

The change of an educational process should results in decreasing the costs of an educational system and improving the understanding of taught processes. Students could familiarize with all elements of specific manufacturing process, even those dangerous and simulate their runs. They can also examine their faulty runs using special virtual models of the manufacturing environment. Of course these models must fulfill more complicated requirements.

The presented approach could be also utilized in the area of technical process planning. The visualization technique allows to prepare the model of the analyzed process and to conduct

researches basing on that model [1, 2]. This approach allows to decrease production costs and to solve problems at the beginning phase. Moreover it allows to improve the process scheme at the preparatory phase.

In the presented work the process of pipes pressure welding, using currents of high frequency has been analyzed. This process has been investigated in a steel mill and next has been modeled using a CAD system. Results are presented below.

Fig. 1. Coiled metal sheets

Fig. 2. Specification of a metal coil

2. Description of the chosen process

Welded pipes are manufactured from metal sheets formed in coils (Figure 1). The metal bends are hot rolled and coiled in circles. In this form they are placed in a magazine of metal sheets.

The bends of metal sheet must be normalized and heat-plastic treated. The preparatory process must be agreeable with specified industrial standards and clients orders.

It is important that all information about the raw material must be placed on each coil of metal bands what is shown on the Figure 2.

The main information described on the label includes: dimensions of a metal band, type of material and characteristics of plastic-heat processes.

2.1. Transport system

As it was described above the coils of metal bands are transported using special trolleys (Figure 3). Each trolley must be operated by a crane.

Fig. 3. Trolleys with metals coils

The transport system links a stacking yard with a production room. The end stations of the transport system are simultaneously the first stations of the main production process. In the production room the coils of a metal band are transported with a crane to the first stand to prepare them to the next phase of a technological process, where they are initially worked.

2.2. Stand for initial working

The bends of a metal sheet must be uncoiled and straightened on the input stand. On this stand all uneven elements of metal bands are also cut (Figure 4).

Fig. 4. Cutting stand

Cut elements are stored and transported on the scrap yard. The prepared metal bands are transported to the next operation stand.

2.3. Joining of bands

Prepared bands are joined by welding to obtain long bands and to allow pulling one band by another (Figure 5).

The weld obtained in this phase is not controlled because, as it was stated, it has only the auxiliary role. When the pipe is finished this weld is cut out and scraped.

The process of welding is conducted automatically.

Bands' welding is needed to make possible the process of continuous pipes welding.

Such prepared bands must be straightened because, during previous phases, it bends in a result of cutting and welding. This operation is conducted on a special stand consisted of many rows of rolls (Figure 6). A bend moving over these rolls becomes straightened as a result of influence of the gravity force.

Straight bands must be still worked to prepare them for welding (Figure 7). The last preparatory phase is mechanical working.

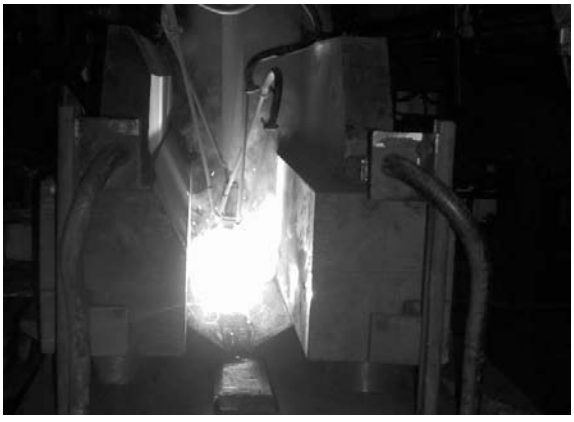

Fig. 5. Bands welding

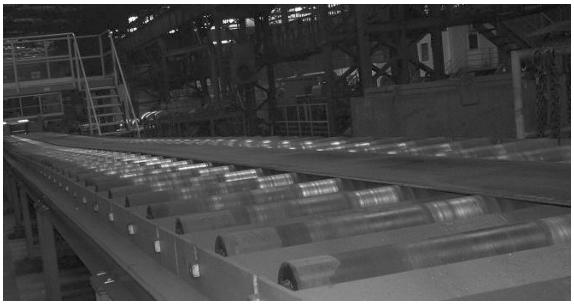

Fig. 6. Bands straightening

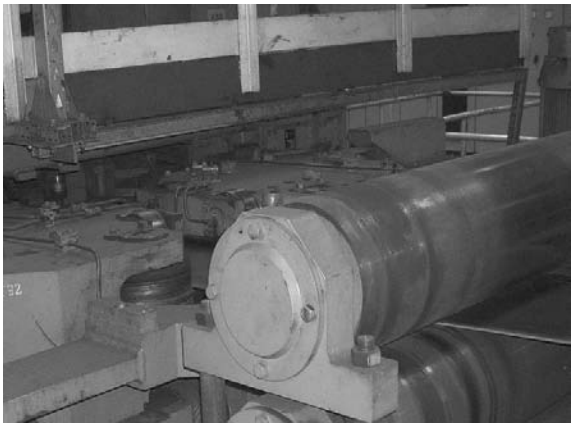

Fig. 7. Working of edges

2.4. Mechanical working

To obtain even and non-deformed edges the milling working is conducted. In this operation the edges are prepared for welding. The smoother are band edges the better are welds. Milling operation is conducted for bands prepared on pipes of diameter larger than 220 mm. For pipes of smaller diameter the milling operations is not needed because the welding operation could be more controlled.

The milling operation is conducted on milling station equipped with heads with sintered carbides [3] which is presented in Figure 8.

Fig. 8. Milling head with sintered carbides

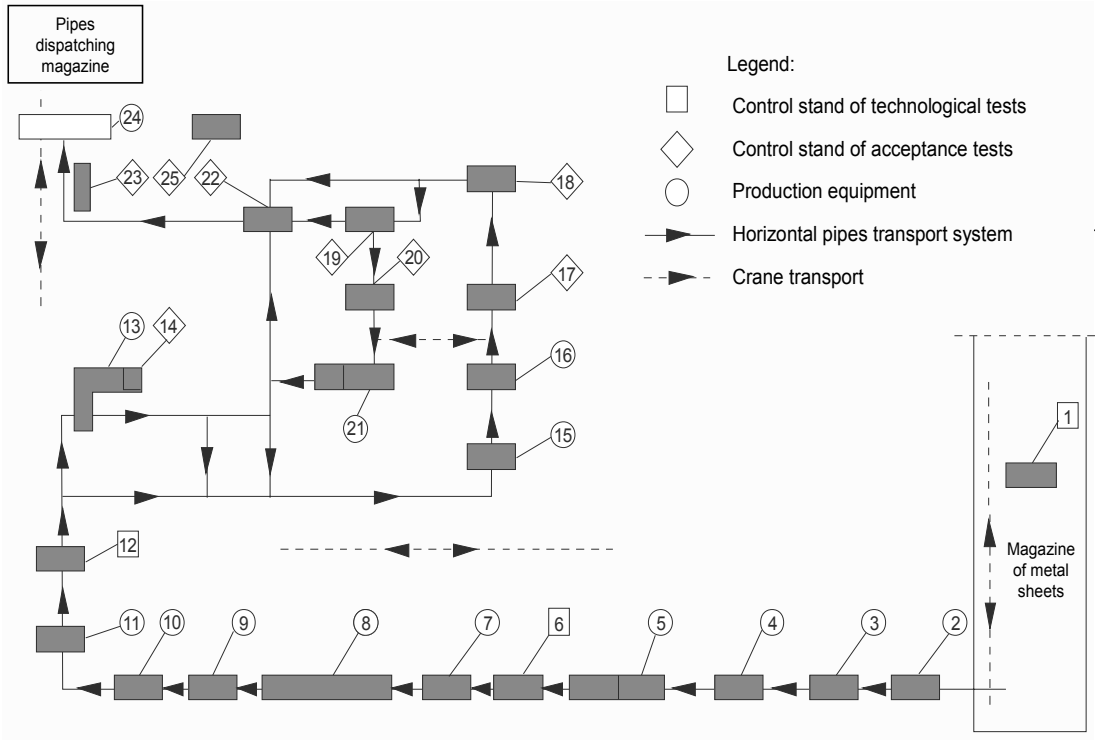

Fig. 9. Scheme of the technological process

At this moment bands are prepared for a very complicated pressure welding operation combined with space rolling of metal bands.

3. The production organization

In the Figure 3 the organization of the production process is presented. The process begins with a quality control operation (1). During this operation metal sheets, in a form of coils, are controlled to eliminate all unrepairable faults. The verified coils are transported (2) to the input stand (3) where metal sheets are cut. The cut metal sheets are worked (4) and prepared for welding process. The forming and welding operation is marked 6.

After these operations one obtains a manufactured pipe. Next the manufactured pipe is controlled on the ultrasound stand (6) to check the features of the weld. The pipes are heat treated (7) after control operation. This operation allows to equalize mechanical and chemical parameters of a pipe. The water-air cooling system (8) aids the cooling process. Cooling operation could result in changing the dimensions and the shape of a pipe. So it is needed to straight and to calibrate them (9). The straightened and calibrated pipes are cut (10) and cleaned (11).

On the stand 12 a pipe is controlled to find all visible faults. Next the specimens are cut to conduct laboratory tests (13). These tests should determine the mechanical characteristics of a pipe. It is also important to control the ring flattening (14).

After the (14) operation the process could be conducted according to one of two possible runs. For not responsible pipes the next one is the (22) operation. During this operation a pipe is measured to determinate its dimensions and weight. Next the pipe is visually and magnetic controlled (23). It is also marked. On the stand (24) pipes are packed and prepared for dispatching. The forwarding documentation is prepared on the stand (25).

The more responsible pipes are manufactured according the longer process loop. Firstly the edges of a pipe are worked (15).

Secondly the inner surface of a pipe is rinsed (16). Such prepared pipe could be investigated on a stand for investigation the leak tightness (17) by pressing water in a pipe. All tested pipes are visually controlled (18) and automatically tested (19). Also are conducted manual ultrasound tests (20). Not verified pipes are repaired on the stand 21.

4. The manufacturing process

As it was stated below the visualization technique has been applied to model the process of pipes welding with currents of high frequency. It is possible to show two main stages of this process [4, 5]. In the first one the metal sheet is formed in a cylindrical shape. Then the edges of the formed cylinder are heated and clenched to obtain the constant weld. All these stages are the objects of the visualization process.

The second analyzed topic is the problem of welding parameters. The quality level of the manufacturing process strongly depends on the proper choosing of those parameters. Secondly those parameters influence the simulation investigations of the analyzed manufacturing process.

4.1. Process parameters

According to the bibliography of a welding process there is a lot of parameters that affect that process [6]. Analyzing them it is possible to show following parameters:

- speed of a welding process
- current generating
- power of a current
- frequency of a current
- heating time
- time of pressing
- speed of pressing

Using these parameters it is possible to control the whole welding process. Moreover it is possible, using them, to modify the process or each simulation.

4.2. Process characteristics

The presented process of pipes pressure welding, with currents of high frequency, is one of the most economic manufacturing processes. The welding process is conducted continuously what increases its productivity. The manufactured pipes could differ in a diameter and wall thickness. Moreover it is possible to manufacture, using this technology, pipes from such materials as: ordinary steel, alloy steel, high-alloy steel, aluminum, titanium, nickel and copper. This proves the universality of this manufacturing process.

The characteristics of a raw material do not change during the process of pressure welding. So it is not needed to conduct other operations considered with unification material features of manufactured pipes. It is possible to join only materials of an adequate level of electric induction.

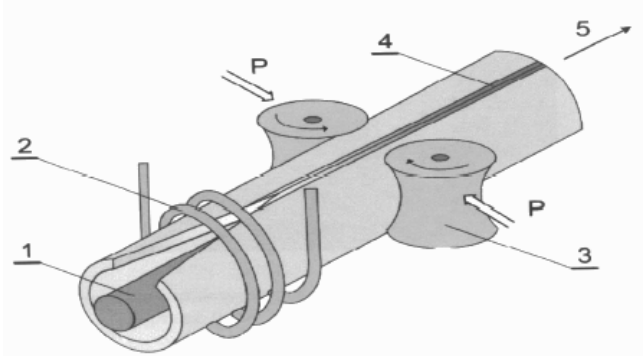

Fig. 10. Pipes welding process [7]; 1 – impulse generator and ring inductor of high frequency currents, 2 – magnetic resistor, 3 – pressure rolls, 4 – weld, 5 – welding direction, P – pressing forces

4.3. Welding process

The process of pipe welding could be divided on three phases: a forming phase, a heating phase and a pressing phase what is shown in Figure 10. It is important to conduct all these phases precisely because the quality level of pipes is proportional to the exactness of coordination of all sub-processes.

As it is presented above the manufacturing process of pipes welding consists of three phases. In the first phase special rolls form the flat metal sheet into a cylindrical tube. It is a very precise operation because during this phase the pipes obtain their final shape.

Next the edges of a tube are heated by the inducting currents [7]. These currents are generated using special impulse generator and ring inductor (1 in Figure 10). The edges of the tube are heated up to the plasticization temperature. So it is controlled to heat only the edge of the tube because heating could results in changing the material parameters.

Finally the heated edges of a tube are clenched to obtain the pressure weld. The characteristics of a weld strongly depend upon the clenching operation [8]. The most important parameter is the leak tightness of a weld.

The presented pressure welding technology is characterized also by some economic advantages. Firstly it is not generated the waste material during this process. Secondly the pipes could be produced continuously so it is possible to increase the productivity factor of this technology.

As it was stated the process of heating is related with the density of inducted currents of high frequency [7, 8]. To increase the concentration of a magnetic field in the welding area the special magnetic resistor is used. This resistor is placed inside a welding pipe what is presented in the Figure 11.

The magnetic resistor is manufactured from the material with high magnetic permeability (ferrite core) [8]. Inductive perimeter resistance, which is generated in a rolled pipe, is larger than the inductive resistance of the edges. It results in higher concentration of the currents in edges of the metal sheet of a rolled pipe. Application of the magnetic resistor allows also decreasing the electric energy consumption. It results in decreasing the power loss, which are generating by currents that flow on the inner perimeter of the pipe.

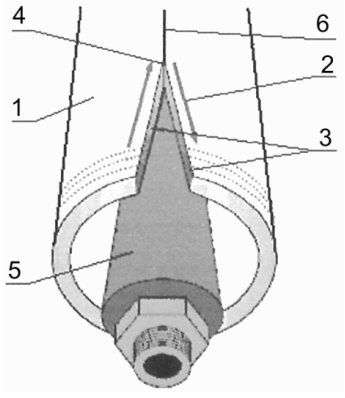

Fig. 11. Magnetic resistor [8]; 1 – welded pipe, 2 – inducted current, 3 – welded metal sheet edges, 4 – welded point, 5 – magnetic resistor, 6 - weld

5. Visualization

The model for visualization of a welding process has been prepared using a CAD system. Particular sequences of a forming process are presented on the Figures from 12 to 19.

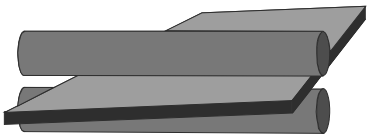

Fig. 12. Driving rolls

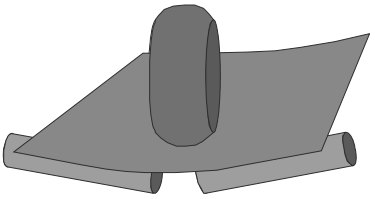

Fig. 13. Initial rolling – phase 1

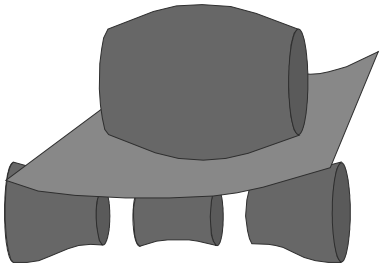

Fig. 14. Initial rolling – phase 2

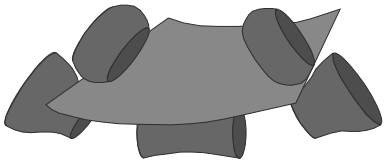

Fig. 15. Edges bending

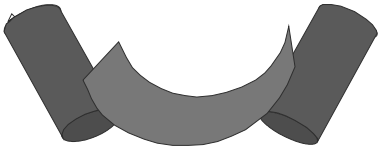

Fig. 16. Line forming – phase 1

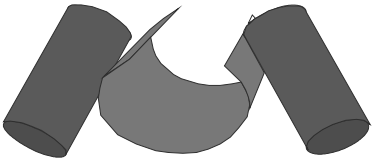

Fig. 17. Line forming – phase 2

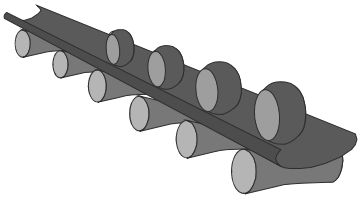

Fig. 18. Bands spinning

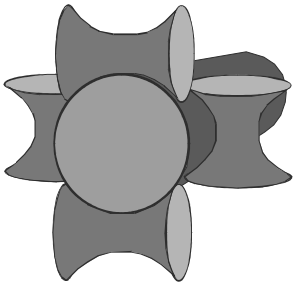

Fig. 19. Final rolling in a knife cell

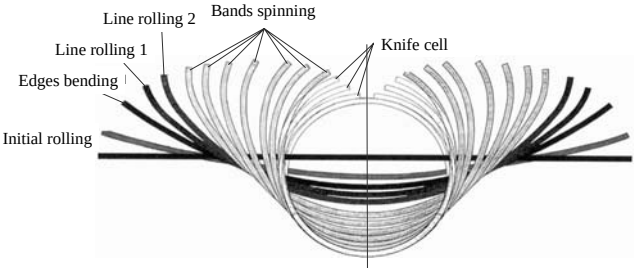

Fig. 20. General scheme of the rolling process

These frames show particular stages of the rolling process (comp.: [9, 10]). It is possible to observe how is manufactured the so called open pipe (Figure 17) and a pipe with a slot (Figure 19). Moreover it is possible to observe the role of each system of rolling in a process of a tube forming.

Figure 20 presents the general scheme of the process of pipe forming. It could be seen how particular rolls take part in forming the final shape of a pipe.

Figures from 12 till 20, which illustrate the rolling process, are a sequence of a computer simulation of this process. They have been elaborated in a CAD program. This approach allows to simulate and to analyze all phases of the pipe shape forming. In this way it is possible to find and eliminate faults of rolls placing and working.

These Figures are also a part of an educational film about the process of pipes manufacturing.

6. Presentation of a welding operation

When a metal band is formed correctly it could be welded what is shown on the Figure 21.

Fig. 21. Welding process

On this Figure one can see the magnetic resistor and the welding head. The operation is conducted on a welding table.

Pipes are welded with currents of frequencies from the range: 100 – 130 kHz. These currents are inducted with special electric coil. Next they are pressured with rolls with a force that could be regulated in a wide range. The welding operation is numerically controlled. After welding all outer riser heads and all inner welds are removed on a special stand. The last phase consists in marking the centering line.

In the next stage the welded pipe is cleaned and transported to stands for quality inspections. As it was stated above quality control system allows obtaining high level of customer satisfaction [11, 12, 13].

Cleaning operations could be divided in two groups: washing operations and mechanical operations. Also the pipe tightness is verified.

After main technological operations some quality inspections are made. The main quality test consists on ultrasound analysis of the obtained weld [14, 15, 16]. In some cases this control operations is perform twice to decrease the level of faulty elements.

All verified pipes are labeling to mark their characteristics and production standards.

7. Conclusions

Presented visualization of the manufacturing process of pipes pressure welding is an element of the development of computer aided teaching and e-learning [17]. Such aiding of an educational process is particularly important for material and technological sciences. It is consider with the fact that most of material processes could be observed only in a narrow range. The computer technique allows to present all phases of material processes. Moreover it allows conducting investigations of some processes in a model scale [18].

Modern computer techniques help also to integrate the tools that allow to design technological operations and technical solutions to obtain an improved scheme of manufacturing processes. It also allows to analyze the similarities and differences of some specific manufacturing processes [19, 20].

Nowadays manufacturing processes are mostly conducted in a manner of a process management. This approach allows to apply specific quality analysis methods for investigations the models of manufacturing processes [21]. It solves some problems of classical methods.

Concluding it must be stated that in this approach it is possible to joint the educational and management advantages of the simulating approach.

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