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TECHNICAL AND TECHNOLOGICAL FACTORS AFFECTING HYDROEROSION SURFACE TOPOGRAPHY

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ABSTRACT: *In the submitted paper, the authors analyse contemporary state of knowledge about factors affecting hydroerosion surface topography. They comprehensively identify particular categories of the factors where other particular factors are specified for each category primary and secondarily influencing performance, quality and costs of hydroerosion progresive processes. In the conclusion, their own scientific, research and experimental results as well as their practical verification and recommendation for practice are given. Specifically, two categories of factors - technical and technological - are specified because they play the most important role in relation to affecting the erosion surface and mainly technological factors affect the whole hydroerosion surface topography.*
KEYWORDS: *Waterjet cutting technology, technical factors, technological faktors*

INTRODUCTION

A water jet technology is a complicated high pressured hydrodynamic process which can be described as a field of jet technologies. The process itself requires as effective and economical use of the water jet energy as possible. It is directly related to optimal determination of water jet production and technology parameters considering basic physical properties of liquid as a cutting medium and hydrodynamic laws [1] .

The factors influencing the erosion surface both directly and indirectly can be expressed in three categories and consecutively identified:

I. Factors of liquid basic physical properties and their hydrodynamic regularities.
II. Technical factors influencing hydroerosive production process.
III. Technological factors influencing hydroerosive surface of the cutting.

TECHNICAL FACTORS INFLUENCING HYDROEROSIVE PRODUCTION PROCESS

This part contains a summary of technical factors depending on a model of a high-pressure pump, for example a pump 50 Hp Streamline SL-V which is the most expanded pump. These parametres and their designing – setting, relatively on principle infuences on smoothness of technological process and its impact on erosion surface [4], [5].

a) Basic power factors:
- *Pump model – model; engine power, maximal working pressure, maximal flow rate*
- *Noise level – model, noise level [dB(A)]*

b) Environs factors:
- *Surrounding environment*
- *Surrounding temperature*

c) Factors of water specification:
- *Factors of cutting water input – low-pressure water system*
- *Factors of cooling water input – recirculative system*
- *Factors of water quality - substances values requirements*

Quality of conveyed water is one of the most important factors influencing performance and lifetime of high pressure pump parts. According to the water analyze results, requirements for its repair can be determined. High concentration of dissolved solid parts, especially calcium, silicates and chlorides has a negative impact on high pressure parts lifetime [6].

d) Factors of hydraulic system and of high pressure water system:
- *Hydraulic system*
- *Pneumatic control valve*
- *High pressure water system*
- *Maximal flow rate*

e) Factors of water and abrasive nozzles selection:
- *Recommended water nozzle inner diameter,*
- *Recommended combinations of both water and abrasive - focusing nozzle sizes,*
- *Selection of water nozzle depending on engine performance and pump pressure,*

- Factors of water nozzles number depending on pump working performance.

TECHNOLOGICAL FACTORS INFUENCING HYDROEROSIVE SURFACE OF CUTTING

The analysis of technological factors related to their impact onto erosion surface represents determination of optimal values which have basicly and qualitatively infuence on erosion surface. It is useful to separate individual groups of factors in following structure according to [7], [8], [9], [10] (for example, a high pressure pump SL-V 50 Hp is assumed):

a) Performance and working factors:

- □ high pressure pump power,
  - electromotor power – 50 HP,
  - high pressure water flow rate per minute - 3,8 l/min ,
  - maximal working pressure – 410 MPa,
- □ high pressure pump oil cooler power – 9 kW,
- □ input water,
- □ cutting water,
  - minimal input 15,1 l/min.,
  - minimal input pressure 2,4 bar dynamic ,
  - maximal input pressure 6,9 bar,
- □ cooling water,
  - minimal input 9,5 l/min.,
  - minimal input pressure 2,4 bar
- □ air pressure – 5,5 - 6,9 bar .

b) Technological and input factors:

- □ Hydraulically:
  - Liquid pressure in MPa (It gives information about how much high pressurewater the pump is capable to produce per minute.)
  - Water nozzle diameter in mm (The water nozzle diameter determines flow rate of high pressure water per minute.)
  - Abrasive nozzle inner diameter in mm (It determines maximal abrasive flow rate related to water nozzle diameter.)
- □ Abrasive:
  - Kind of abrasive (Individual kinds of abrasive determine mainly their hardness and abrasiveness.)
  - Abrasive granularity in MESH (It influences mainly cutting quality at given kind of material.)
  - Weight flow of abrasive in g/min (It substantially influences speed and quality of cutting and some other parameters.)
- □ Material:
  - Kind of material (basic kind of material, its chemical composition and properties)
  - Thickness of material in mm (The thickness influences depth and quality of cutting)
  - Surface processing of material (The surface processing of cut material influences penetration pressure, speed of cutting, angle of jet cutting material.)

c) Technological and production factors:

□ Directly regulatory:
- Cutting speed control (good quality cutting along entire thickness of material),
- Liquid pressure control (high pressure water production rate increasing),
- Regulation of ratio of water nozzle diameter to abrasive nozzle (increasing of suspension flow rate through abrasive nozzle)
- Regulation of flow weight flow (however only up to critical abrasive quantity value),
- Jet dynamic stability (smoothness of abrasive flow, pressure pulsation of input water, etc.)
- Stroke of nozzle above material in mm. (High of nozzle above material influences mainly cutting quality, width of cutting opening, depth of cutting, time of penetration, sharpness of cutting edge, fan-shaping of bottom cutting edge and jet whole dynamic stability.)
- Jet falling angle in degrees (Perpendicular angle of jet falling is considered to be optimal. The angle influences depth and quality of cutting.)
- Jet transition number – used very seldom (Jet transition number can wide thickness of cut material but it can substantially eliminate fan-shaping of bottom part of cutting edge.)

□ Indirectly regulatory:
- Width of cutting opening (all qualitative parameters influence its width)
- Cutting depth (it depends on cutting speed, high pressure water flow rate and abrasive weight rate)
- Time of material penetration (it depends on pressure, high pressure water flow water and abrasive weight rate)

- *Kind of abrasive (this factor can also influence cutting quality)*
- *Cutting direction (linear interpolation can influence cutting speed and circular interpolation can influence cutting speed and cutting quality)*

d) Production, qualitative and output factors:

- *Measuring of product dimensional precision quality (checking of dimensional precision is provided with digital gauge)*
- *Measuring of cutting edge quality – roughness of cutting quality (measuring of roughness is mostly in the middle of cutting edge or according to methodically defined measuring zones which divide whole cutting edge surface onto several zones.)*
- *Angularity of cutting edge (angularity can be measured with angular gauge)*
- *Wear – sharpness of upper erosive edge at place of jet penetration into material (quality focusation of water and abrasive suspension in abrasive focusation nozzle influences sharpness of edge at place where the jet enters the material.)*
- *Difference between jet input and output (This difference can be eliminated by proper setting of technological cutting parameters and input production and technological parameters. In the material, bending of the jet is in the second third of material between its input and output.)*
- *Fan-shaping of bottom part of cutting edge (The fan-shaping in the bottom part of cutting edge is caused by dynamic jet instability and not only by difference between jet input and output but also equal jet input and output.)*
- *Waste water quality (Empirically confirmed four steps sediment separators for waste water cleaning).*

These basic factors represent qualitative extend of evaluation of cutting topography result created by hydroerosion.

CONCLUSIONS/SUMMARY

All the complex of the factors defining cutting erosion surface is described in the papers of the authors. On the base of the given complex specification, a graphic model of factors complex was designed. It was defined in WATING Prešov and at The Department of Technologies and Materials of Faculty of Engineering TU in Košice as a mode KMF1 which is shown in Figure 1.

FACTORS INFLUENCING HYDROEROSION SURFACE TOPOGRAPHY		
Factors of basic liquid physical properties and their hydrodynamic regularities	Technical factors influencing hydroerosive production process	Technological factors influencing hydroerosive surface of cutting
✓ Physical properties • liquid density • liquid viscosity • liquid compressibility • liquid expansivity ✓ Hydrodynamic regularities • Basic hydrodynamic equations • pressure changes propagation speed • water surge – Žukovský´s . theorem • real liquid flow character	✓ basic power factors ✓ environs factors ✓ factors of water specification ✓ factors of hydraulic system and of high pressure water system ✓ actors of water and abrasive nozzles selection	✓ performance and working factors ✓ technological and input factors ✓ technological and production factors ✓ production, qualitative and output factors

Figure 1. The graphic model of hydroerosion factors complex – Model KMF1

Verification of the formulated factors was finally performed with material AISI 304 samples, thickness 8 mm. Figure 2 shows cut 9 pieces of verified samples.

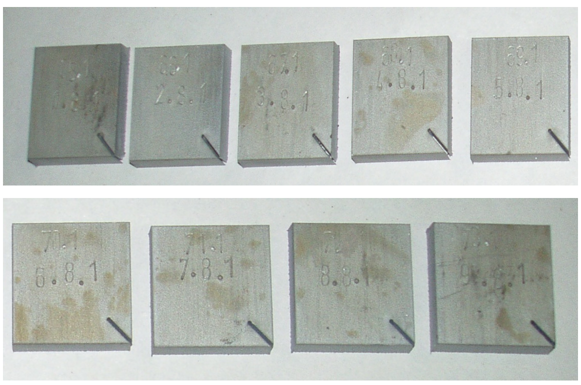

Figure 2. Verified samples - thickness 8 mm

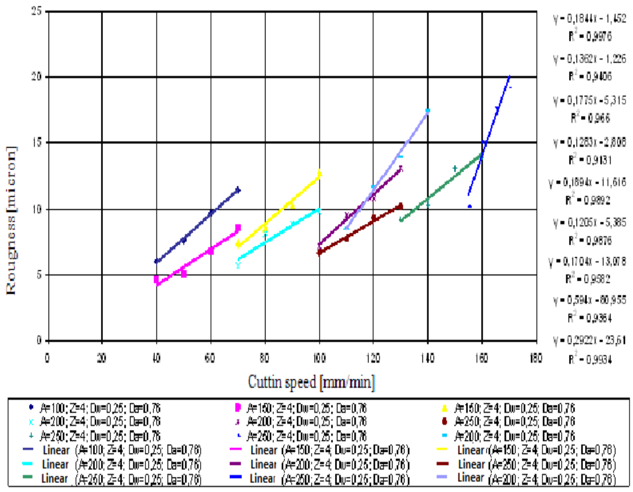

Figure 3. Relation of roughness to cutting speed for AISI 304, thickness 8 mm, at various abrasive weight values

The cutting parameters of given verified samples were records in the records and their evaluation in graphs is in Figure 3.

For contemporary practice and from economy aspect of hydroerosion jet cutting, for example, flow rate fluctuation survey represents a relatively wide clarification of water jet technology parameters themselves, with the ambition to find a way how to define cutting parameters warranting output qualitative technology aspect and in the same time economy aspect of water jet cutting process, at optimal hydroerosion factors.

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