CONSIDERATIONS REGARDING EFFICIENT USE OF ABRASIVE MATERIAL IN WATER JET CUTTING

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ABSTRACT: Abrasive Water jet cutting process fits in the category of unconventional dimensional processing technologies, based on the principle of erosion with complex fluid environments, kinetically activated. Currently, there are multiple researches for process optimization, especially taking into consideration the economic criteria, due to relatively higher costs present in the case of abrasive waterjet cutting. The paper presents a synthesis of a study started from research within the National R & D Institute for Welding and Material Testing - ISIM TIMIŞOARA, especially in the direction of increasing the efficiency of using the abrasive material associated with this cutting process. Several patented results regarding the recycling of used abrasive material in other fields are presented, as well as prospects for further research by studying other methods aimed at reducing costs without reducing the level of quality for abrasive water-jet cuts.
KEYWORDS: water jet cutting, efficiency, abrasive, recycling, construction mortar

5. INTRODUCTION

Based on the principle of erosion with complex fluid environments, kinetically activated, water jet cutting and abrasive fall into the category of nonconventional dimensional processing technologies [5]. From a technological point of view, the efficiency of the method is eloquent considering the multiple applications made so far. Due to the high costs of applying water jet and abrasive cutting technology, researchers are currently concerned with optimizing the technology, following the chosen economic criterion, by to seek to reduce final costs. The costs of applying water jet and abrasive cutting technology have been analyzed by several researchers and manufacturers, [1], [2], [3]. John Caron (Hypertherm) considered, for example, that garnet or aluminum oxide abrasive could represent up to 55% of the total cost of water jet and abrasive cutting, including both the initial purchase of the abrasive and the preparation and shipping of the abrasive. used in a landfill [7]. Breaking down the typical variable costs per hour of operation for this unconventional cutting method, the use of the abrasive by other authors also led to similar views on the share of total costs [10].

Therefore, action was taken in the direction of optimal solutions to the problem of abrasive material recycling, with efficient recovery of waste even in other domains, in this paper for example in the construction materials category.

2. METHODS AND MATERIALS

ISIM Timisoara has over 20 years of experience in the field of research and use of water jet cutting technology, actively and continuously carrying out research activities that have focused mainly on three directions:

• implementation of the water jet cutting process, with additional operating equipment necessary to use the process in as many applications as possible.

• development of cutting technologies for a wide range of materials; providing services for industry.

• development of extensive research programs resulting in the proposal of new, innovative and industrially applicable solutions in the field of water jet cutting, with the lowest possible costs. [9].

The researches regarding the efficiency of its use were carried out mainly in the welding, cutting and heat treatment laboratory of ISIM Timisoara, using the installation from figure 1.

Several experiments were performed on this equipment, both in the direction of the constructive structure and for the extension of its range of use.

Cutting operations are performed on the following types of materials: metal, plastic, cardboard, glass, rubber, granite, alumina, mineral-ceramic carbides, carbon fiber. The installation is equipped with a CNC system BURNY-ETEK, comprising a library with 53 standard programs, ensuring the possibility of making cuts after a programmed contour, with the precision of the automatic tracking system to compensate the zero slot of ± 1.2 mm / 1000 mm, including also materials in overlapping layers without affecting the quality of the cut surfaces. For better functionality, a device has been designed and built (Patent RO 130329 B1), which facilitates the positioning of the part to be processed with water jet, consisting of a honeycomb metal frame, with fixed and movable elements that ensure the horizontality of the device .

Figure 1. Water jet and abrasive cutting equipment

Disposal of used abrasive material

In the context of the possibilities to reduce operating costs, through savings on abrasive material costs, an analysis was performed on the possibilities of constructive optimization of the existing installation. The problem of manual evacuation of used abrasive material, performed manually, with interruptions in the operation of the installation, was identified. Thus, an original device has been designed which ensures the evacuation of the used abrasive material, simultaneously with the cutting process. The designed technical assembly ensures the evacuation (figure 2.), being driven by a gear motor (1) with pinion drive, which drives in motion a drive chain (11) on which they are fixed by means of traction rods (12), some scrapers (2), which are directed, by means of guide rollers (3, 9, 15), to a collecting tank (4), under the work table (5) and the support grate (7), the used abrasive (10)), being discharged through an outlet (13), into a movable collecting vessel (14).

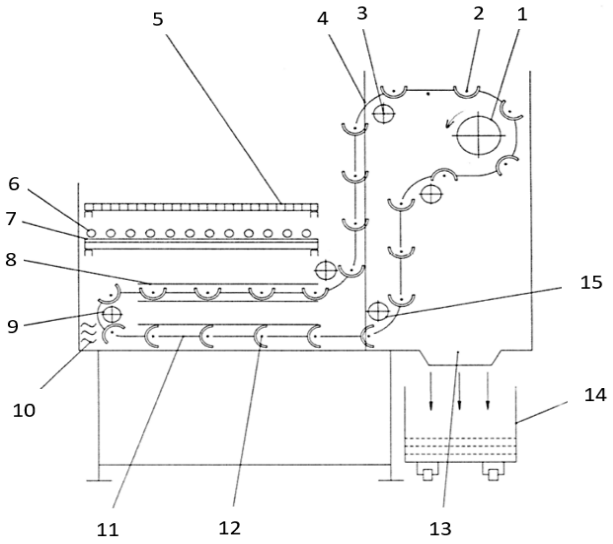

Figure 2. Patented technical solution for waste abrasive evacuation

1 – gear motor, 2 - scrapers, 3 – guide rollers, 4 – collecting tank, 5 – work area, 6 – guide rollers, 7 – support grill, 8 – roller guides, 9 - guide rollers, 10 – waste abrasive exit, 11 – guide chain, 12 – scraper supports, 13 – exit, 14 – collecting tank, 15 – guide rollers

Abrasive recycling

Usually, the abrasive used is a hard sand separated by particle size. The most used type of abrasive is the garnet, considered quite hard, resistant and cheap.

Figure 3. The hard rock garnet abrasive has sharper edges (left) than alluvial garnet abrasive, which has more rounded edges and is considered a general-purpose abrasive for most waterjet cutting applications. Photo courtesy of Barton International [8]

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The most used type of abrasive is the garnet, considered quite hard, resistant and cheap.

For example, garnet abrasive for waterjet applications is available in two basic forms (see **Figure 3**), according to Barton's Rapple [8].

Hard rock abrasive is angular and has very sharp edges. Alluvial abrasive has more rounded edges and is generally considered a more general-purpose product.

The hard rock abrasive is the choice for those fabricators that need an aggressive and fast cutting action and when specifications require a higher-quality surface finish than an alluvial abrasive can deliver.

It is chosen differently, especially in relation to the granulation (appreciated in Mesh units), which can be: 120 - which produces a very smooth surface, 80 - most often used for general use, respectively the granulation 50 for a more cut faster than the others but with rougher cut surfaces.

The optimal size of the abrasive particles depends on the type of material being cut, the average size of the abrasive (size 60) being more efficient when cutting steels.

It is also possible to quantify the effect of the size of the abrasive particles depending on the shape of the abrasive (rate of curvature, sphericity).

For an identical shape factor, but of different sizes of the abrasive, the depth of the cut increases as the size of the abrasive particles decreases.

On the other hand, the loss of impact energy at the outlet of the nozzle for small abrasive particles is higher.

Water jet and abrasive cutting is considered a cumulative process, so the impact of the speed and frequency of the abrasive particles becomes important.

The speed of the particle determines the load on the material and the transfer of energy, implicitly the size of the cutting depth.

The hardness of the abrasive is chosen depending on both the hardness of the processing material and the depth of the cut.

Due to the high costs of the abrasive, the recycling of the abrasive material becomes imperative.

The possibilities of recycling were analyzed in order to reuse as many times as possible, a situation possible especially in the case of particles that pass through the jet without touching the metal during cutting.

Recent developments in water jet cutting technology allow a manufacturer to recycle abrasive material and use it repeatedly.

Before an economic operator invests in this type of equipment, it should first consider the types of abrasive materials that are available, as well as how the recycling technology works.

Statistically it was found that the cutting processes with water jet and abrasive 50-70% of the abrasive is not used, percentage representing the mixture in the core of the jet, only a percentage of 30-40% of the abrasive flow used in the jet is used for cutting.

Abrasive recycling systems allow manufacturers to reuse the material several times, generally 30% of the original amount is lost and 70% can be recycled.

It was found that when performing an analysis using successive sieves of the abrasive used, up to 35% of some abrasive materials do not change their size the first time they pass through the cutting head and material.

After performing water jet and abrasive cutting operations, the resulting abrasive material has smaller grain sizes and can no longer be used for other subsequent cutting operations. in this case this material becomes waste.
Quantities of used abrasive are stored in places intended for this purpose, commonly called used abrasive dumps.
At present, the capitalization of this used material does not take place, as no practical methods have been developed for this purpose.
An analysis of the used abrasive material was performed after it was brought to a dry state.
The results of the particle size analysis are presented in Table 1.

Table 1. Particle size analysis of used abrasive material

Sieve size [mm]	0,063	0,125	0,250	0,500
Used abrasive material Passages [%]	26,8	50,6	96,0	99,7

Based on the characteristics of the resulting waste, the possibility of its assimilation in the composition of mortars usable in constructions was studied.
Thus, the compositions in table 2 were made.

Table 2. Compositions usable for the valorization of used abrasive, for mortars

No. crt.	*Component*	*Composition no.*		
		1	*2*	*3*
1	*Cement/Sand*	1/3	1/3	1/3
2	Worm abrasive (% from cement)	10	5	0
3	Ratio water/cement (%)	0,535	0,535	0,535

For the analysis of the qualities of these mortars, the workability test was performed by the spreading method, according to SREN 1015-3: 2005. by this method successive shocks were applied on a frustoconical shape of the mortar and the measurement of two diameters perpendicular to the resulting circular shape. the apparent density was determined according to SREN 1015 - 10: 2002, by weighing the specimens in water and air.
The values regarding the mechanical resistance to tension and compression were determined after SREN 1015 - 11: 2002, after 7 days from casting.

3. RESULTS AND DISCUSSION

The results of these researches have proved favorable for the efficient use of the abrasive material for water jet cutting, the technical solutions being currently protected by patent.

In the first phase, the constructive solution of the processing device by water jet cutting, (Patent RO 130329 B1), proved to be efficient especially through the facilities of fixing the cutting parts.

The abrasive discharge device (Patent RO 129441 B1) brings the following advantages:

- ✓ Full use of working time for cutting operations,
- ✓ The possibility of scheduling a certain expected productivity for each cutting operation by eliminating the relative manual evacuation times.

The device is expected to be integrated with the sorting system, with the possibility of separating the unused abrasive, to be reintroduced into the cutting process, and the used particles transported to a drying and preparation plant to be used in other destinations. The results of the tests performed on the recycling of abrasive waste highlighted the cost-effectiveness of implementing the proposed solutions.

Thus, the process for obtaining a mortar-type construction material from abrasive waste material (Patent RO 129363 B1, supplemented by Patent RO 129363 A2), has been recognized for its advantages, both economic and technological.

The variation of the density with the amount of used abrasive confirms that the addition of used abrasive fits properly in the granulometry of the sand, which it also significantly improves.

Thus, by using this waste a much more valuable mortar for constructions is obtained, presenting superior qualities regarding the adhesion to the surfaces on salt it is applied, greater resistance to higher temperatures, realizes an activity of greening of the areas in which it is currently stored, used abrasive material, as waste.

One of the main reasons why it makes sense to recycle the abrasive material used is that some particles do not touch the metal during cutting.

The abrasive passes directly through the jet, which means that some particles are the same after they have gone through the cutting process.

The abrasive material that influences the parts of the equipment is usually sprayed, while some of them crack and create sharp edges and new cutting edges. Some particles of abrasive material, even if they do not come into direct contact with the material to be cut, become finer (smaller granulation) during the process and cannot be reused.

Abrasive recycling systems are configured differently, but there are usually two systems installed - the abrasive removal system and recycling.

These results are quite conclusive for the continuation of a study started within ISIM, especially oriented towards increasing the efficiency of the use of abrasive material.

4. CONCLUSIONS

Water jet cutting has proven in many situations to be the fastest possible, regardless of the material being cut or the strength of the system.

Through these few technical solutions, premises were created for a broader approach of the research program on the more efficient use of the water jet and abrasive cutting process.

Further research also covers the field of unconventional processing, which has the potential to increase the accuracy, productivity and secondary recovery of waste, thus leading to an integrated processing process, with a positive impact on the process, the environment and economic results.

Its purpose is to generate process and product innovation (goods and services) in the field of unconventional processing, which has the potential to increase the accuracy, productivity and secondary recovery of waste, thus leading to an integrated processing process with positive impact. on the process, the environment and the economic results.

Next, the prerequisites for future research should be the pursuit of economic efficiency in the already recognized conditions of the versatility of water jet

cutting technology, which allows cold cutting without altering the structure of the processed material. after complex shapes of any type of material with thicknesses between 0-200 / 250mm.

That is why there are continuous concerns for increasing the performance of the technical systems used for this purpose, following the quality of cutting (anyway, usually without material residues, such as burrs), the system does not raise dust or smoke during the work process, using is frequently in solving problems identified innovation. In the analysis of the water jet cutting technology, the optimal capitalization of the flexibility feature of the method was sought, being able to choose the desired finish, maintaining a good control of costs and processing time.

Water jet cutting is an unconventional technology, as spectacular as it is easy to use, with low material losses due to the "nesting" function, without the need to change tools for different types of processed materials.

Significant is the ability to manage the cutting speed during operation to obtain the quality of the edge required by the production process.

The water jet cutting method has offered designers and users the continuous improvement of the multitasking function, in many current construction solutions, CAD-CAM applications, as well as others that can be used even if the machine is in the process of executing a job, and the control function can be executed while the machine is in processing (changing parameters, etc.).

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