Environmental Aspects Of The Green Surface Plastic Deformation Technology Of Car Parts

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Abstract. Foreign and domestic experience in development of dry processing technologies are considered. The results of the introduction of dry processing technologies (cutting, boring, milling, drilling) on the industrial companies in Germany are given. The negative impact on the environment and human health is shown. The possible ways of leakage of lubricoolant components in the atmosphere and soil are considered. Lubricoolants are considered as a required permanent component. Three main tasks for lubricoolant: cooling, lubricating and chip disposal are discribed.

Introduction

Modern engineering plant consumes ten thousand tons of lubricoolants required for machining processes of machine parts. In existing machining technologies and particularly in surface plastic deformation processing (SPD), processing combined with supply of lubricoolants which have a negative impact on the environment and health of production personnel [1]. Some research's shows that energy costs of using lubricoolants (supply, maintenance and cleaning in the circulation system) reach up to 80% of the total energy costs.

The present stage of development of mechanical engineering is characterized by statement and solution of extreme problems to find the optimal conditions in the processing under the changed significance criteria of parameters of machine parts, the change to so-called "green" technologies. This increase of research interest in such complex tasks associated with limit of natural, material, human resources and need to save energy and materials.

There are three main ways of green machining technologies development:

1. Dry processing;
2. Lubricoolant replacement for environmentally friendly materials (vegetable-based and organic lubricants);
3. Using micro supply of lubricoolant during processing.

In 2012 import quota in the Russian Federation of machine and tool production was 91.2%; machines – 93.3%, tools – 88.1%, abrasive production – 83.4%. The value of exports of machine and tool production is high - 58.1%; machines - 41.9%, for the tools - 61.0%, abrasive production - 77.6%.

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Therefore, engineering solutions in this area may contribute to not only import substitution, but forthcoming of export-dependent production. The leading countries of the engineering sector (USA, Japan, Germany) have not such a complex problems as in Russian Federation. Nowadays, active steps are carried out in the solution of the problem. "The Presidential Commission for Modernization and Technological Development of Russia's Economy" was established.

Europe experience: refusal of lubricoolant

Since the 90s of the last century many European companies in collaboration with institutions have been performing developments in the theoretical and practical methods of machining without lubricoolants for Environmental Security of production and expected economic effect. The major project "Dry processing" is carried out in Germany in the spring of 1994 and 2002. It covered a fundamental scientific research, development and optimization of technologies for tools, equipment and processes for machining different materials. The project was implemented under the Federal Ministry of Education, Science, Research and Technology. The project involved 24 companies (DaimlerChrysler AG, Gühring, Huller Hille, Mapal, etc.), institutes and innovation technology centers which was organized into 5 groups with representative industrial companies leaders. In general, dry processing technologies (dry cutting, turning operation, milling, drilling) except SPD processing were investigated.

Two project groups have implemented developments into mass production in December 1996: aluminium milling on the company "Dasa" in Augsburg and dry drilling on company "HDM". Huller Hille company has developed a machining center for dry machining of engine parts (cylinder head).

At the factory of "BMW" company in Steyr on a new automated line in a dry processing was carried out boring of holes of 6-cylinder aluminum block. Cost analysis showed an economy of 17% due to decrease of investment and operating costs. Deep boring is implemented in the company "Daimler-Benz". Introduction of dry machining in Bosch company was planned in 1999-2000, in Nuremberg is production of body of throttle valve (1100 parts / day). In Homburg is boring and milling of body of hydraulic valves from casting (28,000 parts / year). In Feuerbach is the process of deep boring in steel (4000 parts / day).

The BMW, Daimler-Benz companies and ISF Institute of Dortmund’s University developed a list of requirements for the machine, operating on dry processing technologies in mass production. These requirements are implemented on the milling machine "Specht 500-t" in Huller Hille company.

Russian Federation: refusal relevance of lubricoolant

The mechanical assembly production of JSC "AVTOVAZ" operates 356 units of metal-working equipment that consumes 2 thousand tons of fire hazard lubricoolants per year which 60% are irreversible losses. These liquids have a low ignition temperature; it creates the risk of fire; deteriotates the working conditions which cause occupational diseases; leads to environmental damage.

Researches of Russian scientists confirm the fact that petroleum oils vapors can lead to the body’s defeat up to the lipoid pneumonia. Hydrocarbon vapors have a narcotic effect, triethanolamine causes dermatitis, sodium nitrite contributes to gas exchange abnormalities in humans body and damage to the heart muscle, the chlorinated additives can cause damage to the liver and kidneys, trichloroethane is a source of phosgene liberation, etc.

Air pollution occurs not only during operation, but also as a result of evaporation and combustion of used lubricoolants. However, the main danger it is their leak into the soil and get into the subterranean water.

Despite of constant improvement of machining technologies, tools and equipment, lubricoolants are considered as a required permanent component. Lubricoolant performs three main tasks for the steady processing: cooling, lubricating and chip disposal. Total rejection of lubricoolant can solve many problems.

In opinion of the public and consumers the corporate policy of modern industrial company is not acceptable without her efforts to preserve ecological balance. The constant raising the legal requirements for environment protection leads to the search for environmentally friendly processes in mechanical processing.

Experience of processing without lubricoolants technology

Between 2001 and 2012 by scientist of the Togliatti State University (TSU) have been developed: scientific bases of surface plastic deformation processing without lubricoolants of car's parts; process mathematical models; algorithms for calculation of process conditions (confirmed by a certificates of algorithm registration); technological limitations of the process; processing techniques; tools and devices designs implemented in production and patented. The results of work published in more than 100 articles, 50 domestic and International proceedings, were granted 11 patents and 3 certificates of algorithm registration, prepared for defense 1 doctoral thesis and 3 candidate theses.

Environmental compatibility as perspective of developed technology

Components of lubricoolants, bactericides and fungicides, reaction products as well as foreign substance can cause a series of occupational diseases. The German Agency for Environmental Protection also announced that up to 30% of all occupational diseases of engineering companies employees associated with exposure to lubricoolants in labor activity process. Evaporation and combustion of exhaust lubricoolants pollute the atmosphere. Toxic components (sulfur dioxide, organic chlorine and heavy metal compounds) with clouds spread across the planet. Moreover, combustion of synthetic oil based lubricoolants has unpredictable effects.

The leakage of lubricoolants into the soil and infiltration into the subterranean water leads to the formation of "oil lens". The speed of oil propagation is 10.2-10.5 m/s in width and depth. Oil migrates with subterranean water and contaminates it with components: polycyclic aromatic hydrocarbons, polychlorinated biphenyls, sulfur- and chlorine-containing additives, biocides, nitrites, organic metal contents (lead, barium, antimony, zinc). Especially low degree (10-30%) of biodegradation of these substances leads to ecological disbalance: intensive reproduction and mutation of microorganisms assimilating mineral oil.

In this way, processing with total rejection of lubricoolants significantly improves the environmental performance of production and reduces the stress on the region's ecosystem and there is no need to dispose of exhaust lubricoolants.

Technology implementation

The collective of authors propose a finish surface plastic deformation processing technology of surface of revolution without lubricoolants.

It is worth nothing that surface plastic deformation processing does not withdraw the metal. Surface irregularities, remaining from the previous operation, are partially or completely smoothed during processing, and the surface acquires brightness [2-14]. Thus, there is no problem of chip removal from the treatment region as in cutting or abrasion processing, though in SPD method the wear fragments are accumulated on tool's working surface.

Consequently, SPD processing depends on detergency value of lubricoolant which is determined by degree of treatment region purification of sludge containing the fine chip particles of workpiece and tool material (carbides and non-metallic inclusions). Mechanical and electrostatic van der Waals forces retain the sludge on surface of solid's.

The smaller sludge particles easier penetrate into the tool and workpiece and more impacted on the solid surface degrading processing technological parameters. In case of improper lubricoolant purification the sludge are deposited on the surface of workpiece directly from the liquid. The visual control of contaminated workpiece's surface is complicated.

To resolve this problem authors have developed a device for SPD processing of parts without lubricoolants [15]. The device is directed to solve the technical problem of working surface cleaning during processing.

The technical result is provided by the device for SPD processing of revolution surfaces with lubricoolant which remains on workpiece surface after previous operation. It contains the drive holder and tool holder and processing tools (indenters) equipped with rectilinear edge scrapers. The edges are located lengthwise the workpiece surface generatrix, and scrapers contact the workpiece surface at least with one edge.

Figure 1 shows the proposed device. Indenters 1 are pressed against the processing surface with the operating force and fixed in the holder 2 with screws 3.

Fine-fibre felt scrapers 4 are secured on instruments 1. Scrapers are fixed by the inner salient in the hole to the rear end to the indenter or by assembling with a tightness, as shown in the figure 1. The hole in scraper performed with diameter of approximately 1 mm less than the diameter of the tool.

The device operates as follows:

Workpiece starts to rotate. Indenters 1 are contacted with workpiece's surface towards the arrow on figure 1 and pressed against it with the operating force. After that, tools are feeded lengthwise the axis of workpiece, wherein scraper 4 contacts the processing surface with edges "a". Edges of scraper "a" captures sludge particles remaining on the workpiece's surface or occured during processing.

Commonly, the amount of sludge is relatively small. The experience of device showed that the processing of such workpiece as rear axle shaft with two-shift operation mode and the productivity of the machine up to 180 parts/hour requires to replace scraper at most once every two weeks.

The application of this device provides for operator-setter the possibility of permanent equipment visual inspection immediately after the part out of the treatment zone, and also provides the required surface quality and tool's durability.

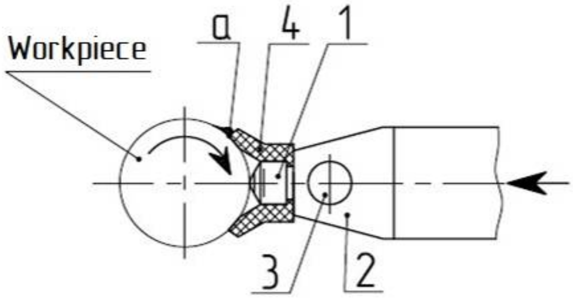

Figure 1 – Engineering solutions implemented for SPD processing without lubricoolants

Practical application

The generalization of the results of theoretical and experimental studies allowed the development and implementation of high productive SPD processing with wide indenter without lubricoolants in mass production. In this processing method the deformation area width matches the width of processing surface [16-18].

At present, with use of SPD technology without lubricoolants produced more than 15 million parts. The research works are carried out to expand the range of parts processed by the proposed technology. Figure 2 shows the machine for processing by SPD without lubricoolants.

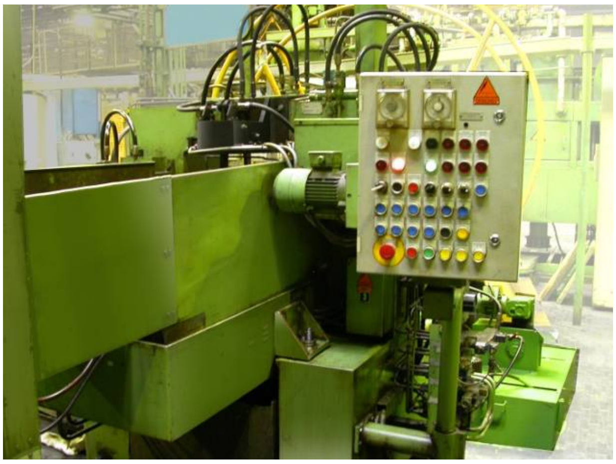

Figure 2 – Machine for processing by SPD without lubricoolants

The application of this developed technology of car part's gland necks processing reduced the number of defects "leaking of gland" 3 times during the warranty period. After polishing by traditional technology (Figure 3) surface receives the required microrelief in connection with gland in a long time period in contradistinction to SPD method (Figure 4).

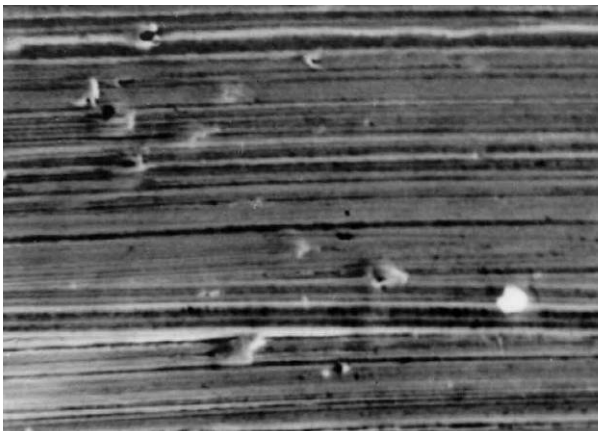

Figure 3 – Surface after polishing processed by "Nagel" machine

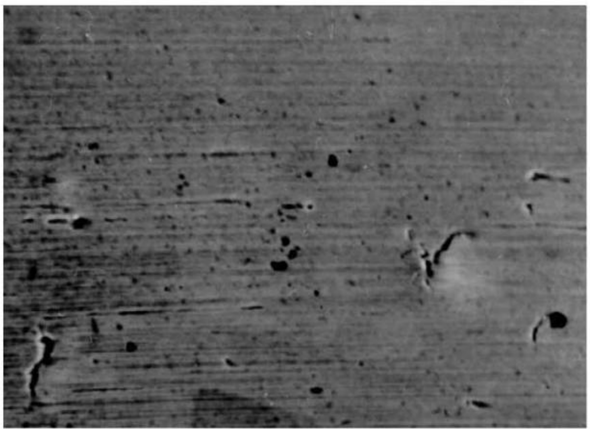

Figure 4 – Surface after SPD processing without lubricoolants

Results and Discussion

Innovative technology of surface plastic deformation processing without lubricoolants has no application analogues in mass production in Russian Federation and abroad. That is the only processing without lubricoolant which uses native tools and technology that is implemented in mass production in Russian Federation.

The total economic effect from the technology implementation in mass production more than 1.5 billion rubles.

The proposed engineering solutions are exclusively based on domestic technology and tools, thus expensive imported equipment (costs up to EUR 1 million per unit) are eliminated and the load of engineering enterprises of the Russian Federation are increased. Processing technology without lubricoolants eliminates the fire hazard, environmental pollution and harm to human health.

Conclusion

The SPD processing technology without lubricoolants has shown high quality results in production of automotive components of LADA cars. Developed technology used for finishing processing of gland neck of primary shaft of LADA car and has the following parameters [19]:

- Processing method: Surface plastic deformation;
- Processing surface: gland neck of primary shaft D 20…40 mm;
- Processing length: 10…20 mm;
- Initial surface roughness: less than Ra 0.8;
- Number of concurrent instruments: 2;
- Nominal force on the tool: adjustable, 150…250 N;
- Nominal spindle speed: 500 rev/min (adjustable by continuously frequency converter);
- Nominal feed: 0.12 mm/rev (0.06 mm/rev for each tool);
- Drive of the tool: hydraulic;
- Drive of feed (slide movement): hydraulic;
- Nominal cycle time: 28.8 sec;
- Productivity with the efficiency factor 0.8: - 100 parts / hour.

Thus, the proposed technology can be applied to any engineering enterprises in processing of the surface of revolution of the parts working in terms of friction, for example: gland neck of shafts, directing gland neck of shafts, surfaces of rolls.

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