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ANALISIS OF THE PROBLEM OF AEROSPASE INDUSTRI IMPACT ON THE ENVIRONMENT

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The article describes the major industrial processes within the aerospace industry, including the materials and equipment used, and the processes employed.

Розглянуто головні індустриальні процеси в аерокосмічній індустрії, матеріали, обладнання та процеси, що використовуються.

Introduction

In the nature there were not and there are not mechanisms of neutralization, utilization and elimination of significant part of waste produced by human civilization that is accumulated in biosphere in geometric progression.

Today around 15 billions tons of firm-solid, liquid and gaseous wastes are annually added to their already available volume.

Modern treatment plants allow no more than 40% of wastes to be rendered harmless. Factory disposals, named "tails", accumulate in storehouses and on allotted for them places are poisoning life of nearby settlements. The following figures give an idea of their general volume: annually from the depth of the earth up to 15–17 km³ of rocks are extracted in the form of minerals and only 7% (up to 1,2 km³) a man receives in the form of a useful final product.

The rest goes to dumps [1].

Today around 28 billion tons of firm-solid waste are concentrated on the territory of Ukraine that is more than 180 thousands hectares of the ground.

On the whole of accumulated waste proportion of household and industrial wastes (mainly this is waste of IV risk class) make up approximately 1:50 while in EU countries only 1:5 [2].

Data on accumulation, formation and use of industrial and household wastes in Ukraine are given (2000) [3]:

Total, billions tons.....	30
for 1 person, tons	600
for 1 km ² , thousand tons	50
Total square, thousand hectare.....	170
Waste utilisation, %	10–15
Waste toxic neutralization	0,5

The system "aviation enterprise – environment"

Interrelation in the system "aviation enterprise – environment" is realized in the following way. Whole product that is manufactured by the aviation enterprise synthesizes in itself definite quantity of natural potential of surroundings in the form of raw materials and energy.

The enterprise takes away from environment natural resources recycling of which manufactures the final product. At the same time, the environment gets products of technological redistribution – different kinds of waste [4].

The modern aeroplane is saturated with different equipment, devices and mechanisms.

Quantity of details in the glider construction of a large aeroplane runs up to more than one thousand thousand items.

Special devices and mechanisms are calculated by hundreds.

This peculiarity of the aeroplane needs in use of numerous and different technological processes, special tool sets, complicates planning, control and accounting of incomplete production and also great number of different in composition waste.

At present approximately 70% of total quantity of details of passenger plane are manufactured from light alloys of different models, 25% – from alloyed steel and the rest part – from plastics, rubbers, fabrics, ceramic and metal-ceramic materials [5].

Materials

There are many different materials involved in the production of engines and parts. The most common materials are alloys of aluminum, which are used primarily for aircraft structural components and exterior skin sections.

Other materials are titanium, stainless steel, magnesium, and non-metallics such as plastics, fabrics, and composite materials. Typical forms of materials are honeycomb, wire mesh, plate, sheet stock, bar cast, and forged materials.

Metallic Alloys

Aluminum is used as a primary structural material in the aerospace industry because of its light weight, and because its alloys can equal the strength of steel.

The ability to resist atmospheric corrosion also favors the use of aluminum. The type of alloy metal used depends on the desired characteristics of the finished product such as strength, corrosion resistance, machinability, ductility, or weldability.

High strength alloys typically contain copper, magnesium, silicon, and zinc as their alloying elements. Other alloying agents that may be used are:

- lithium for lightness;
- nickel for strength and ductility;
- chromium for tensile strength and elastic limit;
- molybdenum for strength and toughness;
- vanadium for tensile strength, ductility, and elastic limit;
- silicon as a deoxidizer;
- powder metallurgy alloys for strength, toughness, and corrosion resistance.

The development of the gas turbine and the evolution of engines required materials with great resistance to temperature, stress, and oxidation. Nickel-based alloys have a high resistance to oxidation and are used for compressor blades and guide vanes, discs, turbine blades, shafts, casings, combustion chambers, and exhaust systems. Titanium alloys have excellent toughness, fatigue strength, corrosion resistance, temperature resistance, and a lower density than steel. Titanium alloys are frequently used to make hot-end turbine components and turbine rotor blades.

Non-Metallic Materials

Plastics, carbon and glass fibers, and synthetic resins and polymers are all used in aerospace manufacturing. There are two types of plastics used, thermoplastics and thermosetting materials. Thermoplastic materials are softened by heating and will harden on cooling and can be extruded (material is pressure forced through a shaped hole), injection molded (soft material is forced into a mold through a screw injector and pressure), or thermoformed (material is cast in a mold with heat and pressure). Thermosetting plastics are hardened by heating and form rigid three dimensional structures through chemical reactions. They are typically compression molded.

Carbon and glass fibre strands are used to reinforce plastics for strength and stiffness while remaining lightweight. Synthetic resins and polymers are used as adhesives which produce smooth bonds and a stiff structure which propagates cracks more slowly than in a riveted structure.

Metal Shaping

Another major process in the manufacturing of aircraft and other aerospace equipment is metal shaping.

Shaping operations take raw materials and alter their form to make the intermediate and final product shapes. There are two phases of shaping operations: primary and secondary. Primary shaping consists of forming the metal from its raw form into a sheet, bar, plate, or some other preliminary form.

Secondary shaping consists of taking the preliminary form and further altering its shape to an intermediate or final version of the product. Examples of primary and secondary shaping are listed below.

Primary shaping operations: abrasive jet machining, casting, drawing, electrochemical machining, electron beam machining, extruding, forging, impact deformation, laser beam plasma arc machining, pressure deformation, sand blasting, ultrasonic machining.

Secondary shaping operations: stamping, turning, drilling, cutting and shaping, milling, reaming, threading, broaching, grinding, polishing, planing, deburring.

Raw Materials Inputs and Pollution Outputs

The Aerospace Industries Association estimates that there are 15,000 to 30,000 different materials used in manufacturing, many of which may be potentially toxic, highly volatile, flammable, contain chloroflourocarbons, or contribute to global warming.

Pollutants from metal fabricating processes are dependant on the metal and machining techniques being used.

Larger pieces of scrap metal are usually recovered and reintroduced to the process, while smaller shavings may be sent off-site for disposal or recovery.

Surface preparation operations generate wastes contaminated with solvents and/or metals depending on the type of cleaning operation.

Degreasing operations may result in solvent-bearing wastewaters, air emissions, and materials in solid form.

Chemical surface treatment operations can result in wastes containing metals.

Alkaline, acid, mechanical, and abrasive cleaning methods can generate waste streams such as spent cleaning media, wastewaters, and rinse waters.

Such wastes consist primarily of the metal complexes or particles, the cleaning compound, contaminants from the metal surface, and water.

In many cases, chemical treatment operations are used in conjunction with organic solvent cleaning systems.

As such, many of these wastes may be cross-contaminated with solvents.

Surface finishing and related washing operations account for a large volume of wastes associated with aerospace metal finishing.

Metal plating and related waste account for the largest volumes of metal (e.g., cadmium, chromium, copper, lead, mercury, and nickel) and cyanide bearing wastes.

Air Emissions

Air emissions, primarily volatile organic compounds (VOCs), result mainly from the sealing, painting, repainting, bonding, finishing application processes including material storage, mixing, applications, drying, and cleaning. These emissions are composed mainly of organic solvents which are used as carriers for the paint or sealant and as chemical coating removers. Most aerospace coatings are solvent-based, which contain a mixture of organic solvents, many of which are VOCs. The most common VOC solvents used in coatings are trichloroethylene, 1,1,1-trichloroethane, toluene, xylene, methyl ethyl ketone, and methyl isobutyl ketone. The most common VOC solvent used for coating removal is methylene chloride. The VOC content ranges differ for the various coating categories. Air emissions from cleaning and degreasing operations may result through volatilization during storage, fugitive losses during use, and direct ventilation of fumes. Releases to the air from metal shaping processes contain products of combustion (such as fly ash, carbon, metallic dusts) and metals and abrasives (such as sand and metallic particulates).

Wastewater

Wastewater is produced by almost every stage of the manufacturing process.

Metalworking fluids, used in machining and shaping metal parts, are a common source of wastewater contamination.

Metalworking fluids can be petroleum-based, oil-water emulsions, or synthetic emulsions that are applied to either the tool or the metal being tooled to facilitate the shaping operation. Waste cooling waters can be contaminated with metalworking fluids.

Surface preparation, cleaning, and coating removal often involves the use of solvents which can also contribute to wastewater pollution.

The nature of the waste will depend upon the specific cleaning application and manufacturing operation. Solvents may be rinsed into wash waters and/or spilled into floor drains.

Wastewater may also be generated in operations such as quenching and deburring. Such wastewater can be high in oil and suspended solids.

Wastewater from metal casting and shaping mainly consists of cooling water and wet scrubber effluent. The scrubber water is typically highly alkaline.

Wastewater contaminated with paints and solvents may be generated during equipment cleaning operations; however, water is typically only used in cleaning water-based paints.

Wastewater is also generated when water curtains (water wash spray booths) are used during painting.

Wastewater from painting water curtains commonly contains organic pollutants as well as certain metals.

Electroplating operations can result in solid and liquid waste streams that contain toxic constituents. Aqueous wastes result from work piece rinses and process cleanup waters. In addition to these wastes, spent process solutions and quench baths are discarded periodically when the concentrations of contaminants inhibit proper function of the solution or bath. When discarded, process baths usually consist of solid-phase and liquid-phase wastes that may contain high concentrations of toxic constituents, especially cyanide. Rinse water from the electroplating process may contain zinc, lead, cadmium, or chromium.

Solid/Hazardous/Residual Waste

Solid, hazardous, and residual wastes generated during aerospace manufacturing include contaminated metalworking fluids, scrap metal, waste containers, and spent equipment or materials. Scrap metal is produced by metal shaping operations and may consist of metal removed from the original piece (e.g., steel or aluminum). Scrap may be reintroduced into the process as a feedstock or recycled off-site.

Various solid and liquid wastes, including waste solvents, blast media, paint chips, and spent equipment may be generated throughout painting and repainting operations. These solid and liquid wastes are usually the result of the following operations:

- 1) paint applications – paint overspray caught by emissions control devices (e.g., paint booth collection systems, ventilation filters, etc.);
- 2) repainting- spent blast media, chips, and paint and solvent sludges;
- 3) cleanup operations – cleaning of equipment and paint booth area;
- 4) disposal – discarding of leftover and unused paint as well as containers used to hold paints, paint materials, and overspray.

Solvents are also used during cleanup processes to clean spray equipment between color changes, and to clean portions of the spray booth. The solvent utilized during cleaning is generally referred as "purge solvent" and is often composed of a mixture of dimethyl-benzene, 2-propanone (acetone), 4-methyl-2-pentanone, butyl ester acetic acid, light aromatic solvent naphtha, ethyl benzene, hydrotreated heavy naphtha, 2-butanone, toluene, and 1-butanol.

Metalworking fluids typically become contaminated and spent with extended use and reuse. When disposed, these oils may contain toxics, including metals (cadmium, chromium, and lead), and therefore must be tested to determine if they are considered a RCRA hazardous waste.

Many fluids may contain chemical additives such as chlorine, sulfur, phosphorous compounds, phenols, cresols, and alkalines. In the past, such oils have commonly been mixed with used cleaning fluids and solvents (including chlorinated solvents).

If metal coating operations use large quantities of molding sand, spent sand may be generated. The largest waste by volume from metal casting operations is waste sand.

Other residual wastes may include dust from dust collection systems, slag, and off-spec products. Dust collected in baghouses may include zinc, lead, nickel, cadmium, and chromium.

Slag is a glassy mass composed of metal oxides from the melting process, melted refractories, sand, and other materials.

Centralized wastewater treatment systems are common and can result in solid-phase wastewater treatment sludges.

Any solid wastes (e.g., wastewater treatment sludges, still bottoms, cleaning tank residues, machining fluid residues, etc.) generated by the manufacturing process may also be contaminated with solvents [6].

Table summarizes the material inputs and pollutant outputs from the various aerospace manufacturing operations.

Conclusions

The best way to reduce pollution is to prevent it in the first place. Some companies have creatively implemented pollution prevention techniques that improve efficiency and increase profits while at the same time minimizing environmental impacts. This can be done in many ways such as reducing material inputs, re-engineering processes to reuse by-products, employing substitution of toxic chemicals, etc. Some smaller facilities are able to actually get below regulatory thresholds just by reducing pollutant releases through aggressive pollution prevention policies.

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Material Input and Pollutant Outputs

Process	Material Input	Air Emissions	Wastewater	Solid/Hazardous/ Residual Wastes
Metal Shaping	Cutting oils, degreasing and cleaning solvents, acids, metals	Solvent wastes (e.g., 1,1,1-trichloroethane, acetone, toluene, etc.)	Acid/alkaline wastes (e.g., hydrochloric, sulfuric, and nitric acids), waste coolant water with oils, grease, and metals	Scrap metal, waste solvents
Grinding/ Polishing	Metals, abrasive materials, machining oils	Metal shavings/ particulates, dust from abrasive materials	Wastewaters with oil, grease, and metal from machining	Abrasive waste (e.g., aluminum oxide, silica, metal), metal shavings, dust
Plating	Acid/alkaline solutions, metal bearing and cyanide bearing solutions	Volatized solvents and cleaners	Waste rinse water containing acids/alkalines cyanides, and solvents	Metal wastes, solvent wastes, filter sludges (carbides, silica) wasted plating material (copper, chromium, and cadmium)
Painting	Solvent based or water based paints	Paint overspray, solvents	Cleaning water containing paint and stripping solutions	Waste paint, empty containers, spent paint application equipment
Cleaning, depainting, and vapor degreasing	Acid/alkaline cleaners and solvents	Solvent wastes, acid aerosols, paint chips and particulates	Wastewater containing acids/alkalines, spent solvents	Spent solvents, paint/solvent sludges, equipment and abrasive materials, paint chips

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