Review of Coating Processes in Order to Improve the Performance of Hydraulic Pumps

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Abstract: Coating processes are used to apply a very thin layer of material (coating) of a certain thickness to the base material, which changes its dimensions and characteristics. They significantly improve the physical, chemical, mechanical, electrical and tribological characteristics of parts and complete systems, and can also serve as protection (eg against corrosion). The reliability and efficiency of devices exposed to this treatment, and thus complete systems, produces their service life, reduces energy loss, expressed by reduced friction, reduced maintenance costs, and thus overall downtime. Coating processes may be classified as follows: Vapor deposition (chemical vapor deposition – CVD and physical vapor deposition – PVD), Chemical and electrochemical techniques, Spraying, Roll-to-roll coating processes, Physical coating processes and etc. The paper gives an overview of the coating processes both in terms of the application process and the achieved hardness and depth of the applied layer. Recommendations for the choice of treatment methods, the quality of the treated surfaces as a comparative analysis of the costs of thermochemical treatment on the example of the basic parts of hydraulic pumps are also given.
Keywords: Coating processes, chemical vapor deposition (CVD), physical vapor deposition (PVD), electrochemical processes (ECP), spraying.

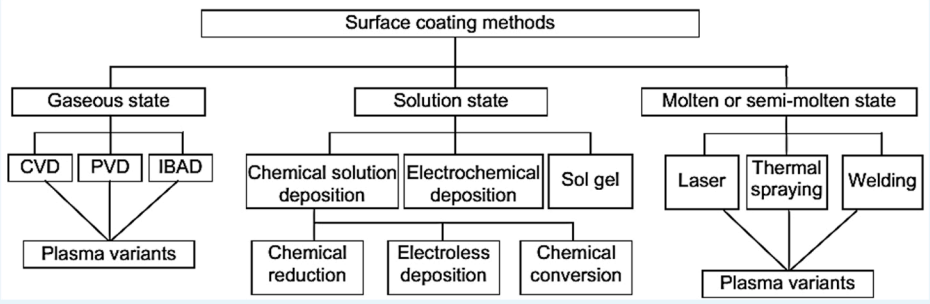

Figure 1: A general classification of surface engineering techniques [1]
Opšta klasifikacija tehnika površinskog inženjeringa

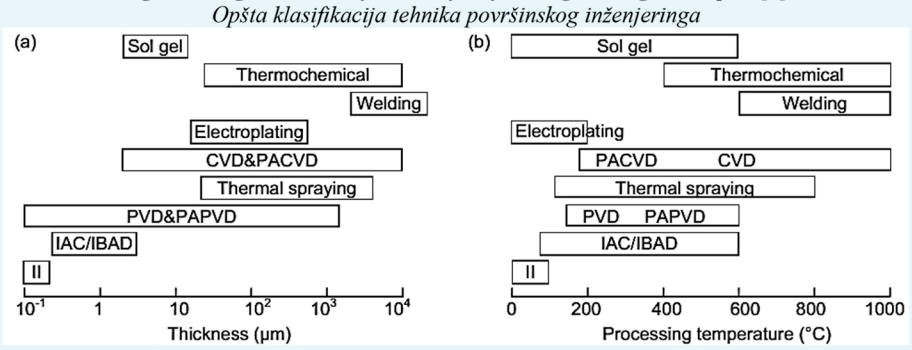

Figure 2: Typical ranges for (a) thickness of coatings, and (b) processing temperature for some surface technologies [1]. II: Ion implantation

Table 1: Comparative characteristics of some of the main coating methods [1]

	Gaseous state processes					Solution processes		Molten or semi-molten state processes		
	PVD	PAPVD	CVD	PACVD	Ion implantation	Sol-gel	Electro-plating	Laser	Thermal spraying	Welding
Deposition rate(kg/hr)	Up to 0.5	Up to 0.2	Up to 1	Up to 0.5		0.1-0.5	0.1-0.5	0.1-1	0.1-10	3.0-5.0
Component size	Limited by chamber size					Limited by solution bath		May be limited by chamber size		
Substrate material	Wide choice	Wide choice	Limited by deposition temperature	Some restrictions	Some restrictions	Wide choice	Some restrictions	Wide choice	Wide choice	Mostly steels
Pre-treatment	Mechanical/ chemical plus ion bombardment	Mechanical/ chemical plus ion bombardmen	Mechanical/ chemical	Mechanical/ chemical plus ion bombardmen	chemical plus ion bombardmen	Grit blast and/or chemical cleaning	chemical cleaning and etching	Mechanical and chemical cleaning		
Post-treatment	None	None	Substrate stress relief	None	None	High temperature calcine	None/thermal treatment	None/substrate stress relief		None
Control of deposit thickness	Good	Good	Fair/good	Fair/good	Good	Fair/good	Fair/good	Fair/good	Manual-variable automated-good	Poor
Uniformity of coating	Good	Good	Very good	Good	Line of sight	Fair/good	Fair/good	Fair	Variable	Variable
Bonding mechanism	Atomic	Atomic plus diffusion	Atomic	Atomic plus diffusion	Integral	Surface forces		Mechanical/chemical		Metallurgical
Distortion of substrate	Low	Low	Can be high	Low/ moderate	Low	Low	Low	Low/ moderate	Low/ moderate	Low/ moderate

Table 2: Some characteristics of deposition processes [1]

	Evaporation	Ion plating	Sputtering	CVD	Electro-deposition	Thermal spraying
Mechanism of production of deposition species	Thermal energy	Thermal energy	Momentum transfer	Chemical reaction	Deposition from solution	From flames or plasmas
Deposition rate	Can be very high (up to 750,000 Å/min)	Can be very high (up to 250,000 Å/min)	Low except for pure metals (e.g. Cu-10,000 Å/min)	Moderate (200-2,500 Å/min)	Low to high	Very high
Deposition specie	Atoms to ions	Atoms to ions	Atoms to ions	Atoms	Ions	Droplets
Throwing powder for: a. complex shaped object	Poor line-of-sight coverage	Good, but nonuniform thickness distributions	Good, but nonuniform thickness distributions	Good	Good	No
b. into small blind holes	Poor	Poor	Poor	Limited	Limited	Very limited
Metal deposition	Yes	Yes	Yes	Yes	Yes, limited	Yes
Alloy deposition	Yes	Yes	Yes	Yes	Quite limited	Yes
Refractory compound deposition	Yes	Yes	Yes	Yes	Yes, limited	Yes
Energy of deposition species	Low	Can be high	Can be high	Can be high with PACD	Can be high	Can be high
Bombardment of substrate/deposit by inert gas ions	Not normally	Yes	Yes or no depending on geometry	possible	No	Yes
Growth interface perturbation	Not normally	Yes	Yes	Yes (by rubbing)	No	No
Substrate heating (by external means)	Yes, normally	Yes or no	Not generally	Yes	No	Not normally

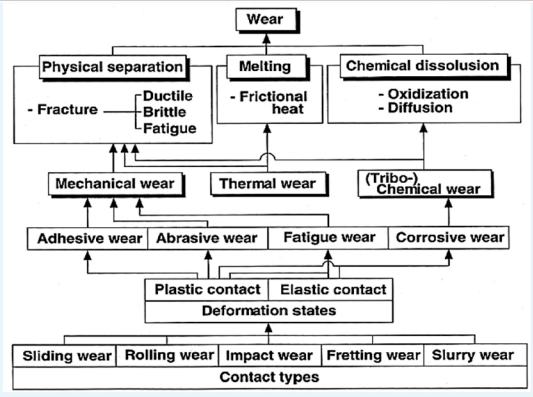

Figure 3: Descriptive key words of wear and their interrelations [1,2]

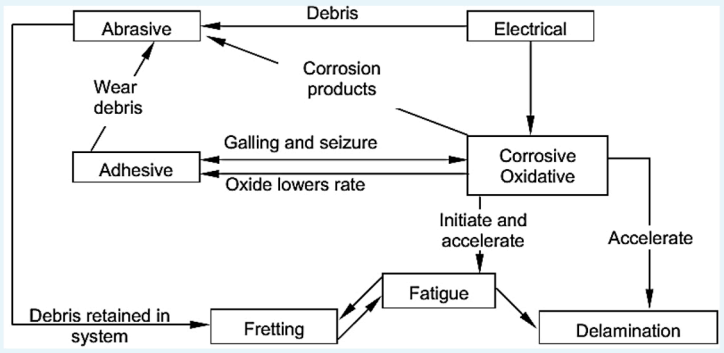

Figure 4: Interaction of wear mechanisms [1]

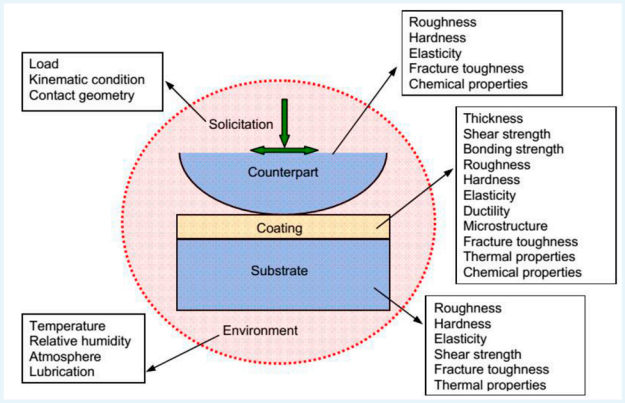

Figure 5: Parameters of a coating system influencing the tribological performance [1,3,4,5]

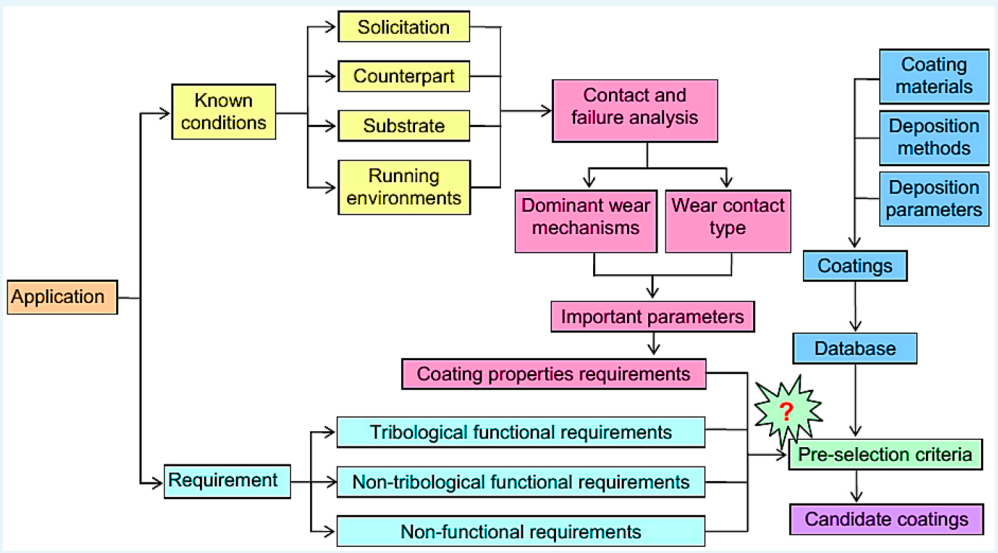

Figure 6: General coating pre – selection process [4,5]

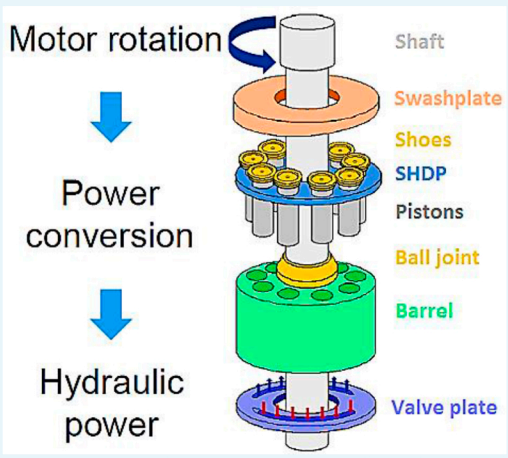

Fig. 7 Axial piston pump exploded view [6]

T – 3 Review of the material of manufacture and coating of contact surfaces

		Vital part of the pump	Material of manufacture	Dressing procedure
Pump type	Klipne pumpe	Bareel	42CrMo4 (Č4732)	Casting
		Sliding pedals	$CuZn_40Al_2$	-
		Pistons	31CrMo12 (Č4738) 34CrAlMo5 (Č4739)	Hardening and cementation
		Valve plate/ Swashplate		Gas nitriding (previously with improvement)
	Vane pumps	Housing	NL 400	Casting
		Valve plate	DC 10 SINTER	Gas nitriding

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