ON THE POSSIBILITY OF THE SHOT - PEENING PROCESS APPLICATION IN THE PRODUCTION OF NEW VEHICLES FORMS

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ABSTRACT:

The paper presents an overview of new vehicles forms, and new projects and their position in the modified Von Karman-Gabrielli diagram, regarding the domain of their efficient activities. In new super high-speed vehicles, a great influence of the fatigue is expected; a shot - peening process would thus be very useful for increasing their fatigue life. This process as well as the peen-forming process has not yet been included in the current shipbuilding practice, so the construction parts of vessels are proposed to be shot peened. The examining results of overgrown corrosion influence on shot-peened immersed Al 5080 samples are also presented.

Key words: shot-peening, new vessels forms, efficient effect, fatigue life, overgrown corrosion,

1. INTRODUCTION

By analyzing the existing vehicles forms, regarding the submerged surface and quantity of their touching the sea water, the following categories could be identified:

1. Displacement ships,
2. Semi-displacement ships,
3. Planning ships,
4. Hydrofoil assisted ships,
5. Hydrofoil boats,
6. Air cavity vessels,
7. Surface effect ships - SES,
8. Air cushion vehicles,
9. Wing -In -Ground effect vehicles, and
10. Ecranoplanes,

as presented in Fig. 1.

The arrangement of these vehicles can be presented for normal speed, fast and high speed vessels, as well as for the trip comfortability vessels, even in the rough sea. If the European shipbuilding wants to keep a step with the world shipbuilding, naval architects should, as soon as possible, aim at designing and building high sophisticated vessels and high – speed vehicles, like the ones presented in Fig. 2. [2], [4]. The Von Karman – Gabrielli diagram [2], modified by the author, shows the domain of some current idea project vessels, and their place within the actual seagoing and aircraft projects, presented in Fig.1. In this diagram, the *technology line* is marked, as the limit line of the actual technological transport vehicles possibilities. The task of the new generation of naval architects and designers of new vehicles of the 21st century is to shift this technology line more "to the right".

Namely, the technical and technological development, the research of new building materials, engines, production resources, and especially the use of the shot-peening process for increasing the fatigue life of materials used, based on the current results of aircraft industry, is a guarantee of this hypothesis.

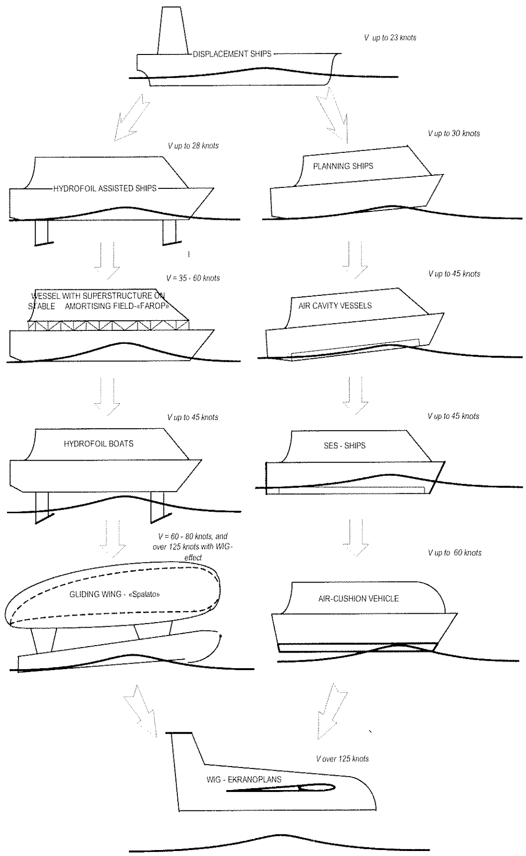

Figure1: The arrangement of vehicles by speed and quantity of their touching the sea water

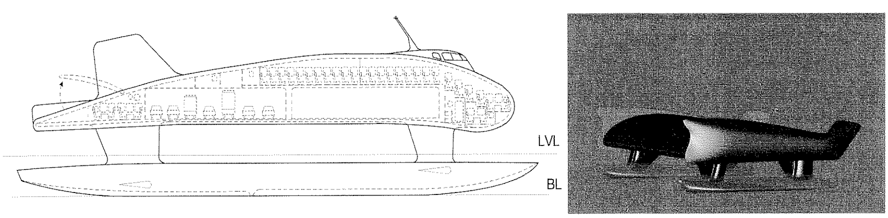

Figure 2: "GLIDING WING", variant SPALATO [2], [4], one of the new idea project (by Prof. R. Markovina, Ph.D. from Split and F. Dizdarević, Bc.S. air.constr. – USA,) with expected speed about 60 – 80 knots, TWIN-HULL and/or TRIPLE-HULL)

However, in Von Karman – Gabrielli diagram, it can be seen in the central quadrant, an area, under the technology line, in which there are no actual new generation vehicles, the area which should respond to the speed v = *50 to 250* knots, and relation *L/D (or W/T) =15 to 50.*

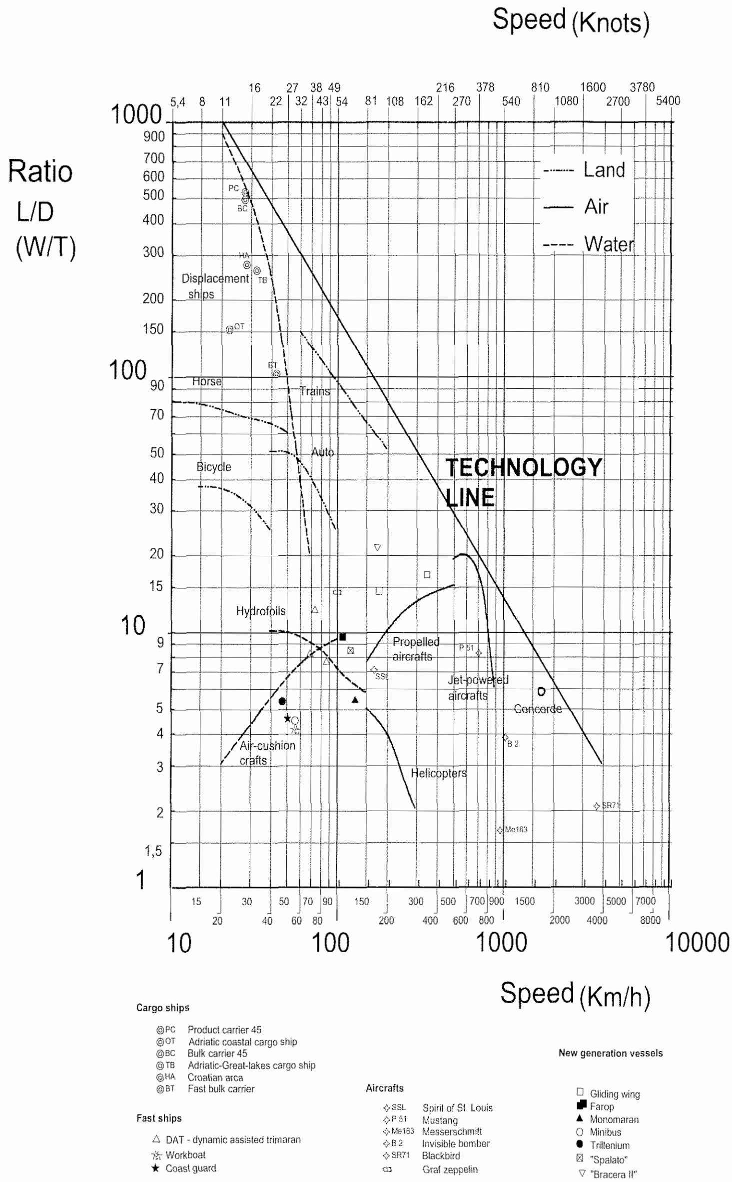

Figure 3: Modified Von Karman – Gabrielli diagram [2]

In this area there are spaces for examining the efficiency of new speed and high speed vessels, which have to be built according to new technologies.
L/D is a relation of buoyancy and resistance, because in stationary flight the weight is equal to buoyancy, and the propulsion force is equal to resistance, then L/D is equal to W/T, i.e. the relation of weight and propulsion force. In big flying vehicles L/D is about 20, and in the smallest ones is about 15].

2. THE NECESSITY FOR A NEW MATERIALS AND SHOT-PEENING APPLICATION

Having a long experience in aircraft production I expect the following materials, unusual in classic shipbuilding, to be used in the production of the of new generation vehicles:
- Al-alloys: 5454(Al Mg2,5Mn), 5083 (AlMg4,5Mn), 6063(AlMgSi0,5), 6353 (AlMgSi1),
- Al-Li alloys: (8090),

whose characteristics are: corrosion resistance, good welding characteristics, low density (1,8 - 2,4 kg/dm^3), good strength and stress characteristics (200-350 MPa) etc. But the use of other unconventional materials is also expected, like:
- Honeycomb panels,
- Sandwich construction,
- Non-metallic materials (composites, polyamides, acryl-glass, textolites, high bearing glues, new jointing materials, protective coatings based on plastics and man made fibbers, etc,)
- Different types of high-bearing steels (stainless austenitic steels, stainless martensitic steels, low-alloy chromium-molybdenum steels, low-alloy chromium-molybdenum- nickel steels, chromium-molybdenum- nickel-vanadium steels etc., with the strength from 700 – 2000 MPa).

Each of these materials will have an important application in the production of new generation vessel's construction parts, particularly those exposed to dynamical loading, from which the most significant are:
- the main engine seating in engine room,
- seating of auxiliary engines and devices,
- fore peak and after peak structure,
- hatches and hatch covers with comings,
- seating of decks engines and cargo gears,
- shaft brackets, shaft bossing, stabilizers,
- different types of springs and dampers, and especially
- mechanical components with gears, axes, changeable sections, loading panels, integral plates, loading bars, girders, etc.

It is well - known, the shot-peening process is one of very important technological processes in vehicles construction and will remain to be in the new generation vessels production as well. The reasons for this are:
- increasing of materials fatigue life,
- decreasing of micro-corrosion and stress-corrosion,
- decontamination of elements surfaces after mechanical machining operations and providing enough roughness for good application of the first coat of paint,
- forming the plates (plastic deformation) of thin skins by peen-forming, etc.

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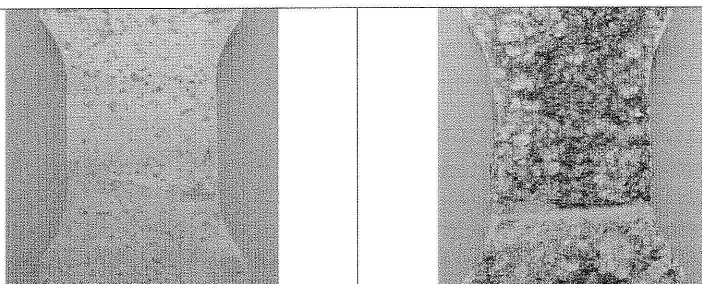
On the basis of experience and research carried out so far, the fatigue life of materials could be increased by shot – peening process from 25% up to 70%,

depending of used material and the influence of various parameters. Besides the ship standard structure loading in the unruffled sea, in high speed and super-high speed regimes, a good part of the ship structure will be loaded by winds and waves (heaving, rolling, pitching and yawing), and/or by loading, unloading, weight moving, and especially by landing and taking off vehicles using WIG-effect, which will produce the fatigue of structural parts with a cracking consequences.
So, each of the mentioned metal materials, passing previously through the controlled shot-peening process, will obtain its own advantages in increasing the fatigue life, forming the thin plates by peen-forming and especially the possibility of decreasing structures weight, which will result in decreasing the final product weight (or it mass) which has not been a shipbuilders practice so far.
It is very important to point out that *the influence of the sea water* on the ship's out-bottom plating usually could reduce its thickness as the result of corrosion caused by sea organisms. Namely, the sea water environment can induce five different kinds of corrosion: monotonous, galvanic, intercristalic, stress, and overgrown. Some of Al-alloys can be very sensitive to intercristalic corrosion, and it then becomes rather dangerous, especially in the sea water environment [3], [5].



Test bar after 2 months in sea- water	*Test bar after 6 months in sea water*

Figure 4. The test bars of Al 5080-alloy after being exposed to sea-water influence [5]

It is well known that the *overgrown corrosion*, caused by sea water organisms (limpets and conchs), develops, by its adhesion to the immerged material surface, growth, detaches small parts of the metal and creates small holes (pitting) on the surface under them; on the surface that was not completely overgrown, the cells caused by higher oxygen concentration, have been created, and its influence on immersed shot peened parts however has been unknown to us.
This process is very intensive in hot and skin-deep seas, and its influence has to be known, because the possible decreasing of shell plate thickness by overgrown corrosion could produce problems in classification of the vessels. For that reason we tested the samples to obtain the real sea-water influence on the shot-peened ship's Al-alloys bottom plates.

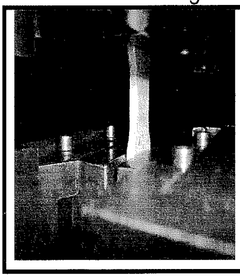
(Eight samples, made of Al 5080 (AlMg4,5Mn), with chemical composition presented in Table 1, were immersed in the sea-water for two and six months, in the depth of 0,5 meter. The pH value was about 8,20 (in Split – Adriatic sea), from April to October (Figure 4). (Shot-peened parameters were: Nozzle diameter d=6,5mm; Shot size S390; Pressure p=3,5 bars, Nozzle distance h=90mm, Time of exposition t=40 sec; Impact angle $\alpha= 75^{\circ}$; and Intensity I=1,001N2).

Table1 - The chemical composition of the Al 5080 alloy sample's structure

Material	*Chemical elements (%)*							
	Cr	*Cu*	*Fe*	*Mg*	*Mn*	*Si*	*Ti*	*Zn*
5080(AlMg4.5Mn)	*0.10*	*0.02*	*0.41*	*3.44*	*0.60*	*0.57*	*0.032*	*0.05*

The rest up 100% is pure aluminium.

Table 2 – The strength analysis results of Al 5080 alloy (AlMg4,5Mn)



TEST BAR	*R_{p02} (MPa)*		*R_m (MPa)*	
	I sp.	*II sp.*	*I sp.*	*II sp.*
Based material Al 5080	*192*	*190,5*	*283*	*281*
Shot-peened material	*191*	*193*	*292*	*290*
Shot peened–sea 2 months	*192*	*194*	*290,2*	*292*
Shot peened–sea 6 months.	*192,5*	*193,5*	*289*	*290,4*

We obtained the breaking and mechanical separating of the basic material, caused by the difference in elongation of the basic alloy (in the middle) and its protective layer, overgrown by sea water organisms. The strength analysis results are shown in Table 2, but the same conclusions could refer to other Al-alloys which will be applied in the new generation vehicles production.

Finally, the shot-peened sample's strength is a little higher than the non shot-peened on, as a result of compressive stress in superficial layer, and also, there is not a significant difference between the immerged shot-peened samples and only shot-peened ones, what we wanted to know.

3. CONCLUSION

1. The modified Von Karman – Gabrielli diagram presents domains in which some of classic and unconventional idea projects forms are positioned.
2. In the production of new generation vehicles, the "new shipbuilding materials" and appropriate production technologies, with experiences from aircraft industry, have to be used.
3. The shot - peening process has to be used in the production of many important construction elements, especially those which are strained, and where increasing of the fatigue life and peen - forming is required.
4. The dominant corrosion process in the sea water is overgrowing by sea water organisms and there is no evidence of other types of corrosion.
5. The total thickness, mechanical characteristics and shot – peened layer of immerged samples were not significantly changed compared with basic non-immerged samples, and it would be enough, in practice, to protect the peened construction elements only by the primer.

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