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CURRENT APPLICATIONS AND PROSPECTS FOR UTILIZATION OF STEEL SHEETS AT JSC AVTOVAZ

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Introduction

JSC AVTOVAZ has large in-house press shops, which manufacture the complete range of external and internal body parts and chassis, engine and wheel components. The press shops process about 1500 tons of cold and hot-rolled steel sheets every day.

According to the global forecasts, steel will remain the main material for vehicle bodies, especially in countries where temperature varies from + 50 up to – 50 °C. Properties of modern automotive steel sheets used by JSC AVTOVAZ are shown in Table I.

Table I. Mechanical properties of automotive steel grades used by AVTOVAZ.

Steel grade	Ultimate strength $\sigma_в$, Н/мм^2	Yield strength $\sigma_{0,2}$, N/mm^2, minimum	Relative elongation δ_4, %, minimum	Ratio of normal plastic anisotropy R_{90} minimum	Index of strain hardening n_{90} minimum
08Al	260 - 330	175	42	2,1	0,22
	270 - 350	185	40	2,0	0,21
	270 - 350	195	36	-	-
	270 - 380	205	34	-	-
	270 - 390	-	28	-	-
01AlTi (IF)	260-330	175	42	2,1	0,22
	270-350	185	40	2,0	0,21
	270-350	195	36	1,8	0,20
	270-380	205	34	-	-

This variety of mechanical properties is used for the mass production of large-size stamping parts requiring a high degree of deformation and applications using hot dip galvanized material. It should be noted that 86 kilograms of hot dip galvanized steel sheets are used in the Chevrolet Niva car, while the latest Lada 1118 Kalina car consumes 252 kilograms. The welding lines in the body shop are arranged in such a way that the integration of even higher number of hot dip galvanized parts is possible (door outer panels, bonnets, etc.).

The 01AlNbTi steel with BH-effect is micro-alloyed with titanium and niobium having a grain size of ASTM 7-8 and has been produced within a joint project at the Novolipetsk Foundry Plant. Table II shows the content of major alloying elements.

Specimens of 80 x 20 mm, cut out in different directions relative to the rolling direction, have been tested according to a specific test procedure for the purpose of determining the BH-effect. The test results are shown in Table III in comparison to the 08Al steel.

Table II. Composition of Bake-Hardening steel.

Conventional Heat No.	**Contents of the main elements, %**			
	Si	**C**	Ti	Nb
1	0,015	0,009	0,033	0,035
2	0,016	0,009	0,029	0,025

Table III. Mechanical characteristics of Bake-Hardening steel

Steel grade	**Conv. Heat No**	**$\sigma_{0,2}$ N/mm^2**	**σ_B N/mm^2**	**δ_{80} %**	**n**	**r**	**WH N/mm^2**	**BH_2 N/mm^2**	**BH N/mm^2**	**σ_B H/mm^2**	**δ_{80} %**
										After ageing	
01AlTiNb	1	169	298	39,7	0,215	2,183	44	-5	39	299	37,3
	2	192	298	37,6	0,195	1,954	30	38	68	311	34,5
08Al	3	165	298	40,0	0,216	2,143	45	-4	41	301	37,5
WH – strain hardening; BH – general hardening											

The results of the tests demonstrated the existence of strain hardening, also for the 08Al grade. Substantial hardening due to the BH-effect can be observed for heat No.2.

Bonnet outer panels were stamped out of these steel grades under study (Figure 1), and comparative stiffness tests were performed using a special procedure. The parts were tested in initial condition and after 30 minutes holding time at 190 °C, which corresponds to the drying procedure after the painting process. Test results are shown in Table IV.

Table IV. Stiffness of bonnet outer parts mad from Bake-Hardening steel.

Steel grade	**Conventional Heat No**	**Sustained load, kg**	
		In initial condition	After heat treatment
01AlNbTi	1	3,60	3,70
	2	3,41	3,42
08Al	3	3,11	3,23

Based on the results it can be concluded that it is necessary to conduct further research for the elaboration of steel melting, rolling, heat treatment processes, and stamping of vehicle components.

Thus, there are prospects for a wider utilization of IF steel, including steels that are micro-alloyed with titanium and niobium. It is also necessary to mention that these steel grades can be coated in a hot dip galvanizing process.

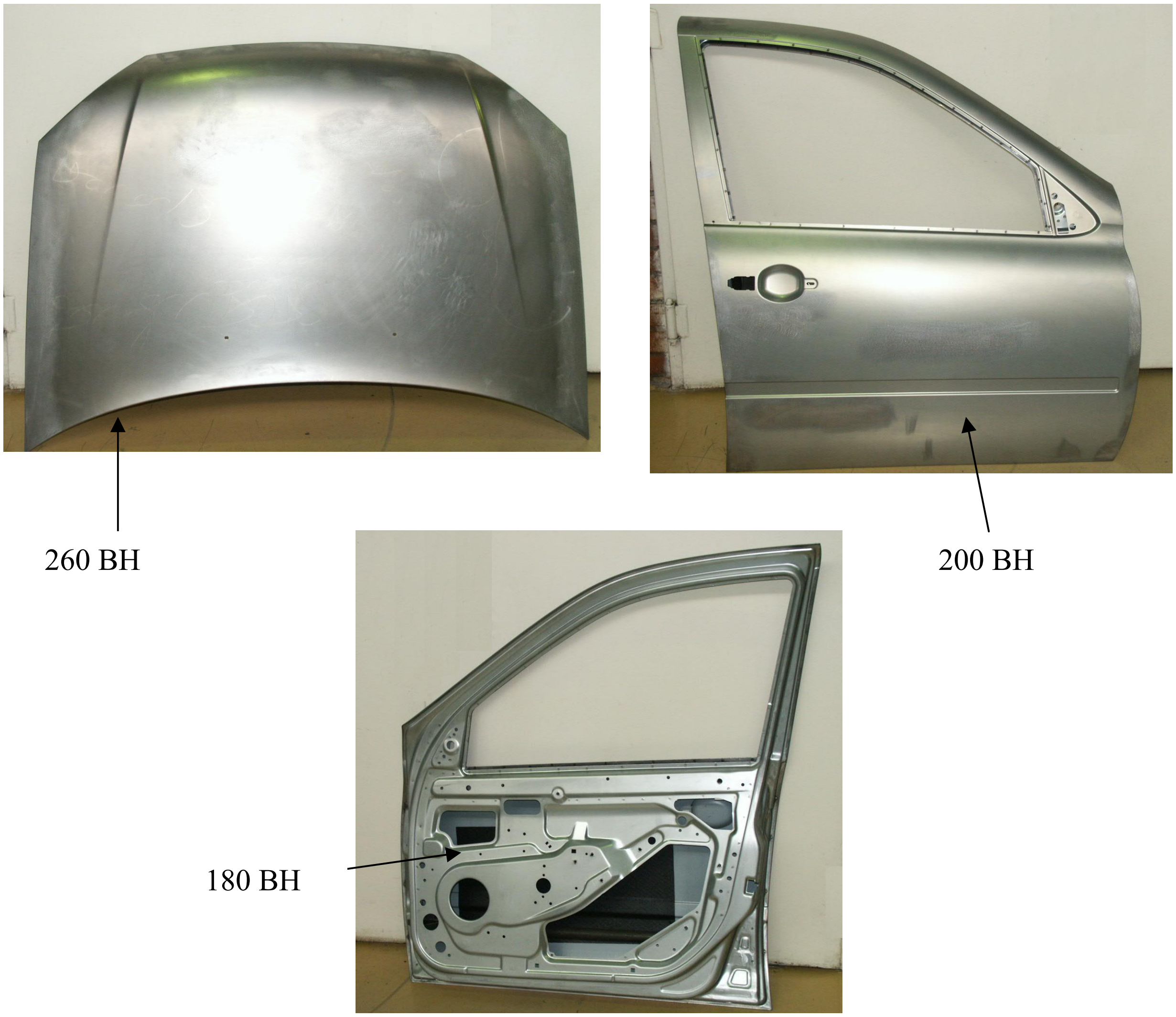

Figure 1. Typical stamped components made from Bake-Hardening steel.

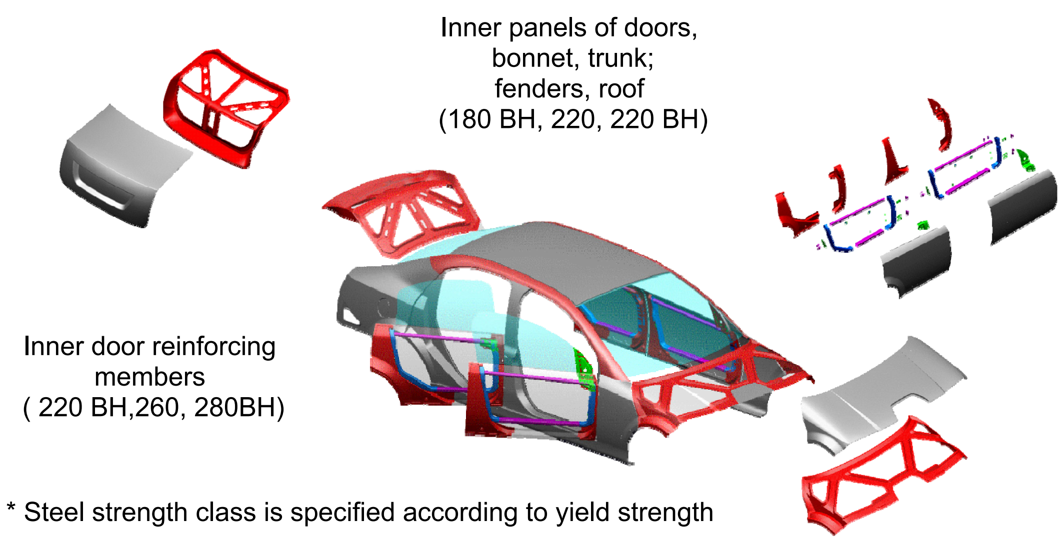

Figure 2. Concept of steel types in VAZ cars for hang-on components.

Higher Strength Steels

The reduction of material consumption in a car as a whole, as well as in the car body, became an acute issue, not only for the purpose of cost reduction, but also to provide for better dynamic performance and economical operation due to the total weight reduction.

Table V shows higher-strength steels being produced and integrated into the AVTOVAZ car body design. They are expected to offer good stampability, reduced spring back, high elongation, substantial increase of normal plastic anisotropy (r), high rate of strain hardening (n), while maintaining a relatively low cost.

Table V. Overview of available high strength steel grades and typical applications at VAZ.

Strength class*	Steel grade	Yield strength, $\sigma_{0,2}$, N/mm^2,	Ultimate breaking strength, $\sigma_в$, N/mm^2	Relative elongation δ_4, %, minimum	Application
280	08MnSiAlTi (08MnSiAlV)	> 275	> 392	30	Body parts, Wheel rim
280	10Al premium	> 290	390 - 540	28	Wheel
300	03CrMnAl 06CrMnSiAl	< 300	> 440	31	Body parts
360	07MnNiAl	> 360	> 480	34**	Chassis components
230	08AlP	> 220	> 340	34	Body parts
280	08AlPV	> 275	> 392	30	Body parts, Wheel rim
335	08MnSiAlTi	> 334	> 412	26	Wheel
280	07MnVAl	> 275	> 400	30	Body parts, Wheel rim
Note: * - strength class according to yield strength; ** - relative elongation δ_5.					

These are rather demanding requirements in terms of design and technology. It is known that a 30-50 % increase in steel strength allows to reduce the sheet thickness by 6-15% in the design of current models and by up to 25 % in advanced designs under development. With the modulus of elasticity being practically the same for all steel grades used, sheet thickness is of major importance to achieve proper stiffness. This is the reason why the required stiffness of a component or assembly should be achieved by changing their design (different shape, additional stiffness ribs, etc.) in order to provide for the maximum effect from the utilization of thinner sheets of higher-strength steel.

The Russian industry (Novolipetsk Foundry Plant and Severstal) has started the production of the low-alloyed dual-phase ferritic-martensitic steel grade 03CrMnAl. Cold-rolled and hot-rolled 08MnSiAlTi (08MnSiAlV) steels were the next to be produced. It was used for non-exposed parts like brackets, reinforcements, supports, links and wheels.

The VAZ 1118 Kalina car was launched at AVTOVAZ in October 2004, and the VAZ 2116 is currently being prepared for production. Table VI shows trends of using sheet steel of various strengths in these vehicles. Microalloyed, rephosphorized high strength steels are given the priority in this development. It also becomes necessary to develop steels of up to 950 MPa strength.

Table VI. Share of steel grades in recent VAZ car models.

Strength class	VAZ 1118 Kalina	VAZ 2116
Low-carbon steels for stamping	71 %	38 %
220/340	10 %	23 %
280/400	4	13 %
360/450	5	18 %
500/800	-	4 %
950/1200	-	3 %
Others	10 %	1 %

In view of a growing energy crisis and increasing cost of micro-alloyed and clean steels, material experts have to estimate and analyze potential trends of the future utilization of sheet steel materials. Besides, the integration of higher-strength steel and laser welding will require dramatic changes to welding and stamping technology, and this also means huge costs.

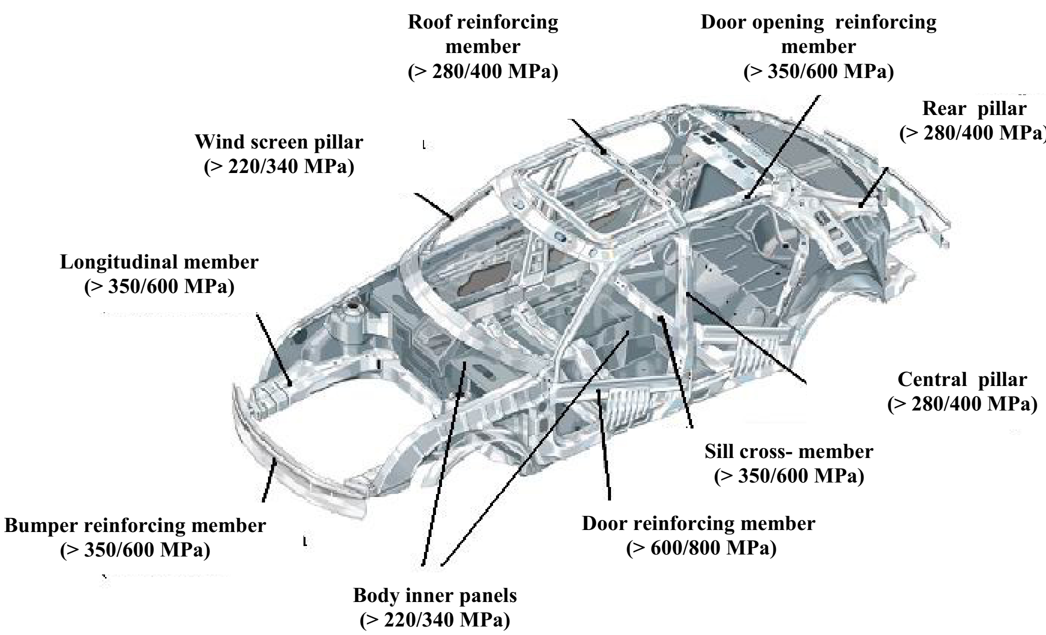

Figure 3. Concept of using steel materials in the body structure of an AVTOVAZ advanced car.

Summary

To summarize the above, AVTOVAZ has to be prepared for such changes in the market. While steel remains the main material for vehicle body manufacturing, energy costs per one ton of aluminum produced are still around 5 times as higher on a per ton basis compared to steel.