STUDY REGARDING THE MANUFACTURING PROCESS OF THE AUTOVEHICLES ROOF BARS

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Rezumat. *Procesul de inovare reprezintă principalul factor ce contribuie la dezvoltarea durabilă a oricărei industrii. Industria auto este una dintre industriile puternic „afectate" de acest proces al inovării continue. Dat fiind faptul că există o gamă largă de producători de autoturisme și de o gamă variată de modele de autoturisme competiția este una acerbă și, deci, pentru a putea rezista aceștia apelează la inovare. O astfel de inovare o reprezintă barele longitudinale de pavilion, acestea evoluând de la banalul portbagaj de pavilion, la bare fixe de pavilion, sau barele longitudinale, pentru ca, in prezent, să devină bare longitudinale modulare de pavilion. Aceste bare putând fi „modelate" în funcție de încărcătura ce urmează a fi transportată pe pavilionul autovehiculului.*

Abstract. *The innovation process it's the main contributing factor in a sustainable development of any industry. One of the most affected industries, by this innovation process, is the auto industry. Due to the fact that is one of the most competitive industries, many car producers and a very different range of cars, it has to resort to innovation. The roof bars it is one of the innovations. They have evolved from the ordinary roof trunk, to fixed roof bars or the longitudinal roof bars, to modular longitudinal roof bars. Last of them giving the possibility of being "modeled" depending on the cargo that it has to be transported on roof of the car.*

Keywords: Roof bars, Dacia Sandero Stepway, Dacia Duster, Novares Group, plastic injection, painting, assembly of car components, BOM, technical drawing

1. Introduction

The scientific paper will present the benefits of product innovation both from a functional point of view and from manufacturing point of view. The presented innovation leads to process optimization and to an increased customer satisfaction by having a brand-new product with better design and better utility.

During the analyze of the manufacturing process of the longitudinal roof bars and the modular roof bars, presenting each stage, starting from the raw material to the final product, I highlighted the benefits of the innovation.

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2. Reference models

2.1 Dacia Duster

Automobile Dacia S.A. is the largest Romanian car manufacturer, which, since September 1999, belongs to the French group Renault [1]. The object of activity of the enterprise is the production and sale of automobiles, car parts, machine tools and installations for the automobile industry.

Dacia Duster is an SUV built jointly by the French manufacturer Renault and its Romanian subsidiary Dacia since 2009.

Dacia Duster was originally introduced in the ice racing version prepared for the Andros trophy, first presented on November 17, 2009. The production version was officially unveiled on December 8, 2009 and was later launched at the Geneva Motor Show in March 2010.

In September 2013, the Dacia Duster facelift was presented at the Frankfurt Motor Show. The exterior has undergone major changes; in front a new chrome grille and redesigned headlights, restored roof bars, 16-inch wheels and modest rear modifications. The interior has also been renewed with design and features similar to the new models in the Dacia range.

The second generation of Dacia Duster was presented between 14 and 24 September 2017 at the Frankfurt Motor Show, entering the Romanian market 6 months later, in November 2017.

Several design elements present on the Dacia Duster remind of the class of off-road vehicles - large and rounded wings, double optical blocks, bumper, imposing roof bars, wheel arches and body protection elements. This model is available both in the 4x2 version, city version, and in the 4x4 version, off-road version.

Dacia Duster refers to the name of an all-wheel drive commercial vehicle produced and marketed by Dacia in the 1980s. Dacia Duster was also the name of the ARO 10 model sold on the UK market [8].

Dacia Duster is the one of the models whose manufacturing process of the longitudinal bars will be presented in this paper.

2.2 Dacia Sandero Stepway

The Dacia Sandero model is a 5-door hatchback car, whose production started in October 2007 and whose official launch, on the Romanian market, was on June 3, 2008. Sandero is also the first model whose launch was with the current Dacia logo.

The Dacia Sandero Stepway model is derived from the Dacia Sandero model. This is a 5-door crossover that began production in October 2008 in Brazil. In May 2009, its European version is presented at the Barcelona International Motor Show.

In 2012, at the Paris Motor Show, the second generation of Sandero and Sandero Stepway is presented, models that could be ordered starting with October 1, 2012. The new Sandero Stepway, whose manufacture continues until now in Romania factory, was equipped with a higher ground clearance, grey plastic sills ornaments, wing protector and crossover-looking bars.

Following some minor design changes, the Sandero Stepway facelift appeared in 2017, and in 2020 the new Sandero Stepway was launched, the design of which was completely rethought. It is presented as a modern and robust crossover with an impressive profile, fluid horizontal lines, new "Y" shaped lights and a high ground clearance [9].

Sandero Stepway has kept its functionality over time and is one of the models equipped with modular roof bars whose manufacturing process we will analyse.

3. Technical drawing

In Fig. 1. a it's presented the first page from the 2D drawing where are specified the main demands of the product:

• Note no. 1 refers to the specifications, norms and rules used. These are the special features of the product and refer to the security and regulatory requirements. The table contains all the rules applicable to the product. The safety requirement refers to the fixing of the bar on the vehicle and the resistance of the product to the forces applied to it by the load.

The applicable regulations for this product are R064 and R071:

R064 - refers to the recyclability of the product.

R071 - refers to the conditions that an exterior part \ accessory of a motor vehicle must comply with.

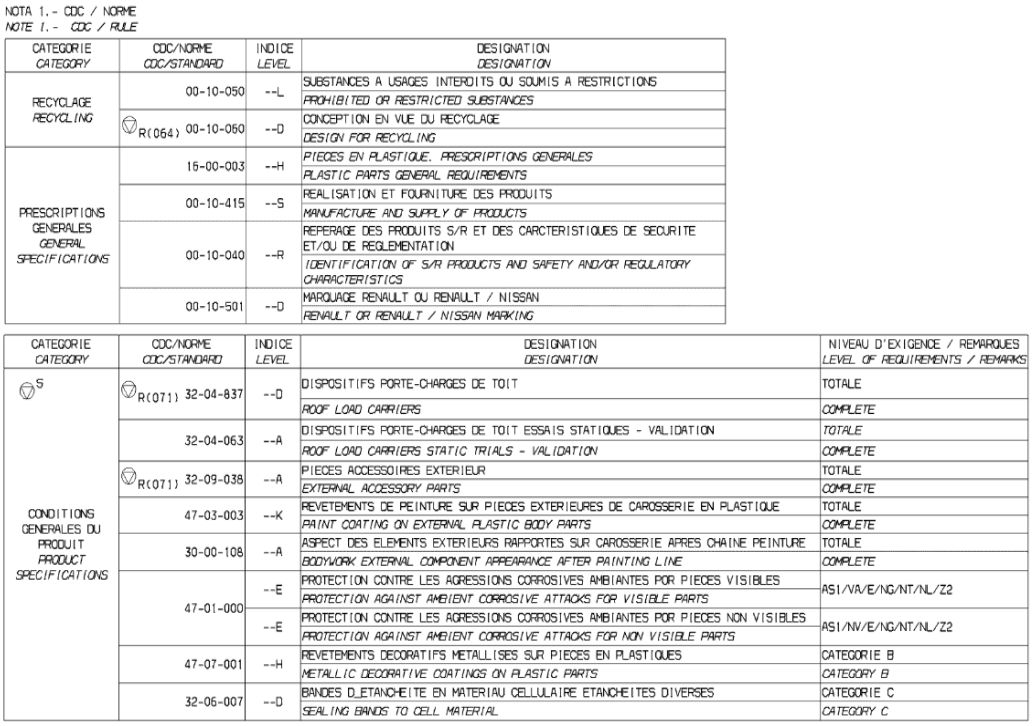
• Note no. 2 refers to the marking of the part: what type of characters are used and what dimensions, the marking of the materials from which the piece is produced, the supplier's code, the logo, etc.

• Note no. 3 refers to specific or particular requirements, for example: the tightening torque of the part, the load capacity, the parts must not have excess material or scratches on the visible surface, etc.

• Note no. 4 contains other specifications, for example the explanation of norm 071.

• Note no. 5 contains the points of impact for the shock test.

The first page of the 2D drawing also contains the general tolerances, the reference to the HCPP (hierarchy of special features - rules, regulations and requirements), all the changes made, over time, on the product and the references to the annexes of the detailed drawing, see Fig. 1.



NOTA 1.- CDC / NORME
NOTE 1.- CDC / RULE

CATEGORIE *CATEGORY*	CDC/NORME *CDC/STANDARD*	INDICE *LEVEL*	DESIGNATION *DESIGNATION*
RECYCLAGE *RECYCLING*	00-10-050	--L	SUBSTANCES A USAGES INTERDITS OU SOUMIS A RESTRICTIONS
			PROHIBITED OR RESTRICTED SUBSTANCES
	R(064) 00-10-060	--D	CONCEPTION EN VUE DU RECYCLAGE
			DESIGN FOR RECYCLING
PRESCRIPTIONS GENERALES *GENERAL SPECIFICATIONS*	15-00-003	--H	*PIECES EN PLASTIQUE. PRESCRIPTIONS GENERALES*
			PLASTIC PARTS GENERAL REQUIREMENTS
	00-10-415	--S	REALISATION ET FOURNITURE DES PRODUITS
			MANUFACTURE AND SUPPLY OF PRODUCTS
	00-10-040	--R	REPERAGE DES PRODUITS S/R ET DES CARCTERISTIQUES DE SECURITE ET/OU DE REGLEMENTATION
			IDENTIFICATION OF S/R PRODUCTS AND SAFETY AND/OR REGULATORY CHARACTERISTICS
	00-10-501	--D	MARQUAGE RENAULT OU RENAULT / NISSAN
			RENAULT OR RENAULT / NISSAN MARKING

CATEGORIE *CATEGORY*	CDC/NORME *CDC/STANDARD*	INDICE *LEVEL*	DESIGNATION *DESIGNATION*	NIVEAU D'EXIGENCE / REMARQUES *LEVEL OF REQUIREMENTS / REMARKS*
S	R(071) 32-04-837	--D	DISPOSITIFS PORTE-CHARGES DE TOIT	TOTALE
			ROOF LOAD CARRIERS	*COMPLETE*
	32-04-063	--A	DISPOSITIFS PORTE-CHARGES DE TOIT ESSAIS STATIQUES - VALIDATION	*TOTALE*
			ROOF LOAD CARRIERS STATIC TRIALS - VALIDATION	*COMPLETE*
	R(071) 32-09-038	--A	PIECES ACCESSOIRES EXTERIEUR	TOTALE
			EXTERNAL ACCESSORY PARTS	*COMPLETE*
CONDITIONS GENERALES DU PRODUIT *PRODUCT SPECIFICATIONS*	47-03-003	--K	REVETEMENTS DE PEINTURE SUR PIECES EXTERIEURES DE CAROSSERIE EN PLASTIQUE	TOTALE
			PAINT COATING ON EXTERNAL PLASTIC BODY PARTS	*COMPLETE*
	30-00-108	--A	ASPECT DES ELEMENTS EXTERIEURS RAPPORTES SUR CAROSSERIE APRES CHAINE PEINTURE	TOTALE
			BODYWORK EXTERNAL COMPONENT APPEARANCE AFTER PAINTING LINE	*COMPLETE*
	47-01-000	--E	PROTECTION CONTRE LES AGRESSIONS CORROSIVES AMBIANTES POR PIECES VISIBLES	AS1/VA/E/NG/NT/NL/Z2
			PROTECTION AGAINST AMBIENT CORROSIVE ATTACKS FOR VISIBLE PARTS	
		--E	PROTECTION CONTRE LES AGRESSIONS CORROSIVES AMBIANTES POR PIECES NON VISIBLES	AS1/NV/E/NG/NT/NL/Z2
			PROTECTION AGAINST AMBIENT CORROSIVE ATTACKS FOR NON VISIBLE PARTS	
	47-07-001	--H	REVETEMENTS DECORATIFS METALLISES SUR PIECES EN PLASTIQUES	CATEGORIE B
			METALLIC DECORATIVE COATINGS ON PLASTIC PARTS	*CATEGORY B*
	32-06-007	--D	BANDES D_ETANCHEITE EN MATERIAU CELLULAIRE ETANCHEITES DIVERSES	CATEGORIE C
			SEALING BANDS TO CELL MATERIAL	*CATEGORY C*

Fig. 1. 2D drawing - the main demands of the product

3.1 BOM (Bill Of Materials)

BOM represents the list of constituent components of the product. For each manufactured component is specified the type of material used, it's supplier, technical specifications, part reference and composition coefficient.

For Dacia Duster (HJD project) the constituent elements are the following, see Fig. 2. a. and Fig. 2. b.:

01. Aluminium bar
02. Rivkle nut M6
03. Front support
04. Support rear interior
05. Support rear exterior

06. Overmolded stud
08.Cover upper front
09. Cover upper rear
10. Cover lower front
11. Cover lower rear
12. Double thread stud M6
14. Fixations foam
15. Centering foam
16. Cushion front
17. Cushion rear
18. Hot stamping foil
19. Foam after sale
20. Square foam

REFERENCE PIECE GAUCHE / REFERENCE LH PART	REFERENCE PIECE DROIT / REFERENCE RH PART	COMPOSANTS / COMPONENTS									R(064) MATIERE / RAW MATERIAL			
		NUMERO / NUMBER	DESIGNATION / PART NAME	REF. RENAULT PIECE / RENAULT PART N°	REF. FOURNISSEUR / SUPPLIER PART N°	EPAISSEUR / THICKNESS	MASSE (G) / WEIGHT	TEINTE / CODE TEINTE / COLOR / COLOR CODE	BRILLANCE / SHINNING	GRAIN / PROFONDEUR GRAIN / DEPTH	CODE ISO / ISO CODE	FOURNISSEUR / SUPPLIER	REF. COMMERCIALE / COMMERCIAL NAME	TRAITEMENT / TREATMENT
BARRE DE TOIT G ALLIANCE NOIRE : 738217099R / LH ROOF RACK BLACK ALLIANCE : 738217099R	BARRE DE TOIT D ALLIANCE NOIRE : 738200465R / RH ROOF RACK BLACK ALLIANCE : 738200465R	(--A)												
		■ 01	BARRE / BAR		112 241 A1	2.0	1120.0	CHROME SATINE / 205 338		LISSE SMOOTH	ALUMINIUM EN AW 6060	ONAT/ALPROF	EN AW 6060-2	T5 or T6
			BARRE / BAR		112 240 A1			BLACK ALLIANCE / 205 313 or BLACK GRAPHITE / 205 09		LISSE SMOOTH	ALUMINIUM EN AW 6060	ONAT/ALPROF	EN AW 6060-2	T5 or T6
		○ 02	ECROU RIVKLE M6 Ø10.3 / RIVKLE NUT M6 Ø10.3		122 644 A0	-	7.2	NA		NA	C10C	BÖLLHOFF	2339060932-02-A	-
		03	SUPPORT AV / FR SUPPORT		112 226 A1	3.5	3993	NATUREL (NOIR) / NATURAL (BLACK)		NA	>PBT-GF30<	SCHULMAN	SCHULADUR PCR GF 30	NA
					119 559 A1	3.5	3993	NATUREL (NOIR) / NATURAL (BLACK)		NA	>PBT-GF30<	LANXESS	PCAAN T7331	NA
		04	SUPPORT AR INTERIOR / SUPPORT AR INT		112 229 A1	3.5	3916	NATUREL (NOIR) / NATURAL (BLACK)		NA	>PBT-GF30<	SCHULMAN	SCHULADUR PCR GF 30	NA
					120 753 A1	3.5	3916	NATUREL (NOIR) / NATURAL (BLACK)		NA	>PBT-GF30<	LANXESS	PCAAN T7331	NA
		05	SUPPORT AR EXTERIOR / SUPPORT AR EXT		112 230 A1	3.5	3404	NATUREL (NOIR) / NATURAL (BLACK)		NA	>PBT-GF30<	SCHULMAN	SCHULADUR PCR GF 30	NA
					119 558 A1	3.5	3044	NATUREL (NOIR) / NATURAL (BLACK)		NA	>PBT-GF30<	LANXESS	PCAAN T7331	NA
		✱ 06	STUD M6 SURMOULE / OVERMOLDED STUD M6		118 471 A0	-	18.3	NA		NA	ACIER / STEEL	CVB	ACCIAIO 20 Mn B4	
					119 217 A0	-	18.3	NA		NA	ACIER / STEEL	MKF FASTENINERS	SAE 10B21/ 15B25/ 20Mn B4	22-32 Hrc
		08	CAPOT HAUT AV / COVER UPPER FR		113 729 A1	3.0	139.0	CHROME SATINE / 205 338		203-29 (0.005 mm)	>ABS<	RESINEX	MAGNUM 3416 SC	
			CAPOT HAUT AV / COVER UPPER FR		112 224 A1	3.0	141.2	BLACK ALLIANCE / 205 353	3 +/-0.2	203-30 (0.02 mm)	>ASA<	BISTERFELD	ASA L1941	
		09	CAPOT HAUT AR / COVER UPPER AR		112 225 A1	3.0	83.5	BLACK ALLIANCE / 205 353	3 +/-0.2	203-30 (0.02 mm)	>ASA<	BISTERFELD	LG CHEM - ASA L1941	

Fig. 2.a. BOM for HJD (Duster)

a. Roof bar black alliance

BARRE DE TOIT G ALLIANCE NOIRE : 738219784R *LH ROOF RACK CHROME SATINE : 738219784R*	BARRE DE TOIT D ALLIANCE NOIRE : 738206669R *RH ROOF RACK CHROME SATINE : 738206669R*	10	CAPOT INF AV *COVER LWR FR*		112 222 A1	3,0	57,1	BLACK ALLIANCE / 205 353	3 +/-0,2	203-30 (0,02 mm)	>ASA<	BISTERFELD	LG CHEM - ASA LI941	
		11	CAPOT INF AR *COVER LWR RR*		112 223 A1	3,0	217,1	BLACK ALLIANCE / 205 353	3 +/-0,2	203-30 (0,02 mm)	>ASA<	BISTERFELD	LG CHEM - ASA LI941	
		✱ 12	DOUBLE STUD M6 *DOUBLE THREAD STUD M6*		112 237 A0	-	54,4	NA		NA	ACIER STEEL	CVB	ACCIAIO 20 Mn B4	
		14	MOUSSE FIXATIONS *FIXATIONS FOAM*		112 236 A0	7,3	1,4	NOIR *BLACK*		NA	>EPDM + PAK<	FORMPLAST	21801.080.7,3	
					119 560 A0	7,3	1,4	NOIR BLACK		NA	>EPDM + PAK<	PRECISION		
		15	MOUSSE CENTREURS *CENTERING FOAM*		112 235 A0	7,3	1,2	NOIR *BLACK*		NA	>EPDM + PAK<	FORMPLAST	21801.080.7,3	
					119 561 A0	7,3	1,2	NOIR BLACK		NA	>EPDM + PAK<	PRECISION		
		16	SEMELLE AV *CUSHION FR*		112 231 A1	2,0	39,2	NATUREL (NOIR) *NATURAL (BLACK)*	3 +/-0,2	203-29 (0,005 mm)	>PP + TPE<	GALLOO MULTIBASE	GP-PP-125T20 MULTIFLEX TES A7512 EVO FXT	
		17	SEMELLE AR *CUSHION RR*		112 232 A1	2,0	104,2	NATUREL (NOIR) *NATURAL (BLACK)*	3 +/-0,2	203-29 (0,005 mm)	>PP + TPE<	GALLOO MULTIBASE	GP-PP-125T20 MULTIFLEX TES A7512 EVO FXT	
		18	FILM MARQUAGE A CHAUD *HOT STAMPING FOIL*		113 475 A0	23 µm		CHROME 3 MIROIR / 205 359 *CHROME 3 MIRROR / 205 359*		NA	POLYSTER	INTERCOM KURZ LTD	CHROME EXTERIOR GLC73725-05	
		19	MOUSSE APRES VENTE *FOAM AFTER SALE*		114 035 A1	7,3	1,4	NOIR *BLACK*		NA	>EPDM + PAK<	FORMPLAST	21801.080.7,3	
					119 562 A1	7,3	1,4	NOIR BLACK		NA	>EPDM + PAK<	PRECISION		
		20	MOUSSE CARRÉE *SQUARE FOAM*		44 171 A0	2,0	0,5	NOIR BLACK		NA	>EPDM + L<	MDE CONVERTING	EPDM-L-44171, 2MM PATRAT 40-8MM	

Fig. 2.b. BOM for HJD Roof bar

b. Roof bar chrome satine

For Sandero Stepway (X52 project) the constituent elements are the following, see Fig. 3. a. and Fig. 3. b.:

01. Aluminium bar
02. Modular rotative cover
04.Modular front bracket
05. Modular rear bracket
06. Overmolded M6 stud
07. Front cover
08. Rear cover
09. Rear lower cover
10. Front cushion
11. Rear cushion
12. Fixation foam
13. Center foam
14. Modular M6 screw T27
15. Modular locker cover
16. Modular metal clip
17. Modular hot stamping foil
18. Overmolded M6 nut

NOTA 8: TABLEAU DE COMPOSANTS ET DIVERSITE
NOTE 8: COMPONENTS AND DIVERSITY TABLE

REFERENCES PIECES / PARTS REFERENCES	COMPOSANTS / COMPONENTS									MATIERE / RAW MATERIAL (R06d)				
	NUMERO / NUMBER	DESIGNATION / PART NAME	REFERENCE NOVARES ROMANIA / NOVARES PART REFERENCE ROMANIA	REFERENCE NOVARES MOROCCO / NOVARES PART REFERENCE MOROCCO	EPAISSEUR / THICKNESS	MASSE (G) / WEIGHT	TEINTE / CODE / COLOR / CODE	BRILLANCE / SHINING	GRAIN / PROFONDEUR / GRAIN / DEPTH	NOM / NAME	FOURNISSEUR / SUPPLIER	NON METALLIQUES: NOM COMMERCIAL / COMMERCIAL NAME	METALLIQUES: NORME DE REFERENCE / REFERENCE STANDARD	TRAITEMENT / TREATMENT
TANGER - CASABLANCA - LH : 73821 2921 R / RH : 73820 1077 R 119333 A1 / 119333 A2 ULAR G/D SS LH/RH 0081 R	1	MODULAR ALUMINIUM BAR	118 438 A1/A2	118 438 A1K/A3K	3/2.15	1038	GREY QUARTZ 235-400			ALUMINIUM EN AW 6060 T6	NOVARES		SR EN 575-3	DEGREASING ACIDE ZIRCONIUM PAINT
	2	MODULAR ROTATIVE COVER	118 439 A1/A2		3	26.9	BLACK ALLIANCE 235-353	4.5 +/- 0.2 UB	203-77 (0.02 mm)	>ASA<	LG CHEM	ASA _1941		
	4	MODULAR FRONT BRACKET	118 441 A1/A2	119 344 A1/A2	3.5	283	BLACK			>PP-GF30<	SUMIKA	THERMOFIL HP F181X99		
	5	MODULAR REAR BRACKET	118 442 A1/A2	119 345 A1/A2	3.5	375.2	BLACK			>PP-GF30<	SUMIKA	THERMOFIL HP F181X99		
	6	OVERMOLDED M6 STUD	118 471 A0			15.8	COLORLESS			STEEL 20 Mn B4	CVB		EN 10025	Zn/Ni 8
	7	FRONT COVER	118 431 A1/A2	119 336 A1/A2	2.5	168	BLACK ALLIANCE 235-353	4.5 +/- 0.2 UB	203-77 (0.02 mm)	>ASA<	LG CHEM	ASA _1941		
	8	REAR COVER	118 432 A1/A2	119 337 A1/A2	2.5	210.8	BLACK ALLIANCE 235-353	4.5 +/- 0.2 UB	203-77 (0.02 mm)	>ASA<	LG CHEM	ASA _1941		
	9	REAR LOWER COVER	118 433 A1/A2		4	34.2	BLACK ALLIANCE 235-353	4.5 +/- 0.2 UB	203-77 (0.02 mm)	>ASA<	LG CHEM	ASA _1941		
	10	FRONT CUSHION	118 434 A1/A2	119 338 A1/A2	2	56.9	BLACK ALLIANCE	4.5 +/- 0.2 UB	203-29 (0.005 mm)	>PP TD20 + TPE<	GALLOO + MULTIBASE	GP125120 + MULTIFLEX TES A7512 E		

Fig. 3.a. BOM for X52 roof bar
a. Tabel of the components

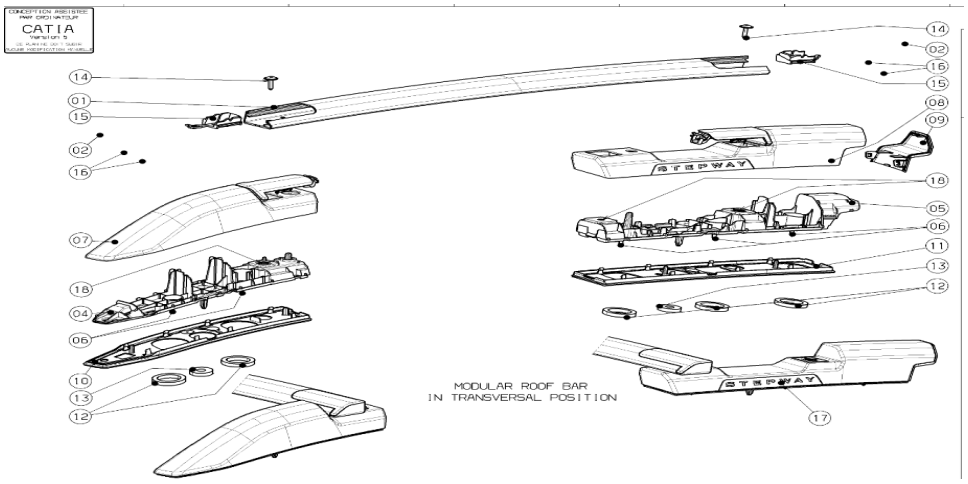


Fig. 3.b. BOM for Sandero Stepway
b. the components of the roof rack

From BOM presentation is quite visible the fact that the new product, the Stepway Roof Bar, have less components that HJD Roof bar. In term of costs and productivity this fact can be translated in lower production costs and better productivity, less processes handled by less operators. I need to mention that the final product price is very close for the two analysed references, so all this gain is translated to the company profit [3],…, [9].

Further the paper presents a short analyse and the analogy between the manufacturing processes of these two roof bars.

4. Manufacturing process

The manufacturing process of modular longitudinal bars consists of three main processes: the painting process, the injection process, and the assembly process.

The painting process:

Aluminium bars go through a preparation process before painting, a process that involves washing the bars and treating them with anticorrosive substances, after which they are directed to the primer application line, and then to the paint application lines.

There are two lines of paint application: liquid paint application line, operation performed by an operator, manually, using painting guns and powder paint application line, using a robotic line, equipped with 2 robot hands.

For HJD roof bar we are using the manual paint application, while for X52 roof bar, we are using the robotic line.

To understand better the difference between these two lines, and how important is the paint application, is important to points the following parameters:

1. Painting angle
2. Distance between the painting pistol and the bar
3. Painting trajectory
4. Painting pressure and debit

Taking into consideration that for liquid line we are using 2 operators per shift and the four key points described above, the conclusion is that a robotic line is a must have.

Using robot hands allows to obtain a better control on the painting process and a better-quality result.

I cannot present the real data for confidentiality reason, but I can sustain that robotized line have two times less scrap rate than the manual painting line.

The new product, X52 Roof Bar, brought a modern painting line, with a huge improvement in the quality product, productivity, and production cost.

The injection process:

The plastic components of the bars are produced during the injection process. The granular material is dried at a certain temperature in the Moretto station, after which it is transported to the injection machines that melt it and inject it into the mold.

The injected parts are then stored in a buffer stock, from where they will be taken, depending on the orders, on the assembly lines. In Fig. 4. is presented the layout for the injection machine and mold of edge caps left and right.

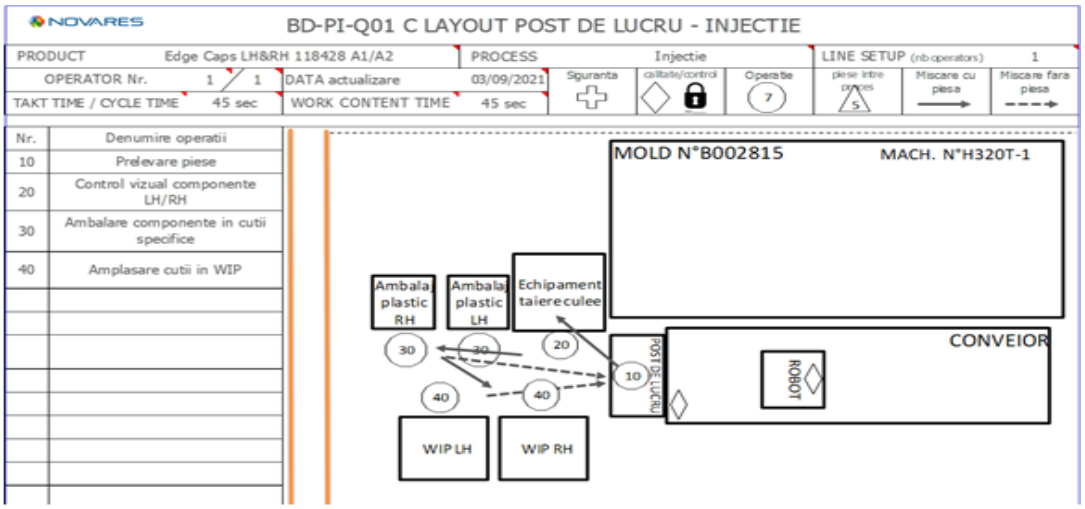


Fig. 4. Injection layout for the edge caps

The lessons learned from the HJD project were applied to X52 project also for injection process. The main action was to reduce the number of operators:

1. The number of molds was decreased from 10 to 7, combining front side part with rear side part, left hand part with right hand part. So instead of using several molds obtaining one set of parts, some of the molds were increased, containing all sides references (ex. for front and rear support, left and right)

2. Second point considered was the improvement of the machines where normally should work 2 operators. (ex.: For the brackets/supports, an automatic feeder was installed for the 16 inserts that need to be used; in current production, for HJD Roof Bar, there are 2 operators that place the inserts into the robot hand)

The assembly process:

The assembly process is the process of joining all the components to create the final product. This process involves joining the components with the help of screws, by clipping and welding.

In Fig. 5. is presented the layout for the assembly line for the roof bars.

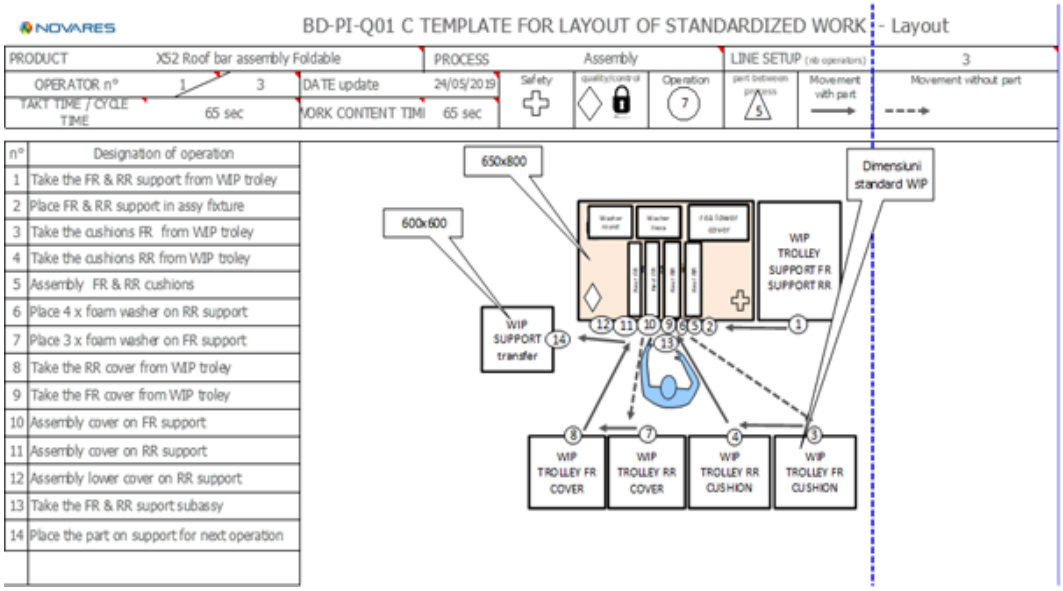


Fig. 5. Assembly layout.

Flowchart of the manufacturing process:

The flowchart is a diagram that uses graphic symbols to describe the nature and the steps made in a process. This type of diagram helps us to understand how the process really works, with its help we can forecast or plan various changes in the process. Among the benefits of using the flowchart we can list:

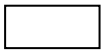
1. It promotes understanding of a process, explaining the process step by step and presenting the steps graphically.
2. It is a tool for employee training because it represents in a graphical way the sequence of the steps. Flowchart can be very useful in training employees to perform the process in accordance with existing standardization procedures.
3. Helps us to identify the problem areas and opportunities to improve the process.

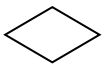
4. Describes the customer-supplier relationship, helping the people involved in the process to understand who their customers are and when they are in the role of supplier.

The symbols used in flowchart have a specific meaning and are connected to each other by arrows that indicates the flow from one step to another.

The general symbols are:

 - Oval - indicates the start and end step.

 - A rectangle - represents a simple step.

 - Rhombus - a rhombus indicates a control point/ self inspection. The decision points can be yes or no. From this rhombus must emerge two possible variants that indicate the evolution of the process.

 - Circle - a circle indicates that a flowchart step is connected to another page or to another part of the flowchart. Usually, a letter is written in a circle to show the connection.

 - Triangle shows where the units of measurement appear in the process.

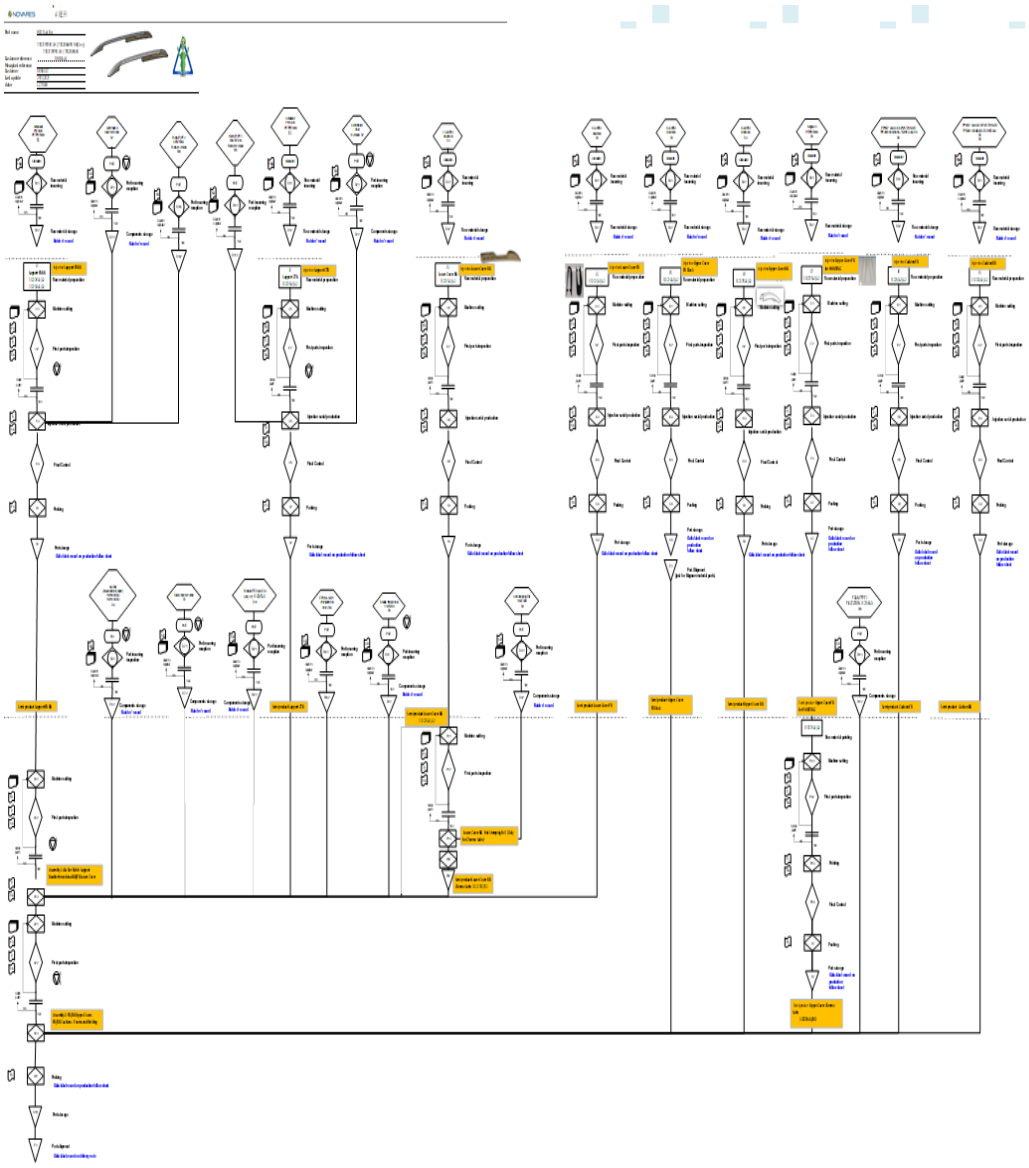


Fig. 6. The flowchart of manufacturing process for roof bars

In the Fig. 6. it's presented the flowchart of the production for the longitudinal modular roof bars within Novares factory [2].

Conclusions

The benefits of the innovation of longitudinal roof bars from fixed version to modular version:

1. For the painting process, the replacement of the manual painting line with the automatic painting line reduced the number of the operators, decreased the scrap rate and improved the quality of the product (painted bars).
2. For the injection process, there was an important improvement by decreasing the number of the molds used to produce all the components, by adding modern solutions for reducing the number of the operators and reducing their efforts.
3. For the assembly line an assembly machine and an operator were removed, using a single operator to prepare the front and rear support subassembly. Here I want to highlight that sometimes the solutions can be reversed, using operators instead of complicated assembly machines, if the part design is user friendly.
4. The part design was a real success. Even if there is something wrong in the process and the final part has a defect, the current design allows to rework (by replacement) all the impacted components. In opposite side, the fixed bars with defects are not reworkable, so lots of components need to be scrapped, causing a major cost in case of nonconformity.

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