Possibilities of replacement of two side metal molds for the production of two facing side composite by one side mold

Lukas Manas[1], Sona Rusnakova[1], Milan Zaludek[1], Ladislav Fojtl[1], Vladimir Rusnak[2]
[1]Department of Production Engineering, Faculty of Technology, Tomas Bata University in Zlín. Vavrečkova 275, 760 01 Zlín. Czech Republic. E-mail: lmanas@ft.utb.cz, rusnakova@ft.utb.cz, zaludek@ft.utb.cz
[2]Faculty of Metallurgy and Materials Engineering, VŠB-Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic. E-mail: vladimir.rusnak@form-composites.com

Presented research paper deals with possibilities of replacement of conventional mold materials by new, unconventional. Traditionally, laminate, wood or gypsum molds (in the case of small production series) are used for the production of composite parts. Furthermore, milled aluminum molds are conventionally used only for mass production. Due to this, thin metal sheet was prepared as an unconventional production mold for manufacturing of motorbike facing part. Vacuum bagging using prepared one side mold was chosen as the most appropriate technology. Normally, two facing sides are not commonly manufactured using this technology. Because of this, possibilities to create two facing sides at areas that are not in contact with mold itself were investigated. Presented results can help manufacturing companies with their production and considerably decrease manufacturing costs due to not necessity to use two side molds.

Keywords: Carbon fibers, Prepreg material, Metal sheet mold, Facing part, Vacuum bagging, Vacuum technology

1 Introduction

Production of composite structures is now possible using miscellaneous technologies, which differ from each other by different technological procedures and mold construction, but also by different support materials. All of these parameters define price of the final composite part.

Only some technologies, traditionally used for production of composite components allow the creation of facing surfaces on final part. The amount of facing surfaces on the part then determines the chosen technology and also resulting price. [1] In case of two or more side molds it is not a problem to create a product that consists entirely of facing surfaces. Conversely, at one side molds are possibilities limited by mold construction. Production of good quality facing surface must meet the requirements of part negative shape – mold surfaces. Surface finish of these molds must be of excellent quality, where every unevenness of the mold surface is reflected on the part surface. [3] [6]

The aim of presented article is design and experimental verification of vacuum bagging technology used for production of two side facing composite part made of pre-impregnated materials (prepregs). [5] [7] This technology allows production of facing surfaces only in contact areas of material and one side mold. Due to this fact, the authors' experimentally verify the possibility to produce facing surface on side, where only support materials are placed. The main motivation for this research was also an emphasis on selection of mold material and possibilities of cost savings of whole technological process.

2 Materials and Methods

Alternative motorbike facing part was selected as simple shape product replaceable by composite materials. This part is placed under the motorbike engine with design and also protective purposes, i.e. to protect the engine against dirt and smaller impacts. Resulting product will be produced from carbon pre-impregnated material due to very good visual properties.

At the beginning, before the mold construction, a part paper pattern was created and after verifycation of dimensions on motorcycle frame, flat sheet part was cut at TRUMPF L 3050 cutting machine from sheet of EN 10130 material with thickness of 1.2 mm. Fig. 1 A shows this paper pattern fastened on the motorbike and subsequently a prototype shaped from cut sheet with marked facing surfaces.

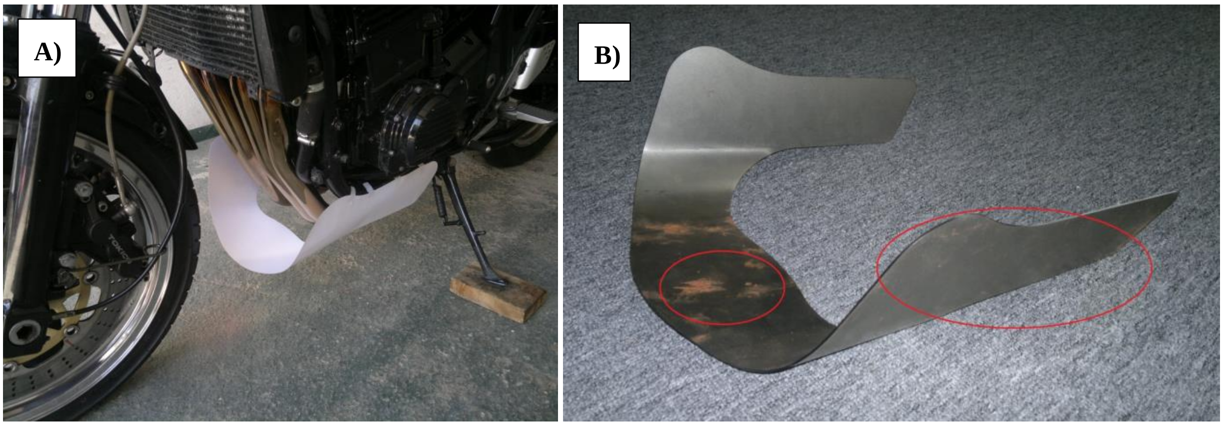

Fig. 1 *Design part for motorbike; A) Paper pattern fastened on motorbike, B) Sheet part prototype with marked facing surfaces*

Molds for composite part production can be prepared from various materials; steel or aluminum block, steel sheet, wood, plastic wood, plaster, composites or by combination of these materials. All these materials have its advantages and drawbacks. Due to this fact, steel sheet was chosen as a mold material with respect to the final product shape. However, usage of steel sheet is not very ordinary. This material will be experimentally verify due to possible cost savings in comparison to plastic wood (like NECURON) or aluminum, where traditional price starting from 120 CZK per kilogram. Regarding the planed part size, utilization of steel sheet can brings savings around 10000 CZK. However, steel sheet is not very suitable for complex-shaped mold, but its utilization in combination with other materials is much more interesting and opens areas for following research.

As was mentioned before, mold thickness was chosen equal to 1.2 mm, where sheets of greater thickness would be difficult to shape on metal sheet forming machine. On the other hand, thicker sheet would be more convenient in terms of rigidity of entire production mold. Thus, thickness of 1.2 mm was chosen as compromise, selected with respect to the previous information. Individual mold parts were cut by laser as developer shape from steel sheet. After shaping, mold itself was reinforced by steel ribs to increase the rigidity and handling of entire mold (Fig. 2).

Fig. 2 *Final shape of designed steel sheet one-side mold*

Final composite part was created from eight layers of preimpregnated fabric named Carbon Fabric TC203T EMT 125 PLUS of Pro-Systems company (Fig. 3A). This prepreg system is impregnated by epoxy resin. Furthermore, carbon prepreg was selected with respect only to its visual properties – carbon texture. Other properties as mechanical were not important for this experiment.

Before laying of individual material layers, it was necessary to prepare support materials and create a mold insert for creation of facing surface from the side, where support materials are placed. For this purpose, a thin aluminum sheet of 0.3 mm was selected as this mold insert (Fig. 3B). This insert does not contain shape as mold cavity, however material ductility allows to shape this sheet during vacuum bagging. At the beginning of the production, aluminum sheet was polished and provided by suitable separator. Facing side of the mold was not polished due to subsequent coating of produced part.

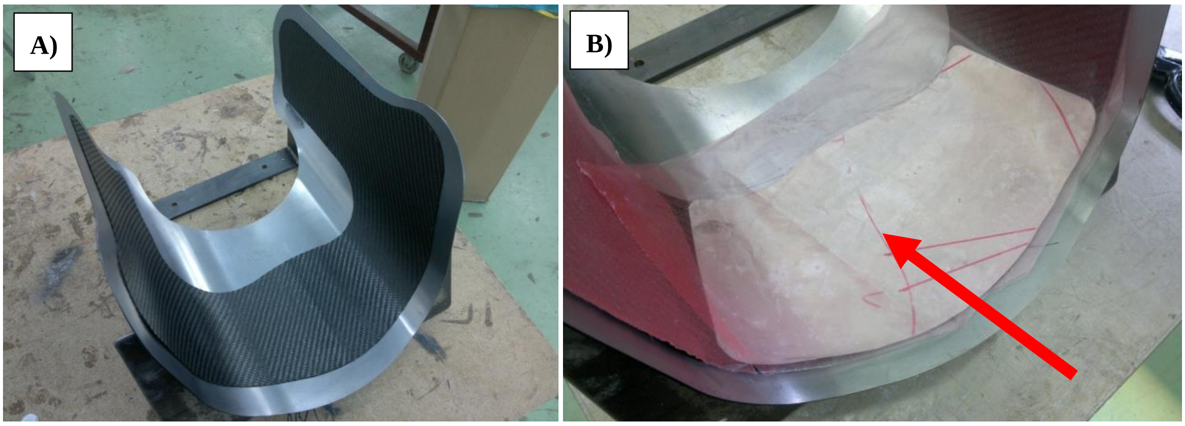

Fig. 3 *Material placing; A) Carbon prepreg, B) Paper pattern of aluminum insert*

After preparation of aluminum mold insert, individual materials were placed into separated mold. Materials were layered in following sequence; eight layers of carbon prepreg, mold insert, separation foil, peel ply and breather. These materials were covered by vacuum bagging foil with sealant tape and vacuum was created between mold and foil (Fig. 4).

Fig. 4 *Mold prepared for placement into oven*

Production process of composite part was started by heating to curing temperature of 120 °C. The part was cured for two hours at this temperature in curing oven. After production, part was demolded from the mold and final product was cut regarding a contour marked on facing side of mold. This finishing operation was followed by part coating by clear lacquer. This varnish added component glossy finish and also highlight the texture of the carbon prepreg.

3 Results and Discussion

Selection of steel sheet as the mold material brought 85 % financial savings of total cost in comparison with the case, where aluminum (Dural) is used as mold material and is machined (milled, grounded and polished). Selected steel sheet was easily formed into required shape and much less production time was necessary for mold production. Beside all advantages, this unconventional caused a few problems. Stiffness of mold was upgraded by several steel ribs to ensure a solid base for subsequent operations.

As was mentioned, aluminum insert was used to create a facing surface on the part (Fig. 5), but also other materials as thin plastic foils, sheets and also other materials with precise surface finish resistant to high temperature incurred during the curing process can be applied.

Proportionally with the number of used support materials, such as separation foil, the price of produced part also increases. For large production series it is therefore appropriate to use multi-part mold, where the support materials are not used in such quantity. On the other hand, small production series are cheaper and is necessary to use one side molds with variety of support materials.

Size of created facing surface is dependent primarily on the size of mold insert for this surface – size of aluminum sheet. Nevertheless, with greater thickness of final composite part, a problem with extraction of excessed resin into breather could occur. On the other hand, this problem did not arise at final product of 2 mm thickness. This effect could be topic of further research work. One other possibility would be to use an aluminum plate on the entire inner surface of the product, thus aluminum plate would replace whole upper side of mold. However, in case of our produced part, this requirement was not necessary.

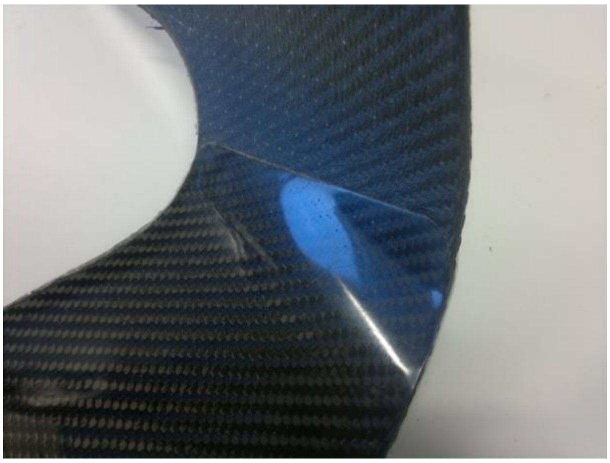

Fig. 5 *Detail of produced facing surface on inner side*

4 Summary

Experimental activities in this paper have described design and production of two facing side composite by one side mold. Production of facing surface by this procedure is not common in practice. Prepared mold allows to produce medium part series, has greater lifetime compared to laminate mold and is much cheaper compared to milled aluminum molds.

Produced facing surface on final composite product is shown in Fig. 6A. This figure also shows the difference between facing surface and the area, where a prepreg material was in contact with the separation foil and breather. Texture created by support materials is easily visible. Moreover, Fig. 6B gives complete look at produced part fastened on the motorbike.

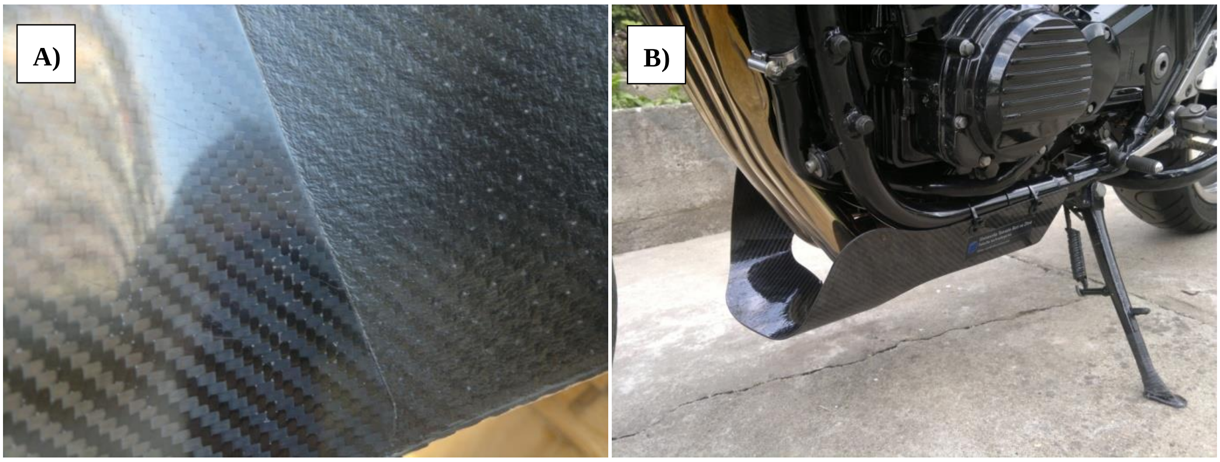

Fig. 6 Final composite product; A) Detail of facing surface, B) Product fastened on motorbike

This method for the production of facing surfaces can be advantageously used especially in technologies using vacuum. In contrast to multipart molds, this method is less expensive and mold production is faster. Moreover, this method can find application mainly on parts where facing surface is not required on the whole surface of complex product.

As was proven in the experiment, it is possible to produce facing surfaces without necessity to use different (more complex) technology or to intricately modify mold itself.

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