Delaminations in Waterjet Cut Fibreglass-Phenolic Composite Panels – Phase 1

SUMMARY

ArmorWorks Canada is a division of the global company ArmorWorks, which designs and manufactures advanced survivability products including personal protective equipment, hard armour for vehicles and blast attenuating seat systems. The Canadian division specialises in hard composite armour used in vehicle seat systems to protect occupants from the shrapnel from improvised explosive devices. Much of the hard armour is produced from a fibreglass-phenolic resin prepreg material consolidated and cured in an on-site autoclave. After cure, parts are trimmed and machined off-site into their final form using an abrasive waterjet (AWJ) cutter. This process includes piercing the laminate with the water jet in order to cut the holes used for bolt-up assembly later in the manufacturing process. Historically this piercing action worked successfully but in recent times, due to unknown factors, delaminations began to appear raising the rate of scrapped parts. Where previously scrap rates were in the order of 5%, they increased to approximately 30% in some recent batches. As each occurrence caused significant direct cost, ArmorWorks engineers were keen to understand the causes of the problem, and to identify methods to reduce delamination.

ArmorWorks Canada Inc.
Winfield, British Columbia

ArmorWorks Canada manufactures various survivability products including blast attenuating seat systems designed to protect vehicle occupants from improvised explosive devices. The armour components are sold to OEMs that subsequently assemble and market the completed vehicles.

Client Contact

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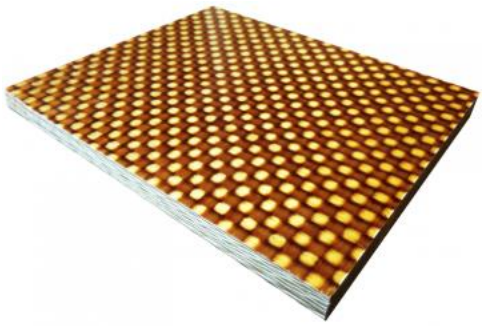
CHALLENGE

Abrasive waterjet (AWJ) cutting of thick laminates poses numerous problems for manufacturers. Particular challenges occur when the initial cut is made as a pierce with no lead-in. Historically, this method has been used by ArmorWorks Canada with acceptable defect rates. Recently, delaminations around pierced holes increased inexplicably, causing part scrap rates to rise to economically unacceptable levels.

APPROACH

CRN designed a two-phase project. The first phase (now completed) executed a thorough literature review to uncover the fundamental mechanisms affecting AWJ machining of composite materials. The second phase (in progress) will use an experimental approach to evaluate the machinability of Armorworks' material under various process conditions. This will involve the preparation of samples, which will be scanned with phased-array probes to identify any pre-existing manufacturing defects. Subsequently, the samples will be subject to piercing hole cuts under various AWJ regimes.



Fibreglass-phenolic prepreg consolidated material

OUTCOME

The literature review in phase one of the project has shown the importance of a number of parameters in the AWJ cutting process, and their effects. These parameters include cutting pressure, travel speed, backing material choice and part orientation. The combined effect of these parameters can lead either to successful machining or delamination. Delamination occurs when the energy imparted to the piece (in order to shear material in the normal direction)—plus the internal energy favouring delamination—exceeds the Mode I interlaminar fracture toughness of the material.

IMPACT

The completed phase of the project has provided ArmorWorks Canada with a better understanding of the AWJ cutting process for composite materials. This information can be used to initiate an analytical and experimental qualification program to determine and monitor the appropriate machining parameters for each laminate. It also provides insight into process adjustments that can be used to combat delamination during machining. Using the knowledge already gained in phase one, an experimental plan for phase two of the project was developed.

> ***A sudden change in the scrap rate from less than 5% to approximately 30% forced us to reconsider the manufacturing process we were using. With a scrapped part costing the company approximately $300, there was plenty of incentive to resolve the issue. Support provided by CRN is helping us work towards a solution.***
>
> *Alex Greer, Chief Engineer ArmorWorks Canada*

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