DEVELOPMENT OF AN AUTOMATED NDT SYSTEM FOR CERAMIC BALLISTIC PLATES

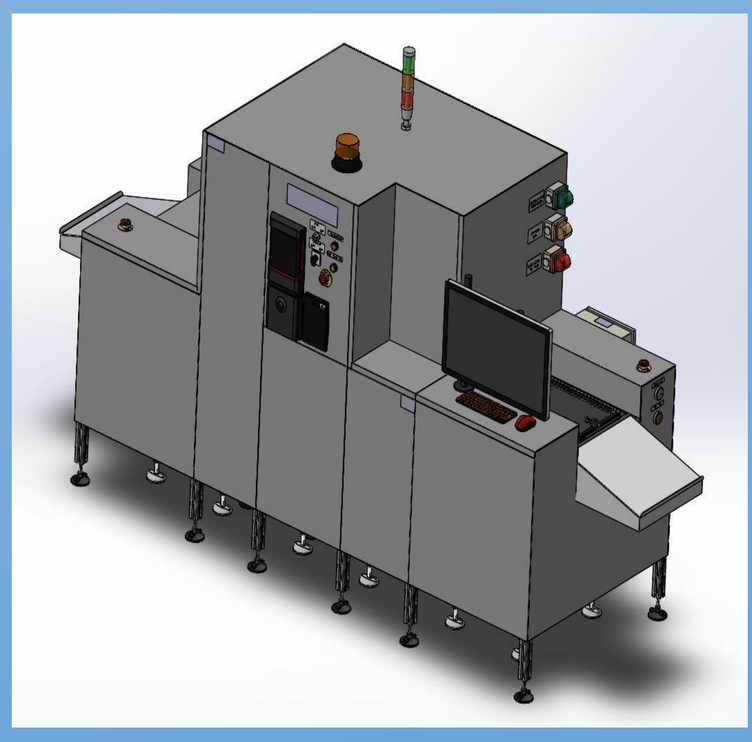
Mihai Iovea[1], Maksude Cerit[2], Aysima Tunç[2], John Duncan Stephenson[3] and Kayıhan Gündoğdu[3]

[1] ***Accent Pro 2000***, *Magurele, Bucharest, Romania, office@accent.ro*
[2]***NUROL Teknoloji***, *Ankara, Turkey*
[3]***Integrity NDT***, *Ankara, Turkey*

Introduction The ceramic ballistic plates are required to absorb the impact energy subjected by high-speed projectiles. The ceramic plates' reliability is of critical importance due to its relationship with both human and critical equipment safety.

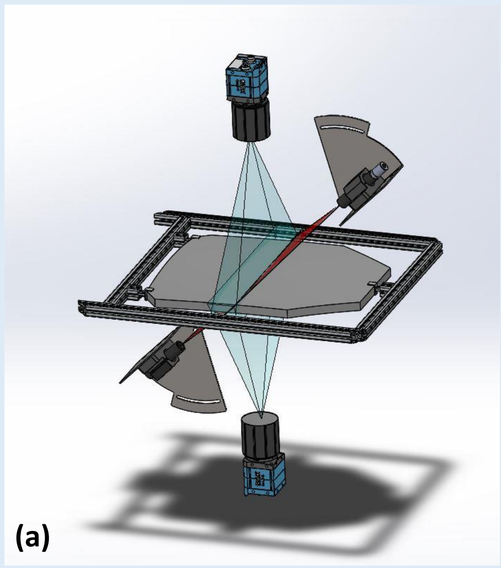
Our collaborative research is the development of an automated non-destructive testing system for ceramic ballistic plates 'XShaper'. The developed system provides an automated process, for the in-line high speed sizing and inspection of the ballistic plates. When integrated into high speed mass production, the rapid collection of valuable component integrity data adds significantly to maintaining highest level of quality control, and the conveyor process will be capable of high-speed high sensitivity production.

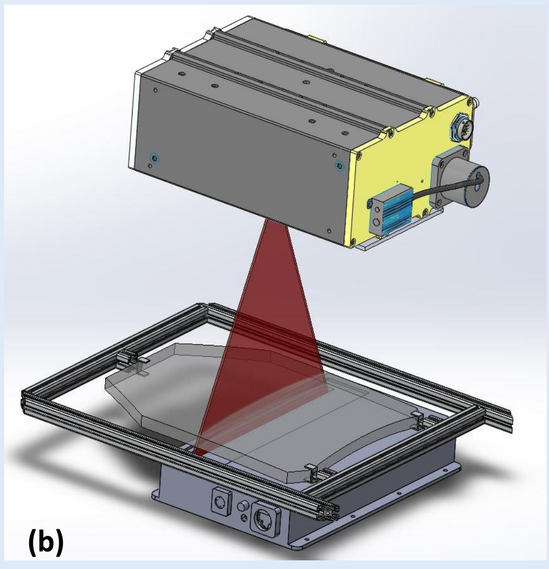
XShaper system is a modular system, facilitating the inspection of complex geometries such as ceramic ballistic plates. This modular design provides the flexibility and potential for the adoption of the inspection of other applications, such as additive manufactured components requiring different specifications.



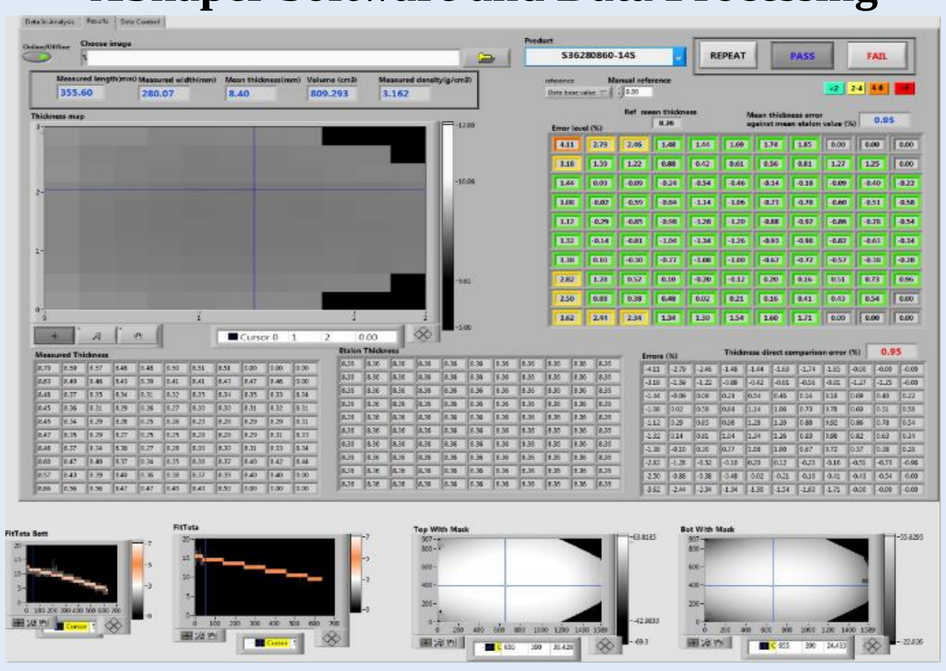
Laser and X-ray System Set-up

XShaper system combines the use of a high-resolution laser 3D profiler (a) and a high-resolution 2D x-ray imaging system (b). The physical size of the ceramic plates (40x30x5 cm) and the contoured profile raises numerous challenges. Using dedicated image processing algorithms on a fully automated conveyor system, the processed laser and x-ray data is used to determine important parameters such as 3D dimension, thickness, density mapping and defect sizing and positioning, to achieve high levels of sensitivity and dimensional resolution. The system measures plate parameters which are compared with acceptance values, and the rapid sample scanning, data acquisition and total accept/reject process takes around 30 seconds.



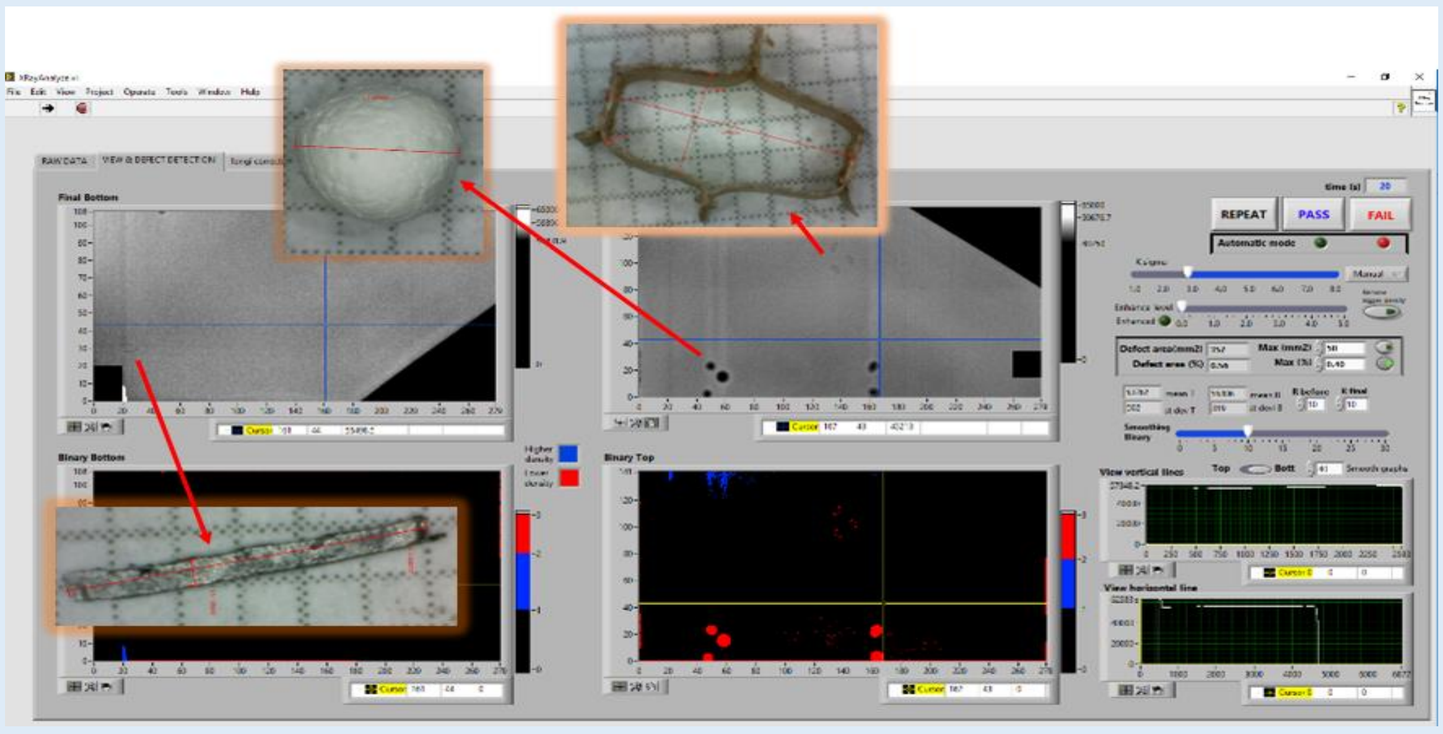


XShaper Software and Data Processing



The XShaper laser measurement software provides a 3D profile of the specimen and calculates volume, surface area and overall density, it maps the thickness over the full surface area and records a matrix of 110 point thickness readings, which is then used for comparative coloured thickness mapping.

Following laser measurement, the sample passes through an x-ray scanner and the raw x-ray image data obtained, is subjected to complex image processing algorithms resulting in coloured density mapping of the sample. As shown here, internal defects and density measurement can be further quantified using the software functions (as shown here on the right-hand side).



Studies are underway to further reduce the rapid inspection below the 30 seconds achieved. By the selection of defect modes (thickness mapping, defect detection and density mapping), the system acceptance criteria can be applied automatically. This high precision rapid inspection application can be disseminated and deployed to other industries such as additive manufacturing, automotive and aviation.

X-ray max. Voltage	160 kV
X-ray max. Current	5 mA
Inspection Time	30 seconds
Thickness Resolution	60 microns
Density Resolution	%1-2

XShaper device works with a maximum x-ray output source voltage of 160 kV and current of 5 mA, and to ensure operator safety, the x-ray measurement system is fully enclosed in lead shielded containment. Dependant on the application, the thickness resolution (60 microns), and density resolutions (1%), can be futher reduced by increasing inspection process durations, a trade-off between inspection time/resolution.