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Quality assessment of critical shaped structural refractory blocks using novel NDT technique

Saumita Gangopadhyay, Nabid Khan, Monoj Halder, Prasanta Panigrahi, Navneet Sinha
Tata Steel, Jamshedpur

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industry**



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Types of refractories used in steel industry:

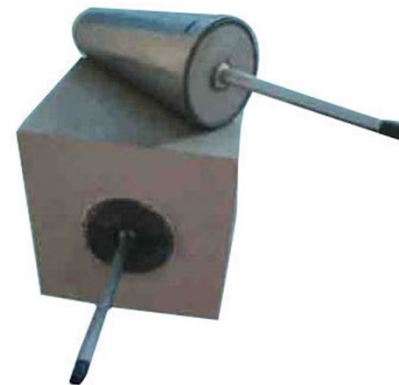


- Normal Regular shaped bricks
- Monolithic
- Special shaped Refractories.

Destructive testing is not possible in these Critical shaped refractories due to:

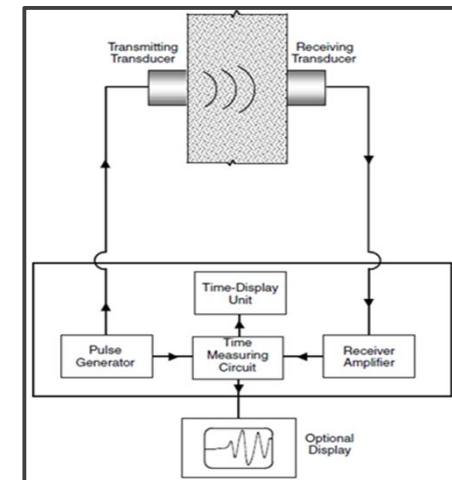
- Bigger and complex size
- Higher cost.

Hence, NDT method opted for evaluation of these structural blocks.



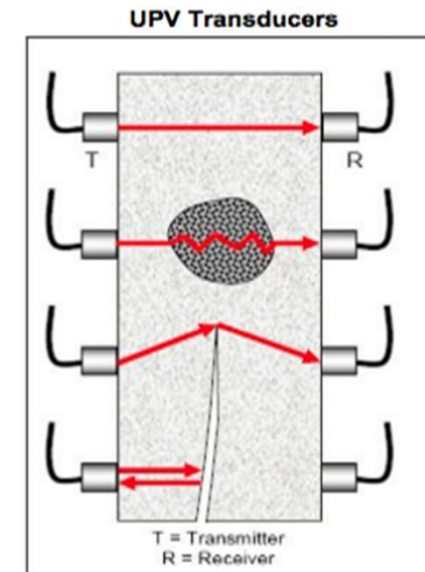
Benefits of using Ultrasonic Pulse Velocity method:

- ✓ Check homogeneity of the refractory blocks
- ✓ Detect presence of internal flaws/cracks in the structure
- ✓ Gives indication regarding density, compressive strength and modulus.
- ✓ Portable equipment provide facility of on-site inspection of refractory blocks before installation.

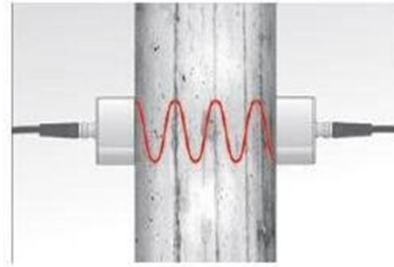


Principles of UPV method:

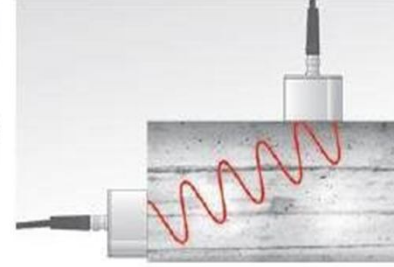
- Velocity of sound V in a solid material is a function of the square root of the ratio of its modulus of elasticity, E , to its density d $V = f\left(\sqrt{\frac{gE}{d}}\right)$
- Ultrasonic pulse Velocity method uses high frequency ultrasonic pulses (25-60kHz) to evaluate the quality and strength of the block.
- The apparatus for ultrasonic pulse velocity measurement consists of transmitting transducer (for generating pulses) and receiver transducer (for receiving pulses).



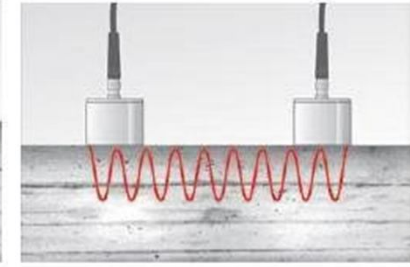
Equipment and its Measurement mode:



(a) Direct Method



(b) Semidirect Method



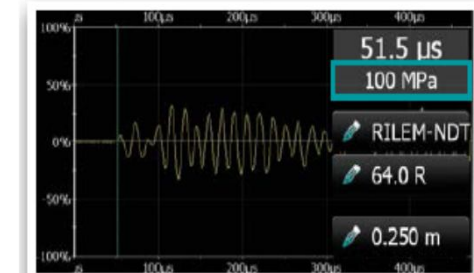
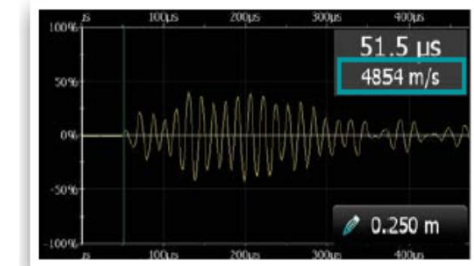
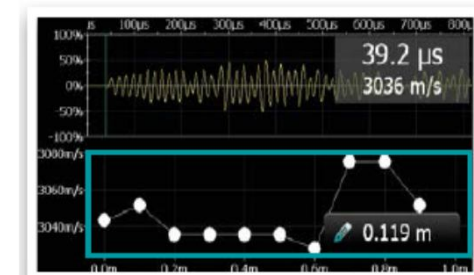
(c) Indirect Method



Equipment and its Measurement mode:



- Assesses the concrete uniformity and detects cracks as well as other defects. The measured pulse velocities are displayed as a line.
- Calculates the pulse velocity of the material under test.
- Determines the compressive strength using Ultrasonic Pulse Velocity correlation,
- Determines the Elastic modulus of the material (density to be provided),

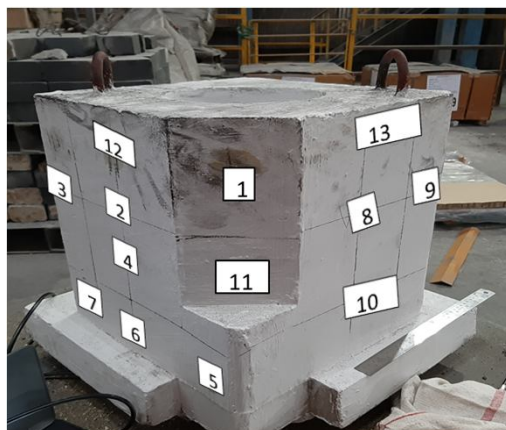


USE OF UPV method in history of Refractories :



- ❑ **1955** - Davis1.' reported the use of Ultrasonic test to determine the correlation between modulus of elasticity and flexural strength for fireclay brick (1955)
- ❑ **1958** - Semler et.al used ultrasonic method to monitor the strength degradation/damage in high alumina refractories resulting from thermal shock exposure.
- ❑ **1979**- Dunworth discussed the use of ultrasonic data to **monitor in-plant the production of slide gates**
- ❑ **1981** - Lawler et al. conducted an extensive evaluation of **fireclay coke oven refractories**, in which ultrasonic measurements were correlated with crushing strength of the bricks.
- ❑ **1983** - Petit" reports the results of an evaluation of **ladle refractories** in which sonic resonance modulus of elasticity data were correlated with porosity, density, and strength properties of the brick.
- ❑ **1984** – Morrow et al' reported the ultrasonic testing results **of slide gates and shroud tubes** and corelated with density and compressive strength.

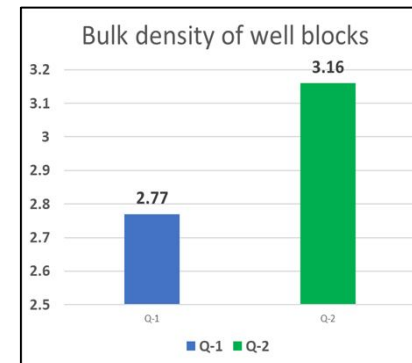
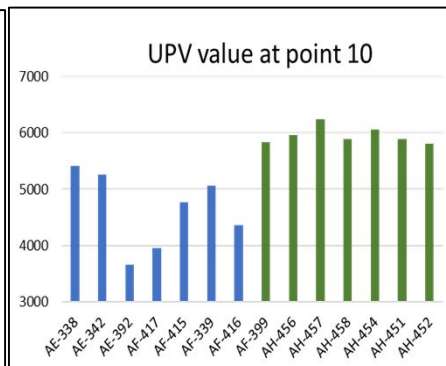
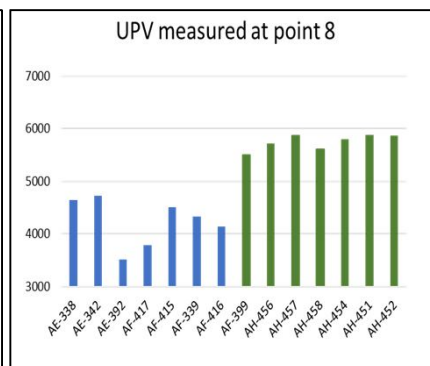
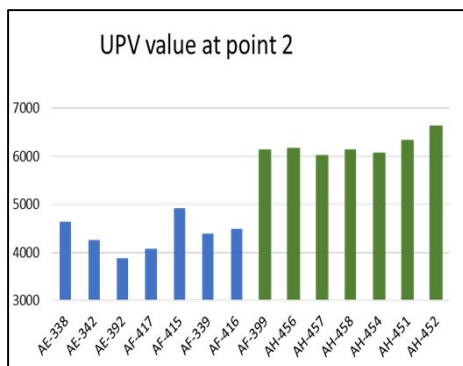
Case Study 1 : Evaluation of well-blocks



Background: Well blocks play an vital role in steel ladle operation. Premature catastrophic failure of well blocks can lead to steel leakage through the ladle bottom and cause safety incident and premature outage of ladle.

Two qualities of well-blocks having different chemical composition but same physical properties has been assessed by UPV method.

- On each well blocks 15 points were marked.
- Measurements were taken through direct mode at all the points.



- Velocity value in Q-2 quality is significantly higher than Q-1.
- Q-2 quality well blocks show more consistency in velocity.

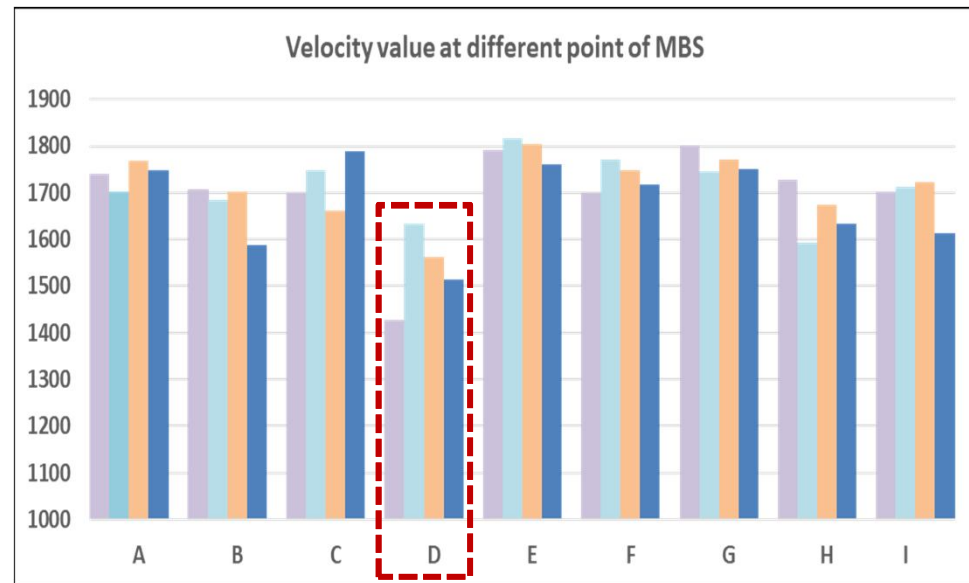
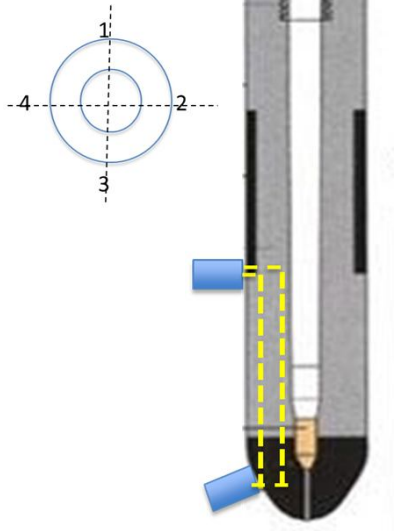
Density of Q-2 > Q-1.

Case Study 2 : Evaluation of monoblock stopper



Monoblock stoppers are used to control the flow of steel through the sub-entry nozzle or the tundish nozzle.

Joint between the body and the tip is the most critical part of the stopper, any crack or internal defects present in the joint can migrate into the body during operation and may led to stopper failure.



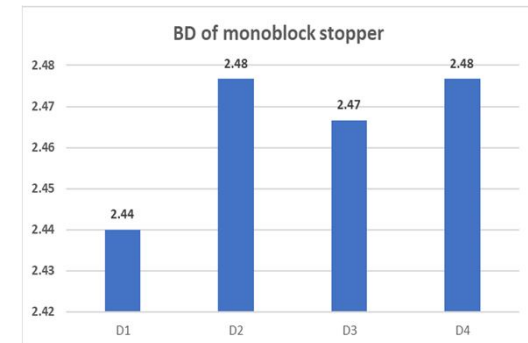
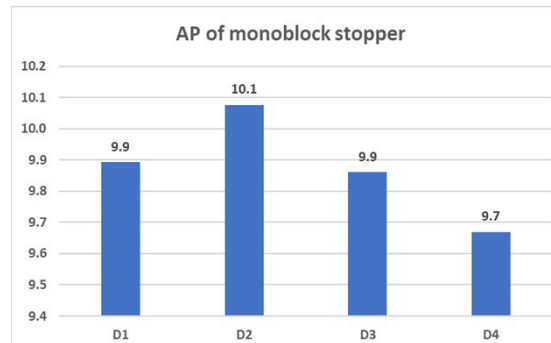
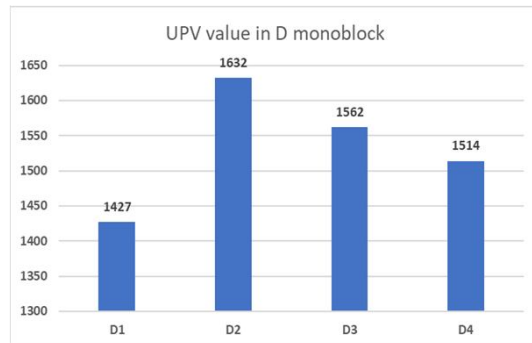
Findings:

- Velocity value at all the point of mono block stopper D has found to be low, which denote lower density and strength value of D.
- D1 and D4 have lower velocity compared to D2 and D3, which denote un-uniform pressing/density during manufacturing .

Case Study 2 : Evaluation of monoblock stopper



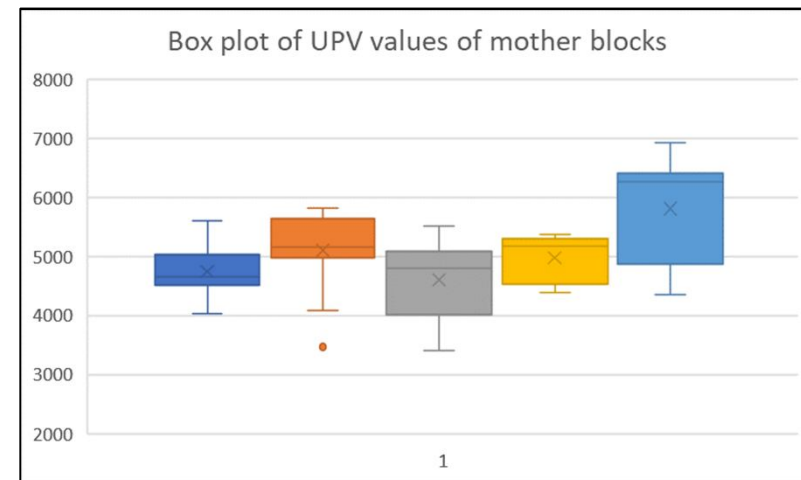
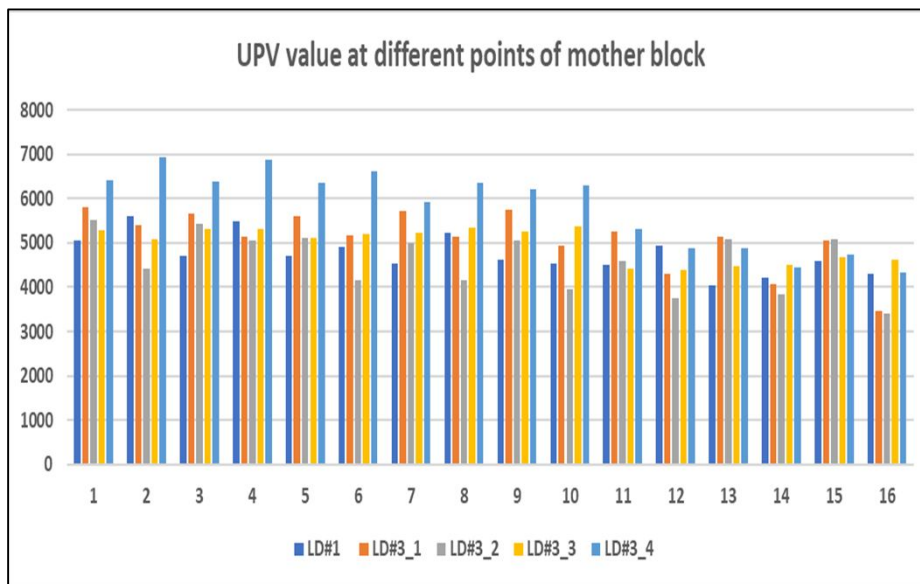
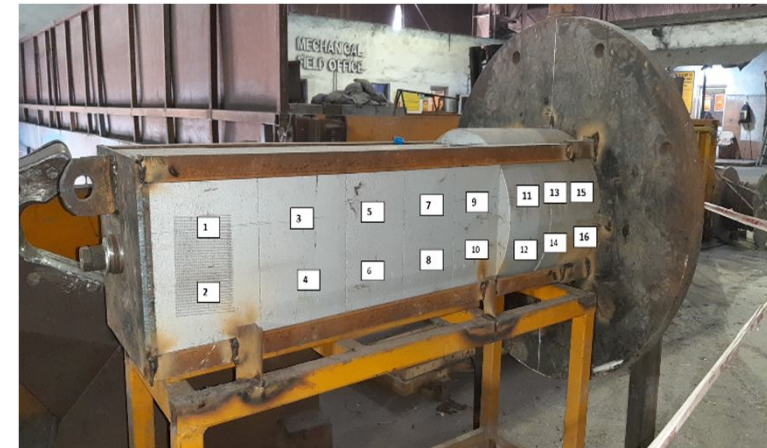
As D is showing wide variation in velocity value, sample D collected and initially 300 mm length was cut from bottom (tip) , again this portion is cut into 4 pieces according to the NDT testing position . From each part 3 no's of AP,BD conducted to check the manufacturing uniformity (pressing) .



Case Study 3 : Evaluation of taphole system of Vessel



Taphole system plays important role in tapping of liquid steel from the vessel.
Ultrasonic testing of taphole system before installation checks structural integrity and qualitative evaluation.



Thank You