

POD Evaluation of Automated Ultrasonic Detection of Hard Alpha Inclusions in Titanium Alloys

Daria S. LOZHKOVA *, Svetlana I. TRIFONOVA *

* FSUE "All-Russian Scientific Research Institute of Aviation Materials" State Research Center of the Russian Federation, Moscow, Russia

Introduction. The problem of POD of NDT is very important for Russian aerospace industry nowadays. Using FAAACC 33.14 data is inexpedient because of significant difference between Russian and foreign titanium disks ultrasonic testing NDT manuals. Probability of defect detection versus its size curves are necessary for the deficiency evaluation of gas-turbine engine basic parts. Evaluation of gas-turbine engine basic parts deficiency is necessary for new procedure of resource calculation introduction.

Methodology

Special research for reliability evaluation of automated titanium disks ultrasonic testing was made in FSUE "VIAM". Special requirements for specimens with synthetic hard alpha inclusions were developed. Synthetic inclusions laying scheme in special specimens is shown in Fig.1.

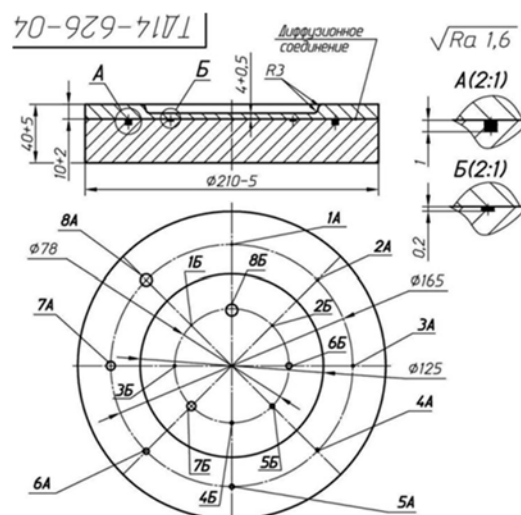


Fig.1 Synthetic inclusions laying scheme in special specimen

Method of obtaining hard alpha inclusions with required nitride concentration was also developed. Using these requirements special titanium specimens with known size of hard alpha inclusions were manufactured. Image of special specimen is shown in Fig.2. SHA sizes are shown in Table 1.



Fig.2 Special specimens containing synthetic hard alpha inclusions of given size

Table 1

Hard alpha inclusions								
D mm	0,5	1	1,5	2	3	4	6	8
№	1A	2A	3A	4A	5A	6A	7A	8A
№	1B	2B	3B	4B	5B	6B	7B	8B

Metallographic researches of individual specimens, which were produced by using developed technique, were carried out for SHA sizes attestation purpose. It is established that the deviation of the put initial SHA sizes from real sizes in produced specimens does not exceed 10%.

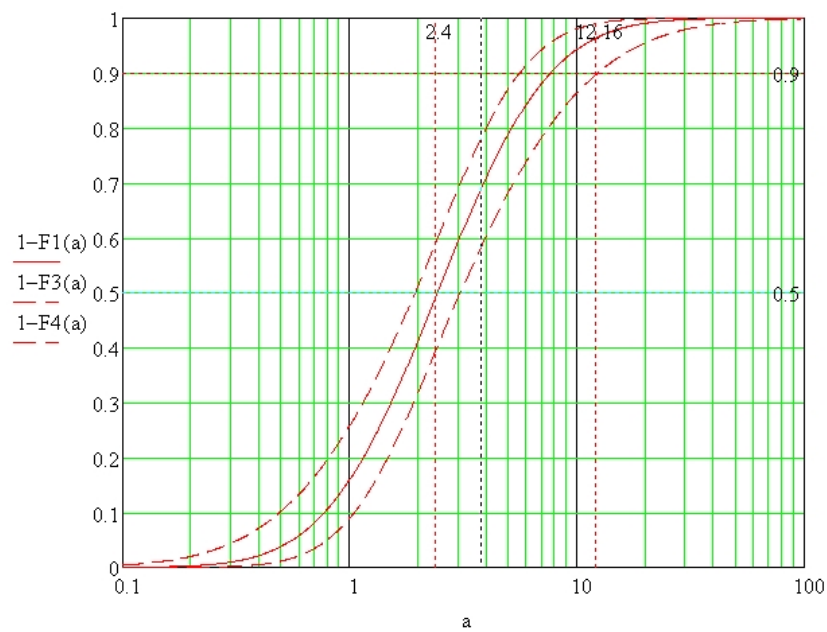
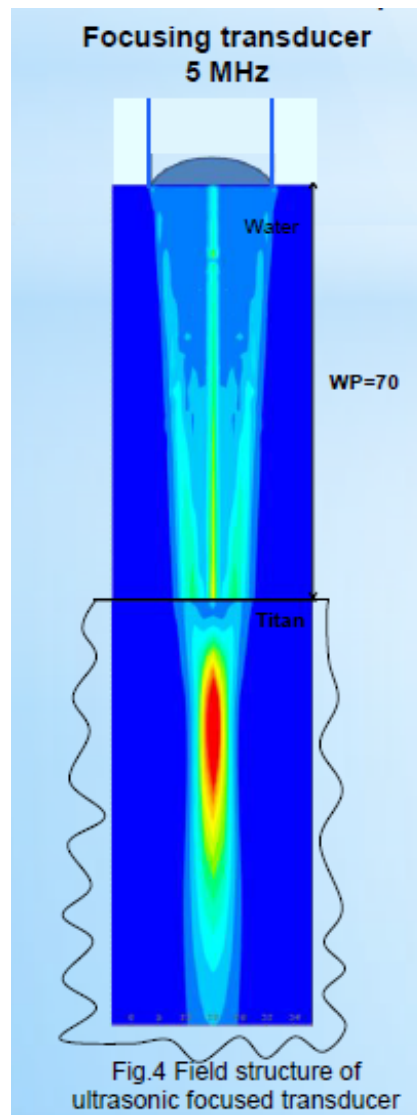
Further produced special specimens were inspected by different operators according to industrial manual of automated immersion UT inspection of titanium disks. Available places inspection was made by automatic ultrasonic immersion system ScanMaster LS-500 LP (Fig.3) with different wave types (longitudinal and shear) insertion using transducer with different frequencies. As a result of automated UT inspection statistic information about defects which were found or missed was collected.



Fig.3 Automatic ultrasonic equipment for specimens testing

Mathematical means based on MIL-HDBK-1823A algorithm was developed for processing of collected statistic data. Preliminary curves of defect detection versus its size were obtained with this mathematical means (Fig.4).

These curves are preliminary because of shortage experimental data for plotting real curves. It is expedient use mathematical modeling data to add an experimental data. Mathematical model simulating automated UT inspection processes is to consider different defects forms and orientation. Specialists of FSUE "VIAM" are working in this direction now. Field structure of ultrasonic focused transducer used at the field enterprises for titanium alloys semifinished parts on water-titanium interface is shown in Fig.5.



Conclusion

The last achievements of ultrasonic testing reliability and perspectives of experiment improvement for the appropriate data obtaining was shown in this paper.

POD Evaluation of automated ultrasonic detection of hard alpha inclusions in titanium alloys

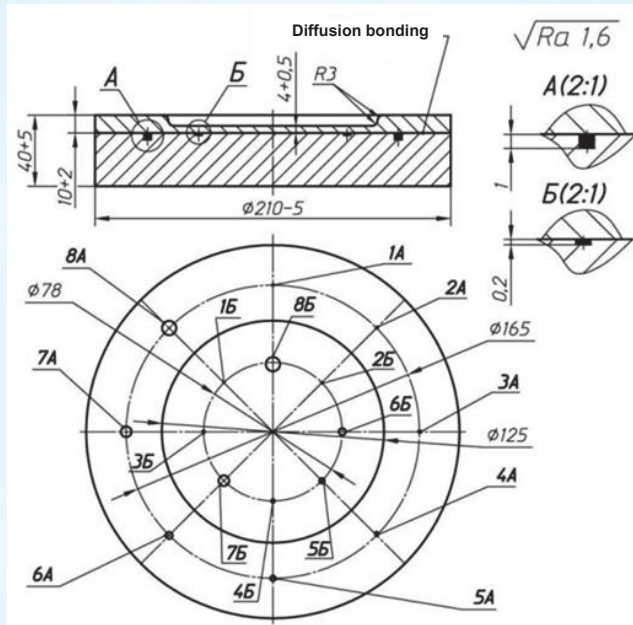


Fig.1 Synthetic inclusions laying scheme in special specimen

Special specimens with synthetic hard alpha inclusions of known sizes are designed and manufactured for the titanium alloys POD researching. Synthetic inclusions laying scheme in special specimens is shown in Fig.1. Image of special specimen is shown in Fig.2.



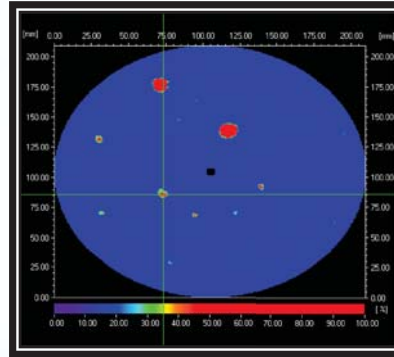
Fig.2 Special specimens containing synthetic hard alpha inclusions of given size

	Hard alpha inclusions							
D, mm	0,5	1	1,5	2	3	4	6	8
Nº	1A	2A	3A	4A	5A	6A	7A	8A
Nº	1B	2B	3B	4B	5B	6B	7B	8B

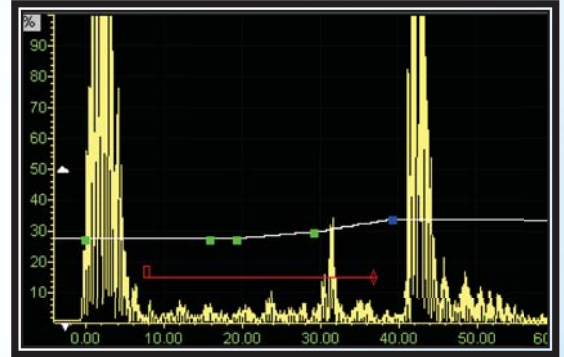
Specimens were tested by using NDT equipment and technique applying in aviation industry. Automatic ultrasonic immersion system ScanMaster LS-500 LP with 5 MHz spherical focused transducers (6" focal length in water) were used in the research.



Automatic ultrasonic equipment
for specimens testing



Testing results image (C-scan)



Testing results image (A-scan)

Testing results are analyzed by A-scan and C-scan by using specialized module.

Focusing transducer
5 MHz

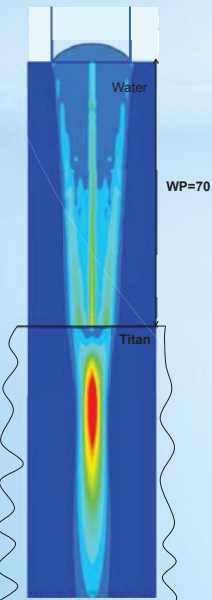


Fig.4 Field structure of
ultrasonic focused transducer

Mathematical technique based on MIL-HDBK-1823A (USA) algorithm was developed. Obtained testing data were processed by using developed mathematical technique and curve of defect detection versus its size is plotted. The curve shown in Fig.3 is preliminary and doesn't show a real situation. Synthetic hard alpha inclusions in special specimens have a favorable orientation relative to ultrasonic wave propagation.

It is expedient to use data of mathematical modeling in addition to experimental data. Various form and orientation of defects should be considered in mathematical model which simulate automatic ultrasonic testing processes. Specialists of FSUE "VIAM" are working in this direction now. Field structure of ultrasonic focused transducer used at the field enterprises for titanium alloys semifinished parts on water-titanium interface is shown in Fig.4.

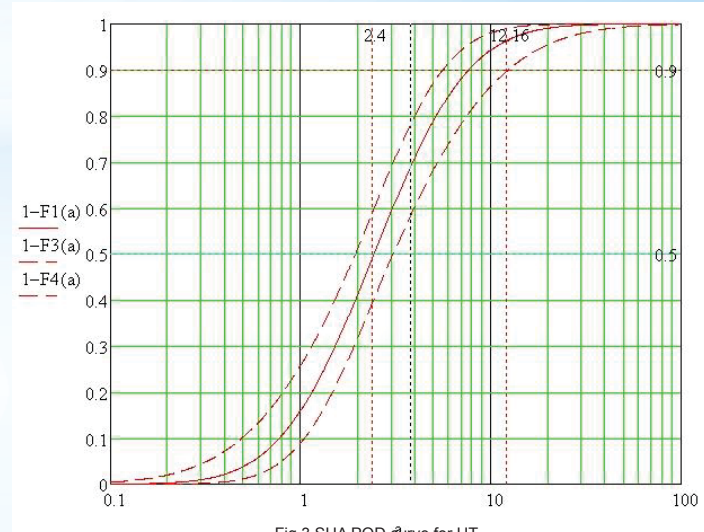


Fig.3 SHA POD curve for UT

Daria Lozhkova, Svetlana Trifonova, Mikhail Dalin

<http://www.viam.ru>

E-mail: admin@viam.ru

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