4.2.5. APPLICATION OF PULSE COMPRESSION TECHNIQUE IN AIR-COUPLED ULTRASONIC NON-DESTRUCTIVE TESTING ON COMPOSITE MATERIAL

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Ultrasonic immersion testing is a popular technique for the investigation of material; however, it can not be used in some materials which have special request in coupling liquid, where the material absorbs water, or where contamination or damage would result. Air-coupled ultrasonic testing adopts air as coupled medium, and then the request of testing mode to material can be satisfied. Air-coupled ultrasonic testing has severe signal attenuation and low signal-to-noise ratio, and it is worst in the composite material ultrasonic testing. Because of such problems, careful attention has to be given to improve system signal-to-noise ratio. Based on T.H. Gan's research, the signal-to-noise ratio and testing precision can be improved effectively by using pulse compression technique in the ultrasonic transducer excitation signal, and then ultrasonic testing on some special composite materials can be implemented.

The primary process of pulse compression technique can be implemented by driving ultrasonic transducer with a linear frequency-modulated signal, where the frequency is swept continuously over a pre-defined domain. And then pulse compression signal in time-domain can be acquired by the correlation of initial excitation signal and received signal. The position of ultrasonic signal in time axis can be denoted by the position of peak in pulse compression signal. System signal-to-noise ration has greatly improved, because noise signal in system usually was white noise and the correlated calculation was effective in this situation. Testing system hardware device included: RAM-5000 high power ultrasonic system from RITEC Ltd, point focus air-coupled ultrasonic transducer form ULTRAN group, AFG3102 arbitrary/function generator, TDS5034B digital oscillatory. The validity of pulse compression method is confirmed by this system, using through mode test carbon fiber composite plate. The increased accuracy of time measurement and signal-to-noise ratio leads to the testing of micro defect can be accomplished easily. Window function is acted to the frequency modulation excitation signal, which is based on transducer frequency characteristic, and the frequency characteristic of excitation signal would be consistent to transducer, corresponding better experiment result has gotten in practical application.

The analysis of experiment result indicated that, broadband ultrasonic transducer has better testing effect, because bigger time-bandwidth product can be adopted. Big time-bandwidth product can be gotten by increasing time width and transducer bandwidth is fixedly, but the result analysis would be hardly possible to be accomplished when material thickness is very small, because the duration time of excitation signal is very long. Therefore, time width must be smaller as possible, and system signal-to-noise ratio would be consistently reduced. The application domain of pulse compression method is restricted by the affect of reflect wave of air-solid interface layer, and the testing result on pitch/catch mode is difficult to analysis.

Theory analysis and the experiment results show that pulse compressing technique can greatly improve testing resolution, which is suitable for composite material air-coupled ultrasonic testing and other low signal-to-noise ratio application. Pulse compression is a potential ultrasonic transducers extraction technique.