

NDT Assignment

by Michael Cheeseman

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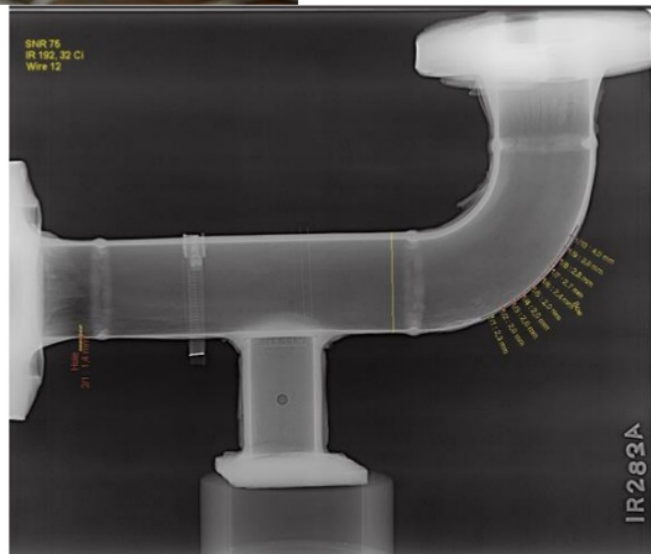
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ADVANCED STRESS AND FEA

Non-Destructive Testing Techniques



Michael Cheeseman (1707473)

1 Executive Summary

Non-Destructive Testing is a form of testing that is able to detect defects and abnormalities within a parts structure. With Industry NDT is constantly evolving not only to detect flaws within parts materials but to check for corrosion, wall thickness and to check electronic joints and components.

This report will go through a small introduction on what is Non-Destructive Testing before comparing NDT against Destructive Testing (DT) where the Non-Destructive Testing has a few advantages against Destructive Testing such as it doesn't destroy the test part and that it can be performed on full assemblies. This report will then look into three NDT methods which are Ultrasonic, Radiographic and magnetic particle inspection and will discuss the following five parts.

1. The scientific principles for each method.
2. Advantages and disadvantages of each method.
3. Any potential sources of error and if there are any assumptions that need to be made.
4. Typical applications that use this technique.
5. Explain how the results of this NDT can be used to improve stress analysis

5. Structure (+)

Within the three testing methods the report will focus on the typical applications of each method and how they are able to improve stress analysis. This report will be concluded with a small conclusion of each testing method as well as a conclusion of NDT against DT.

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5. Presentation(+)

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3 Introduction

3.1 Non-Destructive Testing

Non-destructive testing or NDT is a procedure used by engineers and technicians to be able to detect defects within materials and structures. This process can be completed at any stage of the materials life whether it is during manufacturing or while it is in service. For conducting NDT there are numerous methods available the most typical are "ultrasonic, radiography, magnetic particle, eddy current, dye penetrant and visual methods" according to (Smith, 2015) and supported by (Mix, 2005). This report will be looking into to three of these methods, these are ultrasonic, radiography, magnetic particle inspection.

The use of Non-destructive testing is used throughout the world in many different sectors of engineering and manufacturing to be able to determine damage or defects within parts, raw materials or even structures (NDT Education, 2014) (Hull & John, 1988). According to (NDT Education, 2014) "there are more than 120,000 inspectors" all over the world conducting NDT Tests.

NDT is used by regulatory bodies as proof that industries are compliance with safety and other legislation that should be followed. Using NDT can reduce the amount of warranty claims as company can look for defects of finished product and replace or fix the issue. Anyone Performing any sort of NDT inspection should be "fully competent, trained and certificated in accordance with national and international standards" according to (NDT Education, 2014).

3.2 Non-Destructive Testing compared to Destructive Testing

Where NDT is non-destructive testing there are some companies who prefer destructive testing. Destructive Testing is where a part is taken by test engineers and put under various tests whether it is Environmental, Corrosion, fatigue, 5. Spelling(-) mechanical or stress testing to name a few. These tests are conducted to understand and analyse a parts operation whilst in the field (TWI Global, 2019). Below in table 1 shows a comparison of destructive testing compared to non-destructive testing according to the following (Aire & Chimezie, 2016), (Arooj & Yadav, 2017), (Raj, 2007) and (Gupta, 2018).

5. Colloquial(-)

Comparison of Destructive and Non-Destructive Testing	
Destructive Test Advantages	Non-Destructive Test Limitations
Tests usually simulate one of more service conditions. the results are direct and reliable.	Tests usually involve indirect measurements therefore the results and serviceability must be proved by other means.
Tests are usually measure the load for "failure, significant distortion or damage" (Aire & Chimezie, 2016) or the test can show the life of a product to failure under certan loading and environmental conditions.	"They do not usually measure load for failure or life to failure even indirectly" (Aire & Chimezie, 2016). They may, however, reveal damage of expose the mechanisms of failure.
There is a direct relationship between most destructive test measurements and the material properties being measured.	"Skilled judgement and test experience" (Raj, 2007) are usually required to interpret test results.
Destructive Test Limitations	Non-Destructive Test Advantages
Destructive tests are not conducted on parts in the field. As a part is not fit for purpose after testing.	Non-destructive tests may often be applied to parts in the field without interruption or service.
One test may only show a few desired properties which can cause multiple test being carried out which can cause multiple scraped parts.	Non-destructive tests need repeated checks of a given unit over a period of time. The reason is to be able to check for any damage, and if needed to plan preventative maintenance on the part.
With high cost of material or fabrication replacing the parts destroyed by testing maybe unjustifiable. It may not be feasible to make an adequate number of parts and variety of destructive test parts.	Acceptable parts of high cost of material or fabrication not lost in non-destructive testing.
Tests can be made on only a small percentage of the production batch. They may have little value when the properties vary unpredictably from part to part.	Tests can be made on every unit to be used in service if economically justified. This allows another form of quality check from part to part.
"Tests often cannot be made on complete production parts" (Aire & Chimezie, 2016). The tests are often limited to test pieces.	"Test may be made on the entire production part or in all critical regions of it" (Aire & Chimezie, 2016). Therefore, the results apply to the part as a whole.

4 Findings

4.1 Ultrasonic Method

4.1.1 Scientific principles

Ultrasonic Testing is a method of non-destructive testing that uses high frequency sound energy to conduct assessments and to take measurements on a piece of material. Ultrasonic testing can be used for flaw detection and evaluation, dimensional measurements, material characterization, according to (Smith, 2015) and (Mix, 2005). According to (NDT Education, 2014) normal "ultrasonic testing inspection system consists of several functional units" such as "a pulser, receiver, transducer, and display devices".

The way this system works is that a pulser sends a high voltage pulse to a transducer. This transducer changes the voltage into a high frequency ultrasonic pulse which is transmitted through the part or material. The sound energy passes through the material in the form of a wave. Either a second transducer is placed on to the part or the same transducer can be used to detect the energy waves reflected from through the part as shown in figure 1. The transducer sends the reflected wave energy via voltage to the receiver, from there the receiver is connected to a display showing the results of the wave. If there is a crack or flaw with in the material the wave form will be reflected back sooner than if it is reflective back from the edge of the material (NDT Education, 2014) (Hull & John, 1988). The information that is received can give an engineer or technician the location of the defect, the size and possibly the orientation, this information can be used for further investigation.

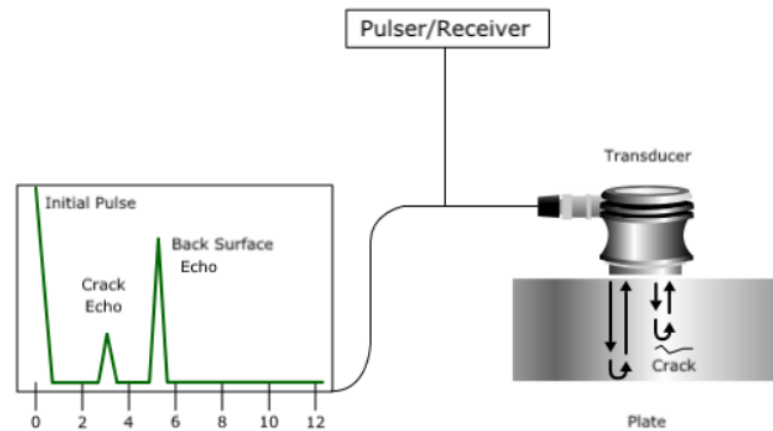


Figure 2: Block diagram of an ultrasonic test equipment (NDT Education, 2014)



4.1.2 Advantages and disadvantages

Some of the advantages of ultrasonic testing are the following:

- Ultrasonic is able to detect both surface and subsurface anomalies.
- Ultrasonic can analysis through thicker material for flaws or measurement is better than some other NDT methods.
- Only one side is needs be used when the “pulse-echo method” (Smith, 2015).
- It can be accurate in determining the position and estimating size and shape of abnormalities within a part
- Little need for part preparation before testing.
- Detailed images of the internal of the part can be produced with automated systems.
- It has other uses such as thickness measurement, in the addition to flaw detection.

As stated by (Smith, 2015) (Mix, 2005) (Blitz & Simpson, 1996) (Hull & John, 1988)

As with all NDT methods, ultrasonic testing has its limitations, which are the following:

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- Surface must be accessible to transmit ultrasound.
- Skill and training are more extensive than with some other methods.
- It normally requires a coupling medium to promote the transfer of sound energy into the test specimen.
- Materials that are rough, irregular in shape, very small, exceptionally thin or not homogeneous are difficult to inspect.
- Cast iron and other coarse-grained materials are difficult to inspect due to low sound transmission and high signal noise.
- Linear defects oriented parallel to the sound beam may go undetected.
- Reference standards are required for both equipment calibration and the characterization of flaws.

As stated by (Smith, 2015), (Mix, 2005), (Blitz & Simpson, 1996) and (Hull & John, 1988)

4.1.3 Potential sources of error and assumptions that need to be made.

According to (Ginzel, 1999) there are numerous potential sources of error such as equipment, parts and human error. With the sources of error from the equipment this can be instrument performance such as if the **5. Spelling(-)** hasn't been calibrated correctly. As every measurement system needs to be calibrated to be ensured that it is fit for purpose. The technician should assume once it has been calibrated that the equipment is work as designed to. For Ultrasonic testing the **2**

A very big potential source of error is that this system is heavily dependent on the person conducting the test to know what they are seeing on the results. Therefore, if the technician makes an error the error will be passed with the part. (Raj, 2007)

An assumption that is need to be made is that once a technician has been correctly trained to use the equipment then they could be deemed reliable to give the correct data for any conducted test. (Raj, 2007)

2. Geometry(-)

2. Waves(-)

4.1.4 Typical applications

One of the most widely used application of ultrasonic testing is weld testing, this is because when welding there are a lot of defects that can happen such “porosity, slag inclusions, lack of side-wall fusion, lack of inter-run fusion, lack of root penetration, undercutting, and longitudinal or transverse cracks” (Wermac, 2019). The use of ultrasonic testing has been greatly adopted for weld testing but it is also, used for testing raw material such as “bar, rods, sheets, pipes and rails” (Raj, 2007) to check for defects. Ultrasonic testing can be used to check the thickness of materials as if . Ultrasonic testing is being used to test and locate fatigue cracks and corrosion effects in parts in service of main industries such as metalworking suppliers and aerospace (Olympus, 2019) and (Hull & John, 1988) as shown in figure 3



Figure 3: Image of test technician performing ultrasonic NDT test on a helicopter tail (Olympus, 2019)

4.1.5 How the results of this NDT can be used to improve stress analysis.

The way that Ultrasonic Testing can improve stress analysis is that once the defect has been found, this method can work out the size of the defect, which will allow the second moment of area to be worked out. With the second moment of area of the abnormally found the

theoretical maximum stress can be worked out. This will show a clearer picture of what could happen to the part. Using Ultrasonic testing can be used to work out the internal stress of a component by the use of “acoustoelastic”. This is a linear relationship with the material stress and the velocity of the ultrasonic wave. (Europe PMC, 2016). Using this relationship, a value for the material stress can be calculated which will then intern give a known stress for any future loading condition of that material.

4.2 Radiographic Method

Good

4.2.1 The scientific principles behind the technique

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Radiography is one of the testing methods that is frequently used to test a materials volume, along with ultrasonic testing. Some materials, either because of their thickness or grain structure may be difficult to test with ultrasonic testing, it may also be the case such as in aerospace industry that visual record of the material structure is required (Smith, 2015).

The way that Radiographic testing works is that an enclosed test rig will produce a short-wave. This wave is normally X-ray or gamma wave which will be directed at the part. The Radiation will move through the material, if the radiation is strong enough for it to pass through the it can be captured on a photographic film. On this film the higher the density of the object the lighter the image will be but if the part has a low density the image will be darker due to more of the waves passing onto the film. This is how a abnormality can be seen in a part as through a constant part the image should be the same all the way through if a dark area is found there is an abnormality as it will have let more radiation through the part as shown in figure 4 (Raj, 2007) (Smith, 2015)

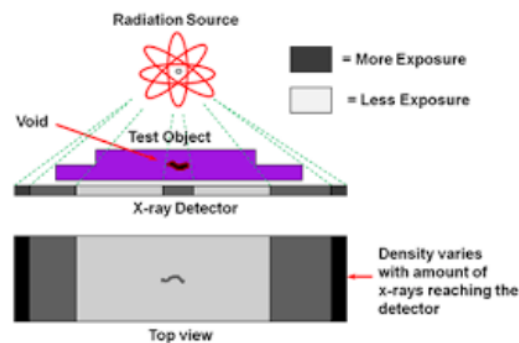


Figure 4: Radiographic Testing block diagram (Kalkars, 2016)

4.2.2 Advantages and disadvantages Advantages of industrial radiography

- Radiography can be used with most solid materials.
- Radiography has the ability to detect internal flaws.
- It can provided a permanent record of the test.
- It discloses fabrication errors and often indicates necessary corrective action.
- It reveals assembly errors.
- The fact that radiographic examination is being carried out improves the quality of the welding.

(Smith, 2015) (Mix, 2005)

Disadvantages of industrial radiography

- Radiography can only detect defects that are in a certain orientation.
- Radiography has difficulty detecting very small defects.
- It is impractical to examine parts of complex geometry.
- It requires two-sided access on the part.
- Radiography requires many safety considerations and obviously, if used incorrectly, can be extremely dangerous.
- Generally, radiography is a high-cost NDT method

(Blitz, 1997) (Mix, 2005) (NDT Education, 2014) (Smith, 2015)

4.2.3 Potential sources of error and assumptions that need to be made.

A potential source of error for radiographic testing the human factor of reading the result from the tests. Another source of error is the potential error of the source of radiation to the test part, as the further away the source is from the part the defect can be distorted. This can cause the defect to be obscured thus the measurement of the part can be wrong. The assumption needs to be made that the operator using the equipment should be trained to know exactly what to look for and how to read the results produced. Another source of error could be down to the machine, which should be calibrated with a standard brown unit with a know flaw to ensure that it is reading the same value.

4.2.4 Typical applications that use this technique.

Radiography is used to detect and inspect the “sub-surface volumetric defects” (Smith, 2015) this would include air gaps and shrinkages within both “ferrous and nonferrous alloys

as well as non-metallic materials and composites" (Raj, 2007). This technique is able to inspect castings and forgings to ensure there is no flaws with in the part. Radiography is used within many industries such as aerospace, Military defence, marine, power-gen, transport and manufacturing to name a few according to (TWI Global, 2019)The use of radiography is used with electronic industry to inspect semiconductor devices to check for cracks, broken solder joints, loose wiring and misplaced components. This method is also used to check sealed electronic components before they are physically tested (Renishaw, 2016) and (Raj, 2007).

4.2.5 Explain how the results of this NDT can be used to improve stress analysis

The way this radiography can improve stress analysis is like ultrasonic it can be used to find defects which can then be used for further analysis using max stresses and yield stress of materials. Radiography can be used to be used to determine the surface strain of a material using X-ray Diffraction. This method measures the "intercrystallite distance of a crystal structure according to Bragg's law" (Europe PMC, 2016). Method will only work when the part is underload.



4.3 Magnetic-particle Method

4.3.1 The scientific principles behind the technique.

Magnetic particle testing (MPT) is an NDT method in which a magnetic field is created in a component at and just below the surface of a ferrous alloy material. This method tests the surface and near surface of the material by passing a magnetic current through the material. Any obstructions to the surface, such as cracks, will produce a magnetic field this is called flux leakage. This will form around the obstruction this field can be highlighted by adding some "detection media" (Smith, 2015). The media will form around the flux leakage and show where the defect is. As shown in figure 5 bellow.

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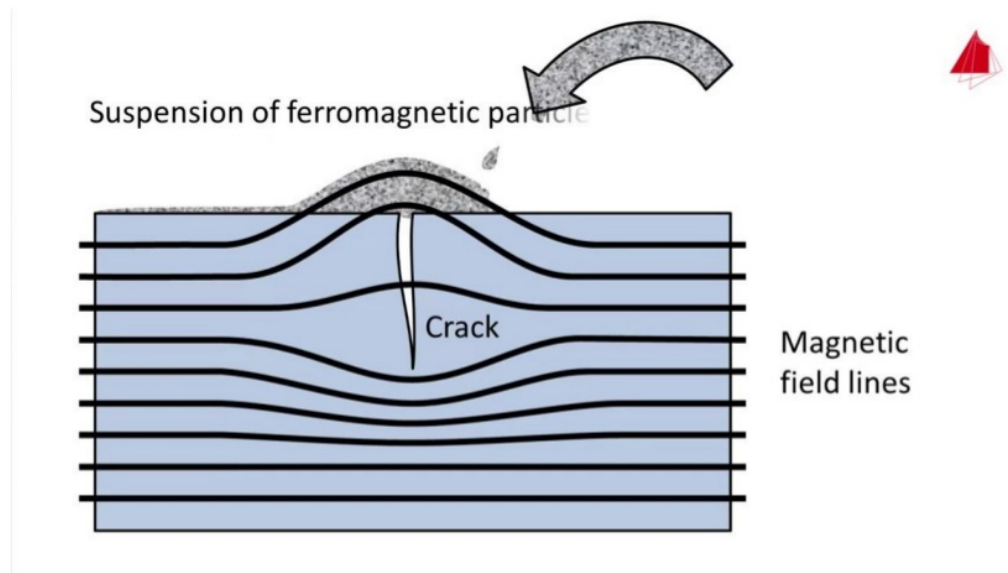


Figure 5: Diagram of MPT flux leakage (NDT Education, 2014)

4.3.2 Advantages and disadvantages of the technique.

The Advantages of magnetic particle testing are:

- Magnetic particle testing is a sensitive method for locating surface and slight sub-surface discontinuities in ferromagnetic materials.
- Indications are produced that can have very good definition of the actual discontinuity.
- The method is relatively simple to learn.
- Components of virtually any size or shape can be tested.
- Cracks which are filled with foreign material may still be detected.
- Discontinuities do not have to be surface-breaking like a crack, for example non-metallic inclusions may be located.
- The equipment Portable equipment can be used to test components in-situ, an electrical supply is not necessary in all cases.
- The method is very rapid. An indication of a discontinuity is formed virtually instantaneously.
- Testing is possible in some cases on painted or coated components.

5. Spelling(-)

According to (Smith, 2015) (NDT Education, 2014) (Raj, 2007) and (Mix, 2005)

The Disadvantages of magnetic particle testing are

- Only ferromagnetic parts can be tested.
- To ensure a part is fully tested, it is often necessary to apply two magnetic fields 90° apart in separate operations.
- Residual magnetic fields may be a slight risk to operators or other components.
- To magnetise a part high currents are used, which can cause arcing between the part and electrical contact, this can cause burning on the part. Thus leading to parts being scrapped.
- Post cleaning is usually required to remove residual consumables.
- Often the part will have been de-greased and cleaned prior to inspection, leaving the part susceptible to corrosion. Protection material is often required after testing.

(Smith, 2015) (NDT Education, 2014) (Raj, 2007) and (Mix, 2005)

4.3.3 Potential sources of error and assumptions that need to be made.

Potential Source of error with MPT is that if the part is not properly cleaned for the test, it could cause contamination with the detection media and cause the result to be hard to see. This method relies on the person conducting the test to find any error visually. The rig needs to be calibrated to ensure that it is detecting defects.

4.3.4 Typical applications that use this technique.

MPT is used to inspect a variety of products including castings, forgings, and weldments. Many different industries use this method for determining a component's fitness-for-use. Some examples of industries that use MPT are the "structural steel, automotive, petrochemical, power generation, and aerospace industries" according to (NDT Education, 2014). MPT is used on the offshore rigs to test items such as the structures and the underwater pipelines for any defects.

Magnetic particle testing (MPT) is widely used in industry for quality control over a few areas of the process from receiving goods, to in process testing, to final quality inspection of manufactured components. MPT can be used to inspect the parts whilst in service for maintenance in some transportation industries as well as on some plant and machinery. If an abnormality is found and can be repaired it could potentially save a company both time and money according to (Smith, 2015)

4.3.5 Explain how the results of this NDT can be used to improve stress analysis

MPT doesn't improve stress analysis as it is only a detection method, to find abnormalities with the surface of a part. Once an abnormality has been found it will need to be tested by other forms of NDT to find how significant the defect is can then be tested by other means to determine if the stress

5 Conclusion

DT Compared to NDT

Destruction Testing is an ideal technique for component verification if there is suitable time and money. However, the process is without its limitations; The technique permanently damages the component, which is costly and wasteful. Therefore, DT cannot be used on in-service components or assets which require future use. This is why Non-Destructive testing is a preferred inspection technique, as it enables the operator to check for defects in the absence of destruction and has the ability to be carried out on all in-service components without any lasting damage to the component or disruption to production.

Ultrasonic

Ultrasonic testing has been adapted for many applications in and out of industry. The method provides quantitative data on component integrity and reliability, which aids in asset downtime and maintenance costs. The process, however, requires an in depth understanding of ultrasonic testing and its capabilities, which requires extensive training. Although the process has high cost concerns attached to it, the information retrieved by ultrasonic testing can provide data on the internal and external stresses associated with certain components.

Radiographic

Radiographic testing has been altered over the years to be able to perform a range of applications within many industries. This method can not only check for defects it can see if there are components missing from an assembly. This method is a high cost method due to the equipment and training needed to conduct the testing. This method is able to find flaws within a part including surface cracks to subsurface deformities. The data gathered from radiographic testing can provide information on the internal and external stresses for components and assemblies.

Magnetic Particle Testing

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Magnetic particle testing is utilised for the inspection of ferromagnetic components. The technique investigates the presence of surface and slight sub-surface discontinuities. Magnetic particle testing can be undertaken during the manufacturing process of a component or utilised for regular maintenance checks, to ensure the asset conforms to its designed structural integrity. The technique, however, cannot be utilised for the detection and analysis of internal or external stresses within a component.

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NDT Assignment

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

66/100

PAGE 1

PAGE 2

QM

5. Structure (+)

Good explicit structure that clearly addresses the brief.

PAGE 3

QM

5. Presentation(+)

Generally your presentation is good

PAGE 4

PAGE 5

QM

5. Spelling(-)

Watch your spelling

QM

5. Colloquial(-)

This should be a professional presented report, do not use colloquial language

PAGE 6

PAGE 7

QM

5. Formatting



Comment 1

Fig 1?

QM

5. Spelling(-)

Watch your spelling



Comment 2

?

QM

2. Geometry(-)

What about the geometry of the part and how this influences the Time of Flight of the signal?

QM

2. Waves(-)

You have not discussed the types of waves that are introduced into the part (Longitudinal and shear waves)

QM

Good

QM

5. Spelling(-)

Watch your spelling



Comment 3

It is not clear why you would use this over UT

QM

5. Spelling(-)

Watch your spelling



5. Spelling(-)

Watch your spelling



5. Spelling(-)

Watch your spelling



Improving MoM

Generally NDT can be used to find defects within a part. This helps stress analysis as these defects are assumed to be absent in most calculations. During Mechanics of Materials analysis, typically a certain cross section/stiffness/UTS is assumed - the presence of any defects will mean that these assumptions are incorrect and these nominal stresses need to be altered accordingly.

GRADING FORM: ADVANCED STRESS 1920 PT NDT

MICHAEL
CHEESEMAN

65.85

RESEARCH-INFORMED LITERATURE



16.5

KNOWLEDGE AND UNDERSTANDING



16.25

PRACTICAL APP



26.4

PROF PRAC



6.7