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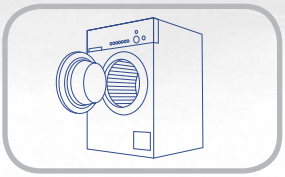
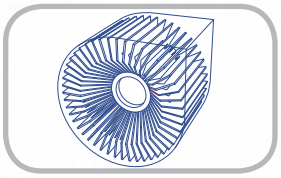
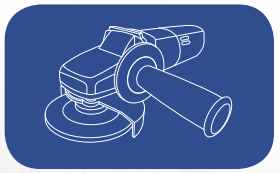
CURRENT STATE AND OPPORTUNITY

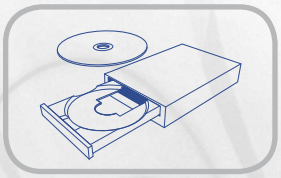
The XYO technology shows significant improvements in angle grinder performance during independent studies. Perpetual Industries wants to work with innovative power tool manufacturers to optimize and implement the XYO balancer in their product.

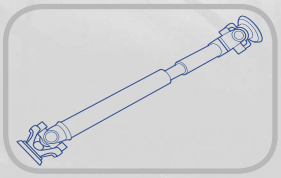
Contact us to see how your product can beat the competition using XYO

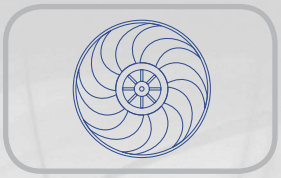


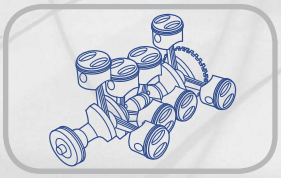


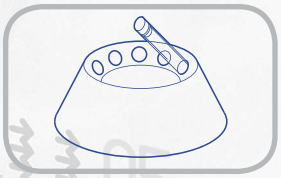












XYO PROTOTYPE BALANCER AS APPLIED TO ANGLE GRINDERS

General Summary Report

RESULT HIGHLIGHTS

The XYO balancer reduces vibration by compensating for variable mass imbalance during the operation of an angle grinder. Tests show that the XYO balancer has a significant impact on the performance of an angle grinder. Benefits of reduced vibrations include:

- Preventing vibration-related health issues
- Allowing longer product usage without discomfort
- Better wear life of grinding disks
- Greater warranty life of the product

Angle Grinder

Vibration Decreased by 63%

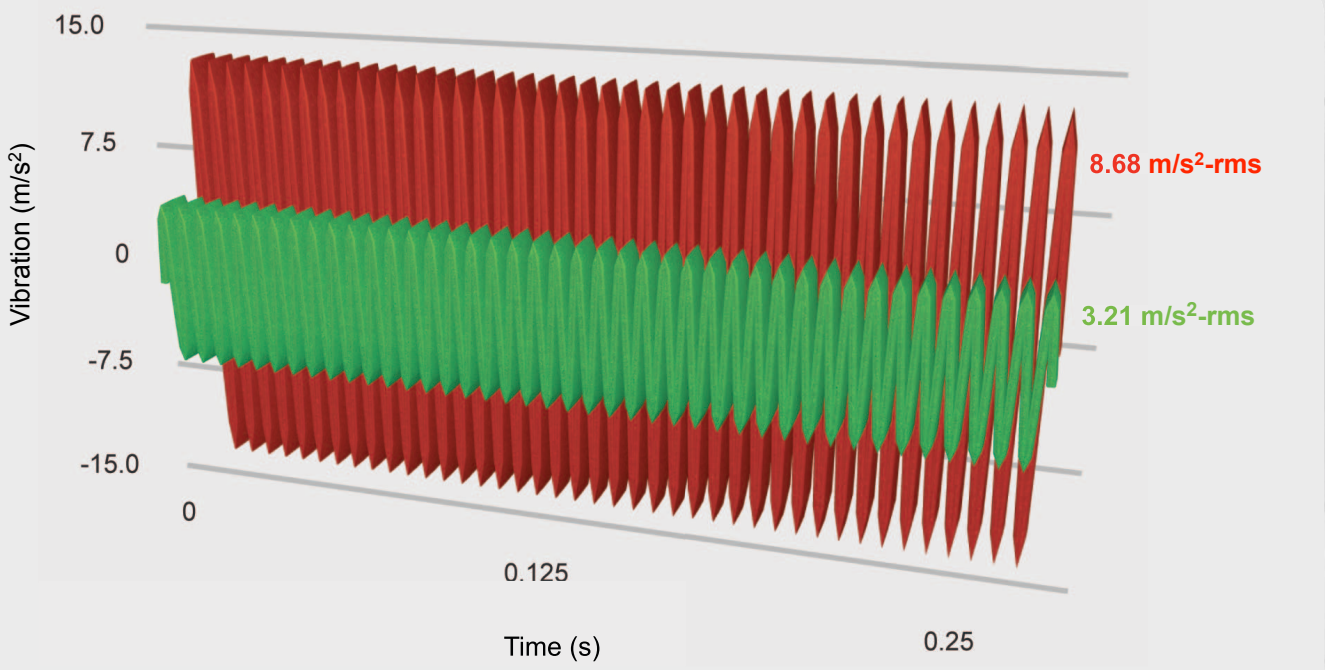


Figure 1. Impact of XYO on vibration of angle grinders

WITHOUT XYO **WITH XYO**

Note:

- **The results in this report are based on prototype XYO balancer designs for two different angle grinder models; another report is available specifically for a Rockwell angle grinder.**
- **While the results shown are significantly positive, it is possible to exceed and improve upon these results with further optimization.**
- **Perpetual Industries is looking for a capable and innovative partner that needs the competitive advantage that XYO can provide.**

INTRODUCTION

Power tools have been known to induce the risk of vibration-related diseases. An acute disease that is caused by regular exposure to hand-arm vibration (HAV) is known as white finger or Raynaud's disease. There are other vibration-related diseases such as: permanent and painful numbness and tingling in the hands and arms, painful joints and muscle weakening, damage to bones in the hands and arms.

Vibration issues have been an important topic in the power tool sector ever since the EU guideline 2002/44/EC where the employer can be held liable for vibration-induced injuries. Depending on the vibration value associated with a power tool the daily usage will be limited (Figure 2).

According the EU guideline, Figure 2 shows that a power tool can be used continuously if the vibration level is at 2.5 m/s^2-rms or less, while a power tool with a vibration level of 5.0 m/s^2-rms will be limited to 8 hours of usage.

Some factors that contribute to angle grinder vibration include:

- mass imbalance on the grinding disk
- alignment and meshing of the gears
- rigidity of the housing
- abrasive action of the grinding disk on the work piece

The main cause of vibration in an angle grinder is due to the changing mass imbalance of the grinding disk during operation (Figure 3).

Manufacturers have introduced anti-vibration handles and gloves to reduce the exposure to vibration. However, these methods do not cure the problem and most workers do not like the reduced precision when these anti-vibration methods are employed.

The XYO balancer can compensate for dynamic or static unbalanced forces during operation. As a result, the XYO balancer-equipped angle grinder will continue to provide consistent performance even when the mass imbalance varies due to wear of the grinding disk that is associated with typical use.

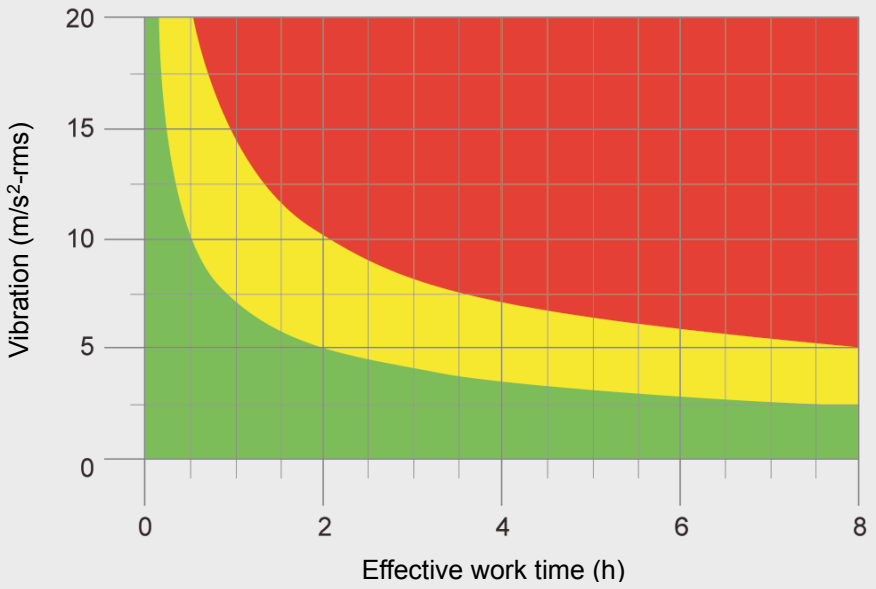


Figure 2. Effective work time versus vibration

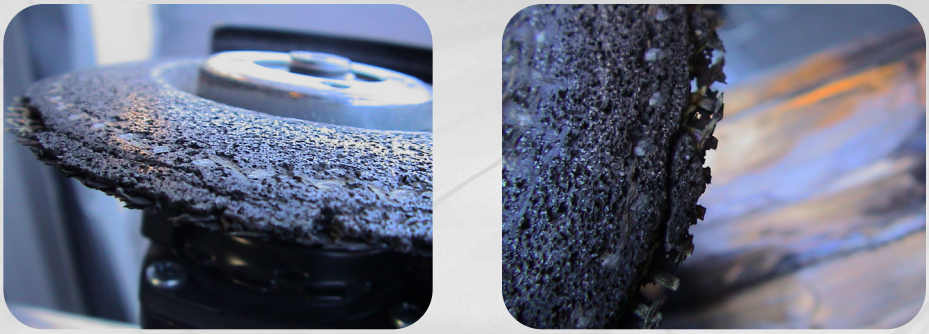


Figure 3. Mass imbalance of grinding disk

TEST OBJECTIVE

The objective of the test was to determine the impact that a prototype XYO balancer would have on reducing the vibration of angle grinders (Figure 4).

TEST OVERVIEW

Testing was performed on two different brands of angle grinder. Both grinders used 125 mm (5”) diameter disks. Four disks with different mass imbalances were used in the test:

- 58 g.mm
- 76 g.mm
- 90 g.mm
- 130 g.mm

Figure 5 shows test disks that were prepared in accordance with ISO 8662-4. The prototype XYO balancer was installed on the spindle, replacing the backing flange, as shown in Figure 6.

Vibration levels were tested with and without the prototype XYO balancer. Triaxial accelerometers were used to record the vibration measurements (Figure 7).

- **Grinder #1** - two triaxial accelerometers, located on the side handle and the body, were used to record vibration measurements. The mass imbalances used for tests were 90g.mm and 130g.mm.
- **Grinder #2** - one triaxial accelerometer, located on the head of the angle grinder, was used to measure vibration. The mass imbalances used for testing were 58g.mm, 76g.mm and 90g.mm.

See the “Appendix” for additional details of the testing procedures.

Figure 4. Sample angle grinder used for testing

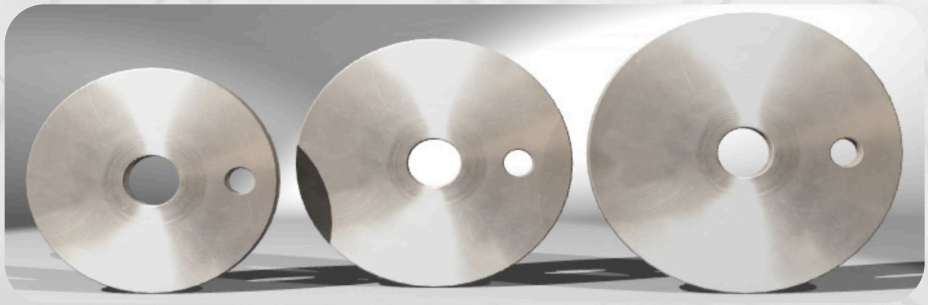


Figure 5. Aluminum ISO-8662-4 angle grinder test disks

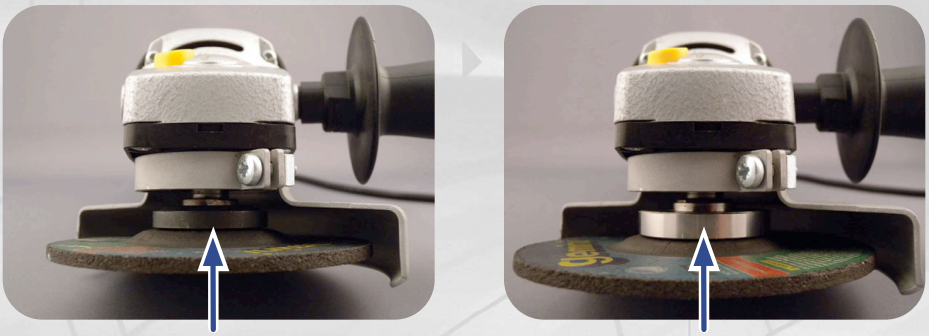


Figure 6. Angle grinder with original backing flange (left) and XYO balancer replacing the backing flange (right)

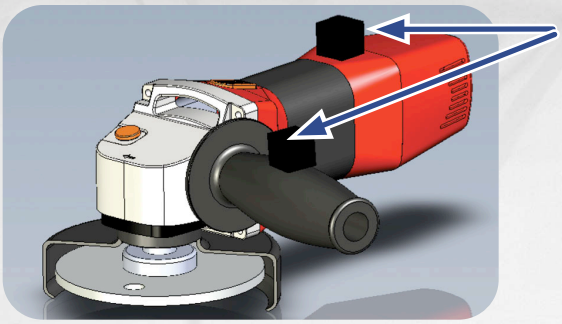


Figure 7. Location of accelerometers for Grinder #2

TEST RESULTS

Grinder #1

Vibration Decreased 51%

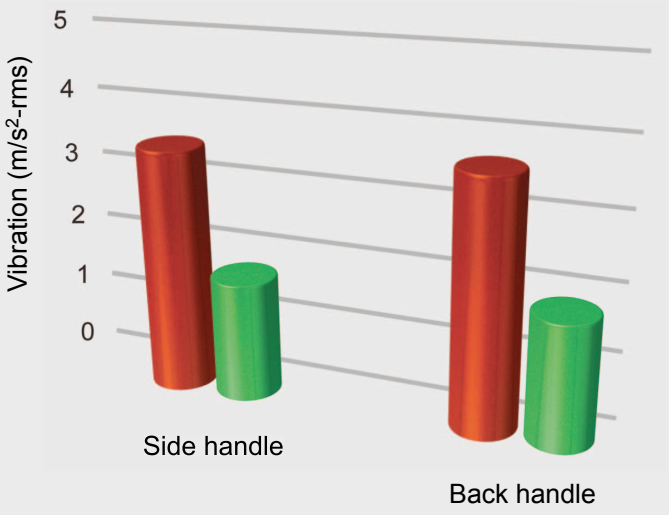


Figure 8. Impact of XYO on 3D vibration of Grinder #1 with a 90 g.mm imbalance

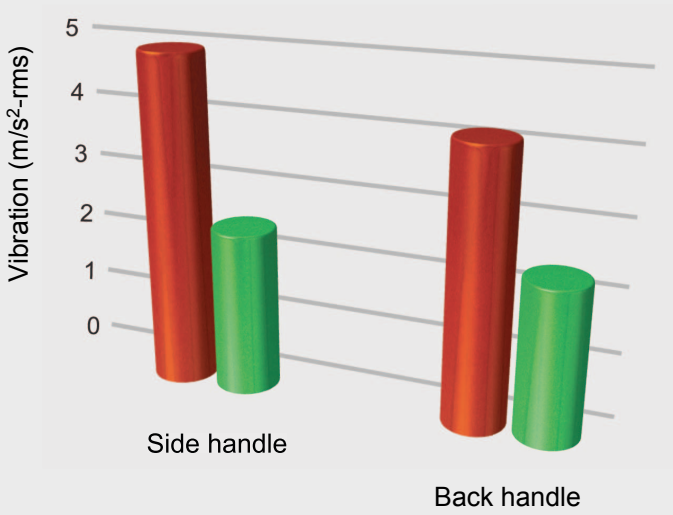


Figure 9. Impact of XYO on 3D vibration of Grinder #1 with a 130 g.mm imbalance

WITHOUT XYO WITH XYO

Table 1. Summary of vibration results for Grinder #1

MASS IMBALANCE	LOCATION	VIBRATION (m/s²-rms)								IMPROVEMENT (m/s²-rms)
		WITHOUT XYO				WITH XYO				
		X	Y	Z	3D*	X	Y	Z	3D*	
90	Side handle	1.71	2.42	1.90	3.52	0.70	1.22	1.00	1.73	1.79 (51%)
	Back handle	2.58	2.41	0.78	3.61	1.35	1.12	0.43	1.80	1.81 (50%)
130	Side handle	2.48	3.74	2.08	4.95	1.18	1.77	1.22	2.45	2.50 (51%)
	Back handle	2.58	2.90	1.36	4.11	1.56	1.52	0.76	2.31	1.80 (44%)

*3D = $\sqrt{(x^2 + y^2 + z^2)}$

Grinder #2

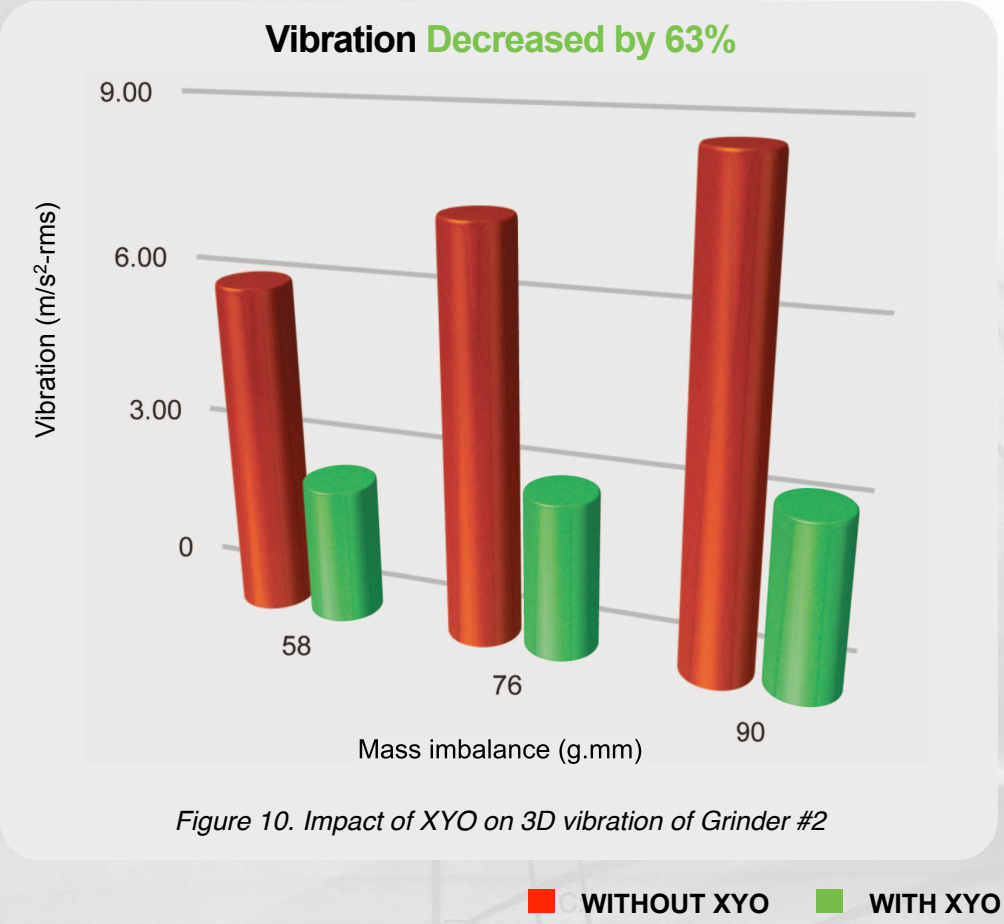


Figure 10. Impact of XYO on 3D vibration of Grinder #2

Table 2. Summary of vibration results for Grinder #2

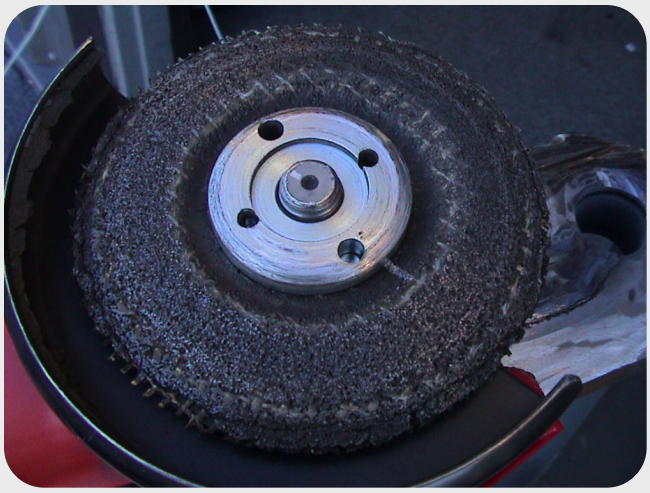
MASS IMBALANCE	VIBRATION (m/s²-rms)								IMPROVEMENT (m/s²-rms)
	WITHOUT XYO				WITH XYO				
	X	Y	Z	3D*	X	Y	Z	3D*	
58	4.53	2.45	3.06	6.01	1.38	1.46	1.50	2.51	3.50 (58%)
76	5.41	3.03	3.86	7.42	1.78	1.58	1.58	2.87	4.55 (61%)
90	6.48	3.54	4.55	8.68	2.07	1.72	1.73	3.21	5.48 (63%)

*3D = $\sqrt{(x^2 + y^2 + z^2)}$

Disk Wear and Examination

As part of the life cycle testing, photographs were taken of the grinding disks at the start and end of the test cycle as well as at the end of every 25 runs to record disk wear. Figure 11 shows the disk on the left (without XYO) displayed more wear than the disk on the right (with XYO). Based on this amount of disk wear, it is estimated that **disks will last three to four times longer** for an angle grinder **with XYO**.

Without XYO Balancer



With XYO Balancer

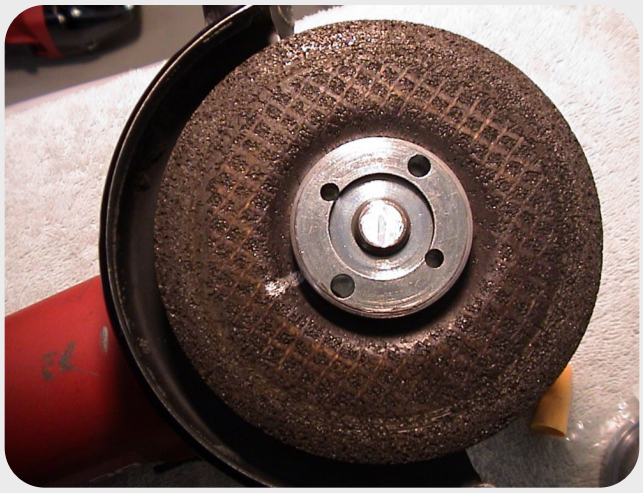
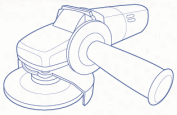


Figure 11. Comparison of wear of grinding disk



FINDINGS AND CONCLUSIONS

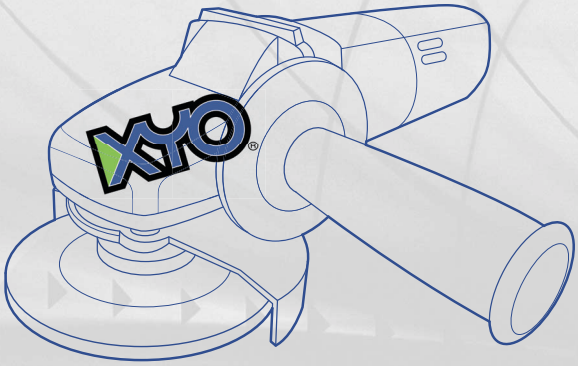
The XYO balancer can have a significant impact on vibration of angle grinders. The XYO balancer can provide the following benefits:

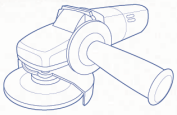
- Reduced risk of vibration-related diseases and ailments
- Limiting vibration exposure increases the angle grinder's continuous usage periods without causing discomfort to the tool operator
- Wear life of grinding disks is increased by a significant margin
- Wear and tear will be mitigated and warranty periods can be extended
- Smoother operation of grinder provides more accuracy

Perpetual Industries wants to work with a capable and innovative angle grinder manufacturer to optimize and implement the XYO technology and provide a strong competitive advantage in the market.

Impact of XYO:

- **63% vibration reduction**
- **Reduced risk of vibration-related diseases**
- **Increased angle grinder usage without causing discomfort**
- **Extended life of angle grinder & disks**
- **More accuracy when grinding**





APPENDIX – TEST DESIGN

ISO Tests:

ISO TESTS PROCEDURE

1. The angle grinder was fitted with Kistler accelerometers affixed to the handle and grip as specified in ISO-8662-4. The accelerometers were powered by a Kistler 5143 power supply and connected to a NI4472 Data Acquisition Card. Proprietary software was used to capture a vibration reading for 8 seconds.
2. The ISO specified test disks were prepared for use in the testing. These were manufactured with imbalances of 58, 76, and 90 g.mm.
3. The imbalance holes in the disks were used as an orientation mark. The imbalance hole was aligned with the orientation mark on the arbour. Each disk was locked to the angle grinder using the stock locking ring.
4. The angle grinder was attached to a harness as specified in ISO-8662-4 which was weighted to produce a simulated feed force of 40 newtons.
5. Each disk was tested as follows:
    a. 5 test runs with the orientation hole in the 0° position relative to the arbour.
    b. 5 test runs with the orientation hole in the 90° position relative to the arbour.
    c. 5 test runs with the orientation hole in the 180° position relative to the arbour.
    d. 5 test runs with the orientation hole in the 270° position relative to the arbour.
    e. The above testing procedure was performed on each of three ISO test disks.
6. Tests were performed using a 67 g.mm balancer, as well as an angle grinder without a balancer.

Test Harness

In accordance with ISO-8662-4, a test harness was constructed to provide 40 Newtons of simulated feed force on the angle grinder during testing.

The harness consisted of a wire attachment fixed to the angle grinder above the grinding wheel (Figure 12), a cable looped through two pullers, and a free weight that was selected to equal the mass of the grinder, plus sufficient weight to simulate the required feed force.

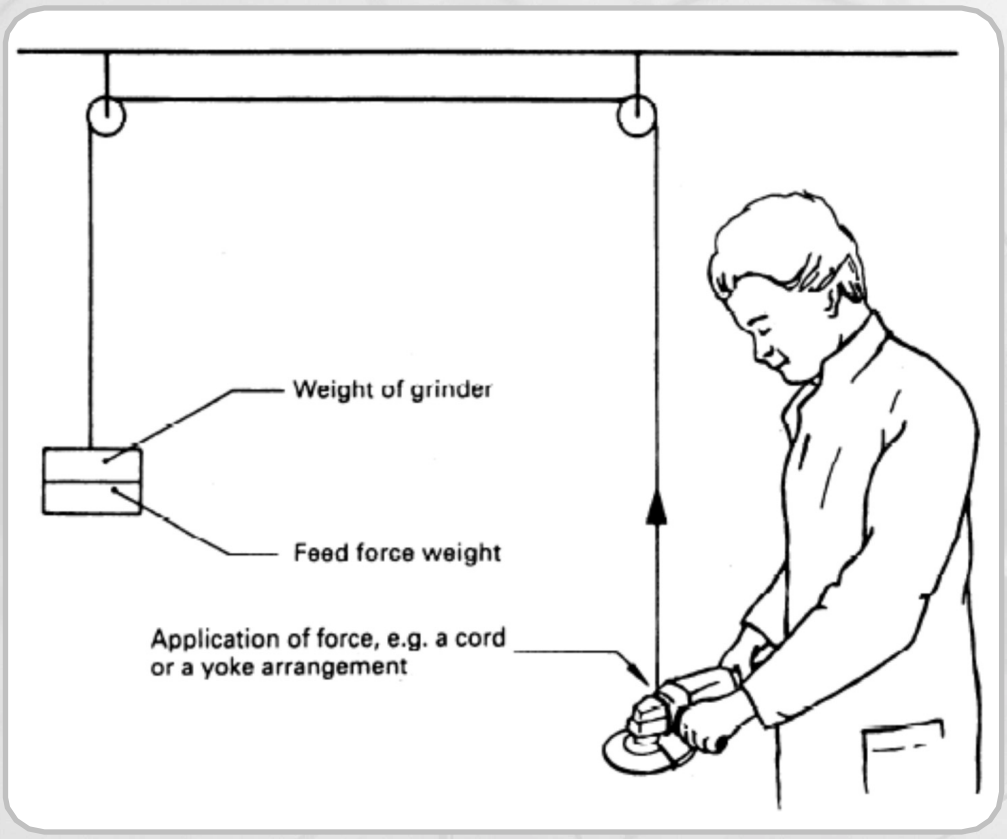


Figure 12. ISO 8662-4 test harness schematic