

University of Southern Queensland

Faculty of Health, Engineering and Sciences

Improvement of Production of Double Disc Planters

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Abstract

Norseman Machinery is an agricultural manufacturing company based in Edgeroi, New South Wales and Toowoomba, Queensland. Originally focussed on importing John Deer and Kinze machinery, they transitioned to manufacturing planters based on the brands they imported. Their main product is the Techniplant, a double disc precision planter used for row crop and broadacre farming.

Norseman is a farmer owned business and does not employ any engineers. Their products have been developed through the replication of existing machines, and trial and error. No engineering or holistic overview has been applied in their development and therefore, many issues have seeped into the design, wasting time and money. This project aims to solve these issues.

A new workshop layout was created that increased the amount of storage space available, reorganised current storage to prioritise important components, improve the access to and working conditions in the component assembly area, and streamline the workflow through the workshop.

Norseman's production processes were analysed and recommendations were made towards their improvement. The main focus of the new production plan was the stores department, as it was found to be the main source of inefficiencies and bottlenecks. The new plan is aimed to improve productivity and efficiency by ensuring sufficient stock levels, predicting accurate lead times, reducing travel times and overhauling the computer stock system.

The majority of this project involved the redesign of a number of components for Norseman's main product line. The new parts are stronger, simpler, easier to assemble and more suitable to handle the rough conditions of Australian farming. An emphasis was placed on finding Australian suppliers and increasing support for local manufacturing.

The research is supported by Norseman Machinery and the findings will be implemented next year in order to improve the productivity of their business.

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1 Project Aims

1.1 A Brief Introduction

Norseman is a manufacturer of agricultural machinery based in Edgeroi, New South Wales and Toowoomba, Queensland. Their main product is the Techniplant, a double disc precision planter. Planters are used for grains and legumes such as sorghum, corn and soybean. Double disc precision planters represent the high end of the planter market and are used in row crop and broadacre applications where precision is paramount.

As their name suggests, double disc planters use two steel discs, offset at an angle, to form a furrow into which a seed is placed via a seed tube. The depth of the seed is set by gauge wheels mounted on either side of the discs. Once the seed is in the ground, the furrow is closed over by a set of press wheels. The whole assembly (row unit) is attached to the toolbar by a parallelogram mount. (J R Murray, 2006) Norseman is currently facing issues with the quality of some of their components. The known problems include warping and cracking of castings, inaccurate machining and inconsistent pressing. Whenever these issues arise, production slows down while problematic components are reworked. The end result of these issues are wasted product, high manufacturing cost, production delays and missed delivery dates. This has negatively affected the business significantly, resulting in lost profits and a tarnished reputation.

The first half of this project will look at improving the manufacturing processes involved at the Toowoomba facility. The second half will involve a redesign of the current machine, fixing the aforementioned issues as well as optimising the design to improve production efficiency.



Figure 1 - 18 Row Norseman planter

1.2 Aims, Objectives and Scope

The aim of this project is to provide Norseman with an improved design and process that will save time and money, thereby increasing productivity and profitability. This new design and process will be implemented and tested from mid-2016 onwards.

The original idea was a complete redesign resulting in a new product, but due to the prohibitively high initial costs, the same product line was kept. Norseman's general manager, Michael Freeman, has specified that the new model should keep as many of the old components as possible in order to reduce setup costs. Therefore, this project will be aimed at resolving existing issues and design simplification.

The second portion of this project is process optimisation. Automation is not currently viable and Norseman is unable to fund any new infrastructure, so this portion of the project is limited to using the existing facilities and infrastructure. The main focus will be reworking the stores department to reduce bottlenecks, delays and misplaced stock.



Figure 2 - Techniplant unit

1.3 Expected Outcomes and Benefits

This project is designed to increase Norseman's productivity and profitability by reducing waste and rework.

The current time taken to assemble a row unit is 4-6 hours. If the unit shank is found to be faulty, the unit must be disassembled and the shank cut, rewelded and powder-coated. This blows the manufacturing time out significantly. The desired outcome of this project is to reduce that time to one hour.

The row unit shanks are made of ten pressed steel plates, welded together. Each of those pressing operations will be assessed and if possible, improved. New pressing dies will be designed to replace the existing ones, as they are worn out and no longer accurate. The inaccuracy of the pressing and welding has resulted in vast amounts of time wasted through rework so it is expected that significant gains will be made in this area.

Currently, the stores department is responsible for most of the delays and bottlenecks in production. This happens through components being understocked, work orders not being picked up and finished parts being stored incorrectly or lost. This project will provide a new workshop layout with improved storage, and a new stores system to ensure parts are always on hand when they are needed.



Figure 3 - 12 Row Wingfold

2 Literature Review

A literature review was performed to gather information on:

- Workshop layout optimisation
- Planting technology

This information was used to further refine the idea behind this research project.

2.1 Workshop Layout

According to KJ Singh (2010), the purpose of layout optimisation is to best utilise the available space in a workshop. By optimising layout, productivity can be increased and delays and double handling decreased. The foremost authority on the topic was Richard Muther, who came up with the six basic principles of best layout. (Chand, 2010)

1. Principle of Overall Integration
 - Take all factors (workers, machinery, raw materials, etc.) into account and find the best solution for all of them.
2. Principle of Minimum Distance
 - Reduce the distance travelled by workers and materials.
3. Principle of Flow
 - Arrange workstations in the order that parts are built.
4. Principle of Cubic Space Utilization
 - Store parts in appropriately sized locations.
5. Principle of Satisfaction and Safety
 - Consider the satisfaction and safety of workers.
6. Principle of Flexibility
 - Arrange the workshop in a way that can produce a variety of products and adapt to any product changes

The benefits of arranging a workshop according to these principles were detailed by Smitri Chand (2010)

- Increased production
- Reduced labour
- Reduced travel time
- Tighter control over production planning
- Reduced handling
- Improved safety
- Better working conditions

The information above was applied to the new layout of Norseman's Toowoomba facility, within the constraints set by management.

2.2 Planting Technology

2.2.1 Basic Principles

The first step toward a successful harvest is successful sowing. Ashworth, Desbiolles and Tola (2010) define the function on a planter (or seeder) as “to uniformly place seeds and fertiliser in the ground and manipulate the soil’s physical condition near the seed zone and surface residue so as to secure the maximum crop emergence and early vigour”. Simply put, the functions of a planter are:

1. Cut furrow to consistent depth
2. Place seed in the bottom of the trench
3. Cover furrow and firm soil

The two main classes of planter are tyne and disc. Tyne machines were first developed in the 18th century and work on the rip-bust-tear method. This method causes significant soil disruption, large draft requirements and slower operating speeds because the tyne has to be dragged through the soil.



Figure 4 - Boss Stump Jump Tyne Planter Row Unit

Disc planters utilise one, two or three discs to slice through the soil, resulting in reduced soil disruption, lower draft requirements and allowing higher operating speeds. They were developed as part of the push for no-till (or zero-till) agriculture that has taken place in the past 50 years. This push came about due to concerns about unsustainable farming techniques and their contribution to soil erosion, escalating infertility and chronic moisture loss. (Ashworth M, 2010) No-till practices focus on reducing soil disturbance and compaction, and increasing residue retention, through reduced tillage, crop rotation and controlled traffic farming (CTF).

A brief review of disc seeding technology follows, with a focus on double disc precision planters.

2.3 Single Disc

Single Disc openers utilise one disc in either a “vertical disc with sweep angle” or “tilted disc with sweep angle”. Sweep is defined as the angle off the direction of travel, while tilt is defined as the angle off vertical. (Ashworth M, 2010) Both types use a seed boot hidden in the shadow of the disc, that can also act as a mud scraper. Some models, such as those pictured below, set the seed depth by running a gauge wheel alongside the disc, while others rely on the depth of the toolbar. Models that are individually height adjustable are able to place seed more accurately and cope with undulating ground and changing soil conditions, than fixed height models.



Figure 5 - NDF SA650

Single disc units are commonly used to plant winter cereal crops and are best suited to applications requiring deeper planting depth as they can plant deeper and require less downforce than double discs. They are more suited to gravelly soils as they require more friction to drive the discs and tend

to bulldoze through soft soils. Currently, there is only one parallelogram mounted single disc opener on the market, the Boss SX25P. All other models are pivot mounted, and lack accurate depth adjustment due to the changing angles inherent in pivoting systems. Also, because of the seed boot's proximity to the opening disc, the seed can catch on the disc as it rotates, causing seed bounce and inaccurate placement. Single disc openers do tend to be cheaper, have less parts and bigger bearings than double disc openers. While single disc openers do have benefits, they lack the ability to place seed precisely enough for modern no-tillage applications. (Freeman, MR 2016 pers. comm., 7 September).



Figure 6 - Boss SX25 Row Unit



Figure 7 - Austil MT2500 Row Unit

2.4 Double Disc

Double disc openers utilise two discs in a mirrored tilt and sweep configuration. Seed placement is via a seed tube that sits between the discs and locates the seed directly into the bottom of the furrow. Seed depth is controlled by gauge wheels on either side of the opening discs, linked to a central depth control. Furrow closing is by one or two press wheels at the rear of the unit. Typical applications include summer crops such as sorghum, cotton and corn. Double disc units require very low draft and cause little disturbance, making them the most suited to no-till applications. Accurate seed placement and fine depth adjust are also possible, due to parallelogram mounting and smooth operation. Because of the tilt and sweep angles of the discs, they tend to try to ride out of the soil and therefore

require a large amount of down pressure to stay in the soil. This can cause the whole machine to float and cause tracking issues in the field. Additionally, because of the disc angle, seeding depth is limited to 100mm, and compaction occurs on the sidewall, hindering root growth. The extra weight of the units limits their application in light soils as they can sink in and bog down. Despite the extra weight and cost, double disc planters are the best choice for accurate, precise seed placement in most soils. (Smith DF 2016 pers. comm., 6 September)

2.4.1 Existing Double Disc Planters

The John Deere MaxEmerge (shown in figure 8) is arguably the leader in the field. There are many similarities between the MaxEmerge and the Techniplant, which is no coincidence because the shank of the Techniplant is modelled off the MaxEmerge. The main difference is that unlike any other manufacturer, the John Deere shank is cast rather than fabricated. John Deere machines come with the option of a central seed distribution, a feature which is highly desirable for farmers, but non-existent on most planter brands, including Norseman. (Deere, 2015)

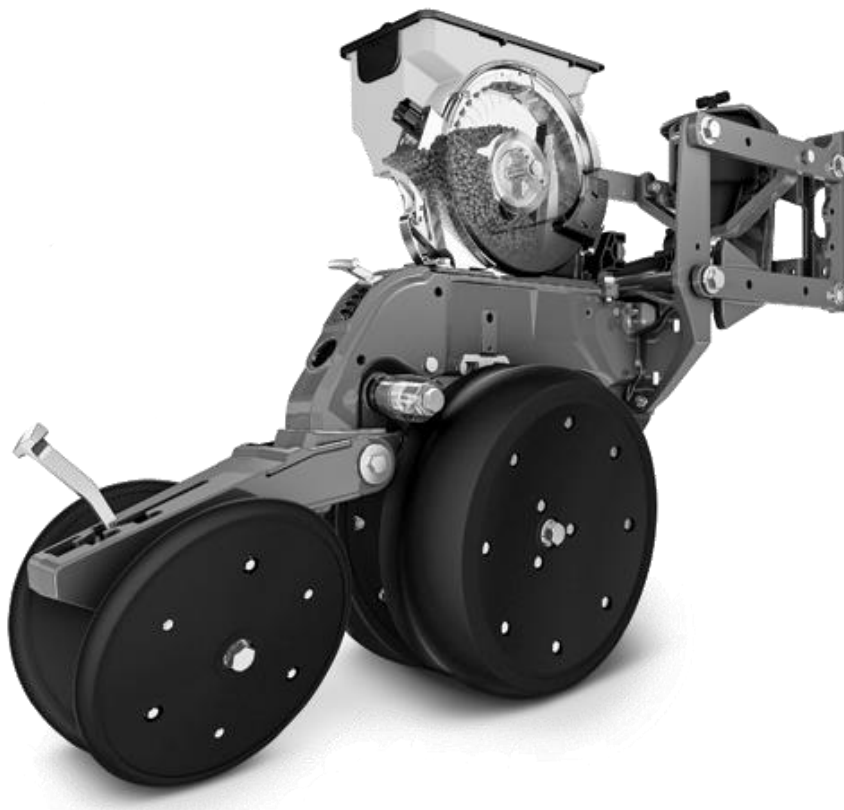


Figure 8 - John Deere MaxEmerge 5

Kinze is an American manufacturer that was established fifty years ago. Norseman had their start importing Kinze planters before moving to manufacturing. The first Norseman units were Kinze clones and some features were carried over to the Techniplant. The current parallelogram setup and the

press wheel assembly are still identical to Kinze's. As the two machines are so similar, there may not be much to be learned from the Kinze planter. (Kinze, 2015)



Figure 9 - Kinze 3000 series. Note similarity to Norseman row unit

Excel is a Toowoomba based company owned by the Brisbane based Great Western Corporation. Their unit, the SP200 (shown in figure 10), whilst being able to fit John Deere and Kinze hoppers and meters, it is a vastly different design. The shank is much simpler and the gauge wheel arms pivot from the front. The gauge wheels and arms are fabricated instead of cast. (Excel, 2015)



Figure 10 - Excel Ag SP200

Boss Engineering, based in Inverell, NSW, has only been manufacturing agricultural machinery for four years, but has managed to firmly secure their place in the marketplace. Their DX-50 planter is similar to the Excel SP200 in that it is mostly fabricated and has front pivoting wheel arms, but differs in the way the parallelogram is mounted. (Boss, 2014)



Figure 11 - Boss DX50 Row Unit

3 The Norseman Techniplant



Figure 12 Norseman Techniplant III Row Unit

Norseman had their start in manufacturing in 1992 when they started making toolbars for imported Kinze units. In 1997 they moved their manufacturing facilities to Toowoomba and started making a clone of the Kinze row unit. Five years later, they started manufacturing the Techniplant row unit (figure 12). It was a new design, but borrowed heavily from the Kinze and John Deere Row units. The current model, the Techniplant III, still borrows from the Kinze design, but is far more suited to Australian conditions. It features a fabricated mild steel shank, parallelogram mount and press wheel carrier arm, and a cast iron throat, gauge wheels and arms. Seeds are metered by airseeders, Kinze brush meters or a John Deere vacuum metering system. Precision Planting electric drive is also available and gaining popularity for its accuracy.

Down pressure is provided by four springs mounted on the parallelogram and changed by moving the top saddle further up or down the parallelogram arm. Two 15" diameter opening discs sit at a 9.5° angle. Seed depth is set by spoked gauge wheels moving on a walking beam to accommodate bumps in the soil. Mud is removed from the discs by a steel, sprung scraper at the front of the disc and a tungsten carbide scraper at the back of the disc. Furrow closing is achieved by a rubber and a cast iron press wheel mounted to a sprung carrier arm.

The purpose of this redesign is to make all the components stronger, cheaper and easier to build. Field tests have identified weaknesses in the following components:

- Gauge wheel arm
- Disc Bearing
- Seed tube guard

Farmers have expressed a desire for:

- Planting deeper with larger diameter discs
- Better serviceability.

Workshop staff have highlighted the following problematic components as time consuming or inconsistent:

- Tungsten scraper
- Gauge wheel arm
- Heavy duty scraper
- Press wheel carrier arm
- Stop Block

Service staff have found difficulty in servicing the following parts:

- Disc
- Gauge wheel arm
- Tungsten Scraper
- Stop Block
- Shank Boss

This project will seek to fix these problems.

4 Methodology

This project was conducted in several stages:

1. Talk with Norseman, their suppliers and customers about possible improvements
2. Design new production process and workshop layout
3. Draft new design for row unit
4. Implementation
5. Write Up

4.1 Discussions with parties involved

The management of Norseman was contacted to obtain current design files and costing information as well as hearing their thoughts on the new model. The storeman, fabricators and assemblers were also consulted and their ideas heard. This information has been compiled in Appendix B.

Next, the suppliers were contacted in regards to how the product could be easier for them to make. This is particularly relevant to the powder coaters and electroplaters, as there are occasionally issues with surface coatings.

Several farmers were consulted about their experiences with Norseman Machinery and their requirements for a planter. This information helped determine which features needed to be changed, added or removed.

4.2 Design Workshop Layout and New Production Process

The feedback from the workshop employees and management was used to develop an improved workshop layout and production plan. The stores department was the main focus of the new plan.

4.3 Redesign Components

Due to time constraints, only components that are sold as spare parts were considered for the redesign. Analysis of the current designs was conducted and all relevant feedback taken into consideration. Engineering models were created and finite element analysis conducted, with models 3D printed where necessary.

4.4 Implementation

The first few stages of the new workshop layout have been implemented and the benefits already seen. The first of several new components has been prototyped and a production run completed. The remaining components will be manufactured over the coming months.

4.5 Write Up

A dissertation was gradually written and compiled throughout the year.

New Production Plan

5 Production Plan Recommendations

For brevity, the recommendations for the new production plan have been compiled in list form with the justifications following.

5.1 Workshop Layout

5.1.1 Stage 1

1. Move stores area to space currently occupied by 300t press
2. Move pallet racks from office wall to sidewall
3. Move assembly area to space along office wall
4. Clear office wall and use for row unit part storage

5.1.2 Stage 2

5. Move grey bins and white buckets onto new rack in pipe room
6. Move yellow stillages into pipe room
7. Move pallet racks from near smoko room to pipe room

5.1.3 Stage 4

8. Move robot welder closer to Welding Bay 1
9. Remove 300t press outriggers and shift toward robot welder
10. Move drill press and lathe to fabrication area

5.1.4 Stage 5

11. Move welding bay 2 workbench to wall
12. Extend machine assembly area one metre toward east wall
13. Build welding screens and separate welding bays from machine assembly

5.1.5 Stage 6

14. Move outside rack to along wall outside Welding Bay 1

5.2 Storage and Picking

1. Store related parts together, eg. Bare metal parts for fabrication, welding jigs, bare components, assembled components.
2. New parts should not be stored outside
3. No more placing parts in bare locations that belong to other components.
4. Each component needs its own location that is not to be shared by any other part
5. There should a small amount of rack space for one-offs and prototypes. This will need to be cleared every few months to prevent a build-up of old parts
6. Locations should be clearly labelled with their contents

7. Parts with quantities too large for their container should be picked from their official location, not the backup location
8. Implement slotting or ABC system
9. Store all parts used in units in assembly area
10. Store parts in appropriately sized containers
11. Do not create work orders that cannot be finished
12. Build trolley specifically for picking
13. The whole system needs to be overhauled. Correct locations need to be assigned to parts and those locations need to be permanent.

5.3 Ordering and Stores

1. Estimate the number of laser cut and machined parts required each month, and place standing orders with suppliers.
2. The storeman should take note of remaining stock whilst picking.
3. Split stock into common and uncommon parts
4. Calculate the reorder point based on demand and lead time.
5. Establish minimum stock levels on the system
6. Calculate economic order quantity (EOQ)

5.4 Maintenance and Housekeeping

1. Implement regular maintenance schedule
2. Implement proper housekeeping
3. Purchase mechanical sweeper
4. Purchase magnetic sweeper
5. Fix leaks in air lines

6 Justifications

6.1 Workshop Layout

The most obvious hindrance to productivity at the Toowoomba factory is poor utilisation of space. Because of the significant impact it has on productivity and the limited amount of space available, this report will consider available space to be of high value and its correct utilisation a priority. Layout drawings are included below in figures 16 and 17.



Figure 13 - Main Pallet Racks. Note pallets on the ground in front of the rack

The current facility has the capacity to handle the current level of production, but due to various factors, that capacity is reduced. These factors include:

- Nonessential machinery taking up space
- Restricted forklift access and pinch points on pathways
- Underutilised pallet racking
- No clearly defined receivals and dispatch area
- Racking placed too close to walkways
- Inadequate access and ventilation in component assembly area

- Fabrication machinery too far apart
- Stores benches and racks too far apart
- Some new parts not stored undercover



Figure 14 - The former stores area. This demonstrates the worst possible conditions

6.1.1 Justification

The above recommendations are based on the assumption that Norseman will remain at the Industrial Ave property indefinitely. In the unlikely event of a new facility being constructed on the corner of Boundary and Lewis Streets, the recommendations will change.

1. For the stores department to operate effectively, it must be positioned next to the door used for deliveries. The best position for the stores racks is the space currently occupied by the 300t press and would allow good access for staff and delivery drivers.
2. The sidewall currently has 12m of underutilised space. Moving the pallet racks from the stores area to the sidewall will triple the number of pallets that can be stored in that space.

3. The current component assembly area lacks proper ventilation and forklift access. The current stores area is bigger than it needs to be and is mostly filled with loose pallets and parts. If cleared out and replaced with component assembly, that space will be properly utilised and component assembly will have adequate airflow and forklift access. It will also reduce the distance completed parts have to travel to stores and machine assembly.
4. Storing parts along the office wall will allow easy access for assemblers.
5. The area vacated by component assembly should be used to store parts that do not require forklift access, such as fasteners and small components. Removing the need for forklift access allows the racks to be placed much closer together, thereby fitting more parts into the same space. The new rack will fit 600 grey bins and 150 white buckets, eliminating the need to store them on pallet racks.
6. In addition to those containers, there is enough floor space to move the yellow stillages out from under the racks. If stacked 4 units high, there is space for 68 stillages, which is equal to the current capacity.
All this will free up 28 spaces on the pallet racks, removing the need to store parts on the floor, mezzanine or outside. This will also free up floor space, improving access and safety, and allow parts to be stored out of the weather where they will not rust, corrode and fade.
7. After the pipe room is cleared, there will be space to fit pallet racks that will continue on from the sidewall racks.
8. The robot welder can be shifted further towards the wall and welding bay 1 whilst still remaining operational. This will free up space in the stores and machine assembly area.
9. Removing the outriggers will reduce the footprint of the press and will allow it slot in next to the robot welder. This will free up space for the new stores area.
10. Currently, the fabrication machinery is spread over the workshop, with some assets obstructing doorways and pathways. Moving all the machinery into one area will improve access and reduce the walking distance between assets.
11. Moving the workbench to the wall will allow the divider between the bays to be used for storing welding jigs.

12. Lengthening the machine assembly area will prevent machines from protruding into the pathway on the other end.
13. To comply with safety requirements, welding screens need to be erected between the fabrication area and the machine assembly area.
14. The outside rack is underutilised and frequently inaccessible. Moving it to along the shed wall allows it to hold work orders processed by welding bay 1 and would free up the concrete slab for holding machines.



Figure 15 - The new south wall rack. This configuration created six extra pallet spaces

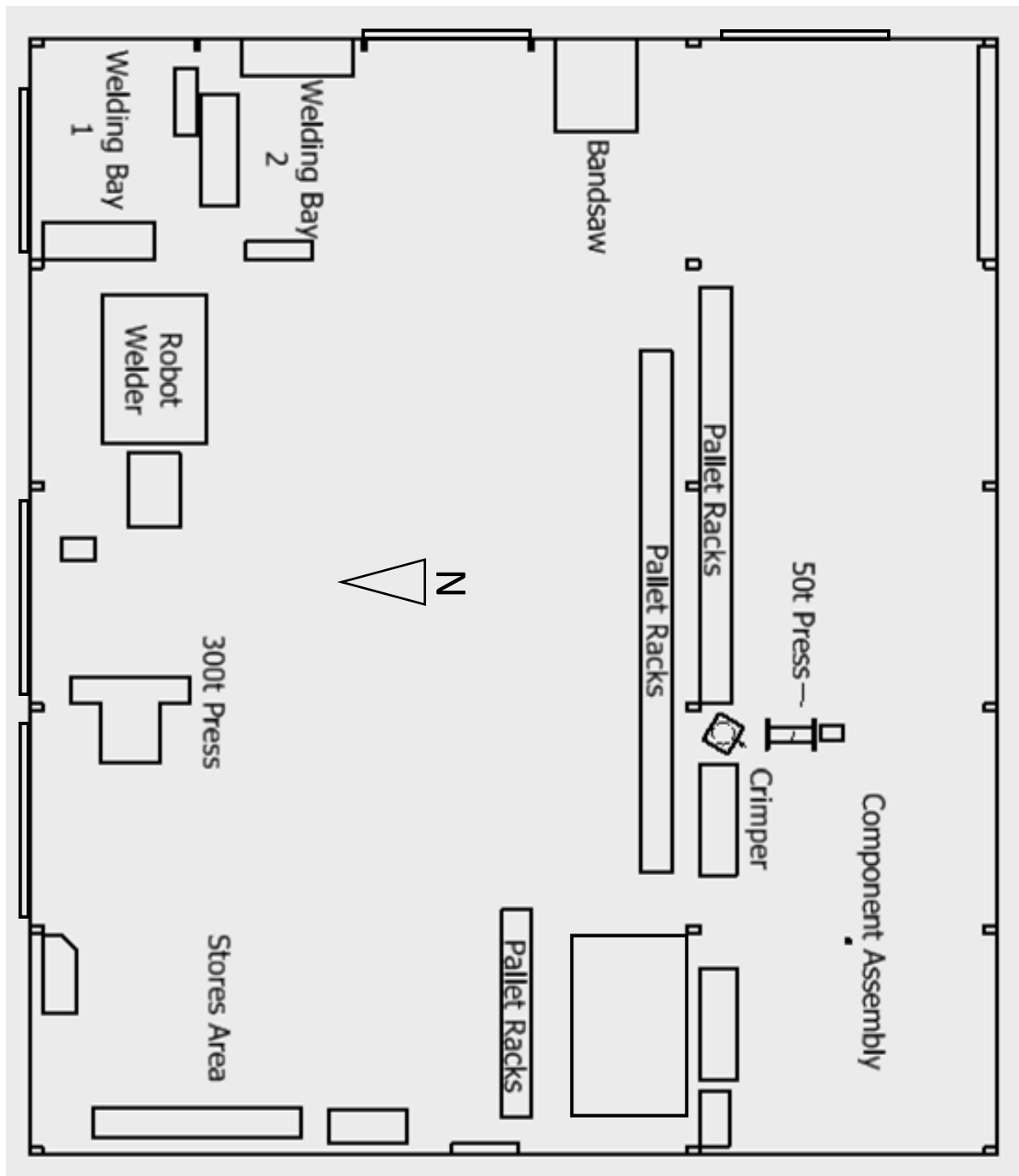


Figure 16 - Current workshop layout

The current workshop is shown above in figure 16. Main access is through the north-west and east doors. It can be seen that forklift access to the component assembly area is inhibited by the main pallet racks, and there is no ventilation in that area. The stores area is oversized and is used as a repository for loose pallets and unsorted containers. The 300t press occupies too much space and blocks two doorways. Loose pallets are commonly stored in front of the main pallet racks, restricting access to the items on the racks.

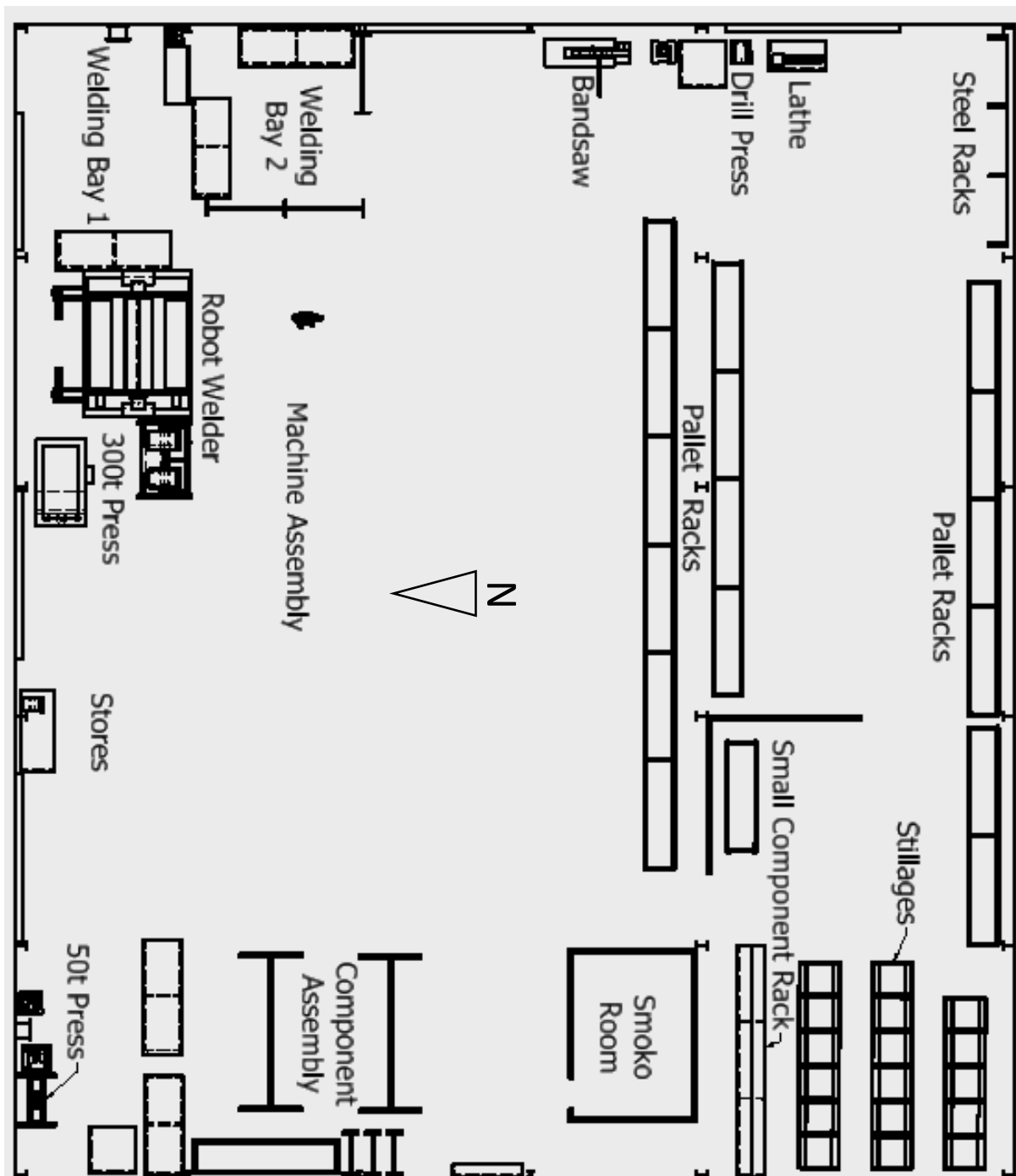


Figure 17 - New workshop layout

The improved workshop layout is shown above in figure 17. Component assembly has been moved to the north-west corner to improve access, lighting and ventilation. The former assembly area has been filled with stillages and small component assembly. The pallet racks from the former stores area have been moved to the south wall. The stores area has been moved to the north wall, between two doors for ease of access. The bandsaw, drill press, linisher and lathe are located together to reduce travel time for fabricators. The robot welder and 300t press has been moved closer together to free up space for the stores area.

6.2 Storage and Picking

1. Keeping related parts close together reduces the distance travelled by the storeman when picking work orders.
2. Some parts are currently stored outdoors, causing them to corrode, fade or become covered in dust. Brand new parts have to be recoated at an extra cost. If parts are stored indoors, this problem would no longer exist.
3. Currently, when an empty space appears on the rack it is normally filled with parts not belonging to that location. This creates two problems, when the new stock of the assigned part arrives, it has nowhere to live, and both parts end up in the wrong location. Each part needs to be assigned to one permanent location. That location cannot be stolen to hold other parts.
4. Currently, locations numbers are spaced one pallet width apart so each rack contains two locations numbers. This works well for pallets, but is problematic for smaller containers as up to 13 containers end up with the same location. Because of this, the location listed on the system is only approximate and the storeman has to spend extra time searching through racks. If each part has its own unique location, picking time will decrease. (Wulfraat, 2013)
5. Inevitably, custom orders are built but not sold, unsuccessful prototype are built and other components that have no permanent place are made. These parts end up on desks, windowsills, under workbenches, in stillages or on the rack near the smoko room. They should be confined to one location, possibly the mezzanine, and sorted through every few months.
6. Containers of all sizes, including crates should be clearly labelled with the part number and description to prevent confusion. (Inventory, 2014) Labels such as "Spring" or "Bolt" are not detailed enough.
7. Currently, if there is too many of a part to fit in its location, the rest is stored nearby. A problem arises when people start picking parts from both locations, rather than the official one. The backup location should be off limits. If the parts are large, they should be stored at the old shed.

8. The guiding principle in both slotting and ABC systems is reducing travel time. Slotting involves placing parts that need to be accessed frequently in easy to access locations, and placing less frequently accessed parts in harder to access locations. (Hyster, 2013) The ABC system is similar, but it sorts parts into three categories, with A being the most frequently accessed and C the least frequently accessed. The workshop is also broken into three zones according to accessibility. Parts are then stored in their corresponding zone. (Wulfraat, 2016)
- The accessibility of a location is determined by the time taken to retrieve a part from it. The travel distance has a major effect as well as the location height. The higher a location, the longer it takes to reach it.

At Norseman, the different zones would be as follows

- A: Lower levels of the main rack
- B: Upper levels of main rack, sidewall, pipe room
- C: Aisle between racks, mezzanine.

The initial division of parts would be:

- A: Parts for units and subcomponents
- B: Parts for machines
- C: Infrequently sold spare parts

By optimising slotting, picking productivity gains of up to 20% can be attained. (Wulfraat, 2016)

9. Norseman's management wants the assembly area set up to make row units, as they are the biggest item made there. Therefore, all of the parts used for units should be kept in the assembly area. By keeping parts close to the area they are used in, the distance travelled by those parts is greatly reduced, thereby saving time. Also, the workers in that area can directly pick the parts they need from the rack, removing the need for the storeman to get involved. Norseman has already begun to do this by storing throats and gauge wheel arms in the assembly area.
10. If parts are stored in a container that is too small, the container can overflow or become unstable. If parts are stored in a container that is too big, the container will occupy more space than it needs to.

11. In the past, it has been fairly common to start work orders without having the necessary components. This usually ends with an incomplete work floating around the system and a bunch of leftover parts.
12. In order to reduce travel time and physical strain, a trolley should be built specifically for picking. It will need to have several levels and be wide enough to hold two white buckets.
13. Explained in the following section.

6.2.1 System

The computer system needs to be overhauled. It currently contains inaccurate stock levels, incorrect locations, old or unused part numbers, incorrectly named parts, misspelled part names and inconsistent naming conventions.

Inaccurate stock levels cause a multitude of problems. Not being able to provide an eta for customers, starting work orders without knowing if they can be completed, not knowing when stock levels are running out, etc. Not having stock when it is required is one of Norseman's major problems, causing massive delays, lost orders, half-finished jobs and creating high opportunity costs.

Incorrect part locations create losses by requiring extra time to search for parts.

Old or unused part numbers, incorrectly named parts, misspelled part names and inconsistent naming conventions make it difficult to find the correct parts on the system, thereby wasting time.

Currently, parts like bolts are listed as: BOLT 5/8x4, BOLT 5/8 x 4, BOLT 5/8"x4", BOLT 5/8 x 4 GDE5, BOLT 5/8x4 UNC GDE 8 YZ, etc. This inconsistency makes it difficult to search parts on the system and is messy. A naming convention needs to be determined and applied.

6.2.2 Recommendations

There is no easy solution to the problems listed above, but by implementing and following proper procedure, they can be ameliorated. Recommendations are as follows:

- Stocktake and relocate small components as they are moved from current storage to new storage
- As space on the racks becomes clear, large components should be moved around to be close to related parts.
- Stocktake and relocate large components as they are moved around.
- During the above process, assess if all of the parts assigned to each location are assigned correctly and are parts still in use. Parts that are obsolete need to be archived to prevent confusion with current parts and clear storage space.

- Upon inspecting the system, it seems that some parts have been created, but never actually existed. These should be removed to declutter the system.
- Assign consistent naming conventions to all parts.

6.3 Ordering and Stores

1. Place standing orders with suppliers. If the monthly quantities required can be estimated, orders can be placed with suppliers long before their required date. This allows suppliers to fill the orders when it most suits them and allows them to work Norseman's orders around their other jobs. This is particularly useful for laser cutters, who can combine jobs onto the same sheet of steel. This will keep suppliers happy and possibly lead to lower costs.
 - a. For this to work, the production rate will need to be even throughout the year, rather than rising greatly during the busy season. An estimate of units sold per year is needed. That number should be broken into monthly quantities and standing orders of those quantities placed.
 - b. During the inevitable busy season there will be a higher demand for parts but with proper foresight, the extra parts required can be added to the standing order. This will ensure that there will always be enough stock for the month ahead and prevent the need for rush jobs.
2. After the computer system is overhauled and a stocktake undertaken, the stock levels indicated on the system should be reliable. Inevitably though, some discrepancies will appear. If the storeman keeps an eye on stock levels on the shelf, any discrepancies should be picked up on before they grow too large.
3. Norseman's inventory has a very large number of parts and it does not make sense to keep stock of all of them. The inventory should be split into parts that are frequently used, and therefore always need to be in stock, and parts that are rarely used and can therefore be ordered in when necessary. This will ensure parts are in stock when needed, as well as keeping inventory costs down. The next two recommendations are only applicable to frequently used (common) parts.
4. Norseman's biggest issue at the moment is lacking stock when it is needed. The first step to fixing this is maintaining correct stock levels as discussed above. The next step is to calculate the reorder point.

The equation for this is: *Reorder Point = Normal Consumption * Lead Time*

For example, if the consumption is 50 parts per week and lead time is 4 weeks; then the reorder point is 200 parts. This ensures that as the stock levels reach zero the new order arrives and you never truly run out of stock. If the consumption rate and lead time is variable, choosing the highest rate and time will ensure that stock levels always remain above zero. Alternatively, adding, for example, an extra week onto the lead time will ensure a minimum stock level of one week's supply.

5. Once the reorder point has been calculated for all common parts, the minimum hold levels should be added to the system and a reminder set to alert the purchasing off when the reorder point is reached. There is no point in having a minimum level set, if no one knows when it is reached.
6. *An economic order quantity (EOQ) is an inventory-related equation that determines the optimum order quantity that a company should hold in its inventory given a set cost of production, demand rate and other variables. (Investopedia, 2015)*

EOQ is used to reduce order and inventory costs by finding the point where the reduced unit cost associated with bulk orders matches the reduced inventory cost of keeping less stock.

The equation for EOQ is:

$$\sqrt{\frac{2 * D * S}{I * C}}$$

D = Annual Demand
 S = Cost Per Order \$
 I = Holding Cost %
 C = Unit Cost \$

The cost per order refers to setup, freight and personnel costs associated with placing and receiving an order. For example, a machinist's setup charge.

The holding cost takes into account storage and opportunity costs associated with keeping a tangible product on the shelf. Norseman's management estimates this to be 7.5%

Annual demand and unit cost are self-explanatory.

6.4 Maintenance & Housekeeping

1. Every business has a significant amount of capital tied down in machinery, vehicles and fixtures. These assets are necessary to the function of the business and it is therefore important that they are maintained properly to prevent downtime. Downtime on critical machinery is a major issue. For example, in the past, issues with the 50t press have caused detrimental disruptions to production. These could have been mitigated by regular maintenance.

It is recommended that a maintenance schedule be implemented for each asset. The maintenance jobs should be treated as work orders and a permanent job card be printed. The production planner will be in charge of allocating maintenance jobs and placing the job card in a worker's job slot. This will ensure that maintenance is prioritised and completed as part of the normal production plan.

2. One of Norseman's largest issues is a lack of housekeeping. Like in many businesses, housekeeping is seen as a non-profit activity, and therefore non-essential. This is incorrect, as proper housekeeping can contribute to the profitability of a business in the following ways.
 - a. Reduced downtime. By implementing preventative maintenance, machinery breakdowns are prevented, reducing repair costs and downtime. Keeping those machines clean and clear of debris helps identify potential problems such as leaks and cracks before they become serious
 - b. Safer working conditions. Cluttered floors, hoses and leads, dust, swarf and oil can all create dangerous working conditions that lead to worker injuries, sick days and compensation claims. Creating a safer workplace reduces those incidents. (MDOL, 2013)
 - c. Increased morale through better working conditions. Dusty, poorly lit or extremely hot or cold conditions can reduce morale and workers' motivation. The higher a worker's morale is, the more motivated they are to do a good job. (Go2HR, 2016)
 - d. Easier access and movement. Cluttered floors, pallets stored on the ground and blocked passageways restrict the free movement of workers and machinery. Better access allows faster and safer movement of parts. (ILO, 2014)
 - e. Increased productivity. Time is wasted through searching for parts, moving pallets to reach racks, clearing workspace on messy benches etc. When all of the aforementioned conditions improve, productivity and profitability increase.
 - f. Meeting legal requirements. Proper housekeeping ensures walkways and emergency exits are free and safety requirements are met.

Housekeeping may not be the most exciting aspect of business, but it is incredibly crucial and a good indicator of the productivity of a business.

After all, if a company cannot successfully conduct housekeeping activities its customers might reasonably assume that it would struggle to deliver even mildly complex products on time. (QMI, 2016)

By implementing proper housekeeping, productivity can be greatly increased. The recommendations for implementation are as follows.

- Add housekeeping to workers' normal responsibilities. Sort the individual duties by their frequency.
 - a. After every job: neatly package finished parts, dispose of bearing boxes and other rubbish, clear workspace, return tools, jigs and storage containers, clear away any pallets, clean off any machinery used.
 - b. Daily: Sweep out area, clear any rubbish or obstacles, return tools.
 - c. Weekly: Empty bins.
 - Enforce the new standard. It will take a while for everyone to adjust to the new plan and shift their attitudes. In the meantime, it will be easier to return to the old standard and not bother changing anything. However, if lasting change is going to take effect and improvements are going to be made, then this stubbornness will need to be pushed past. This requires a commitment to change from management, and a willingness to enforce the new plan. It needs to be clear that each worker's responsibilities have changed and that housekeeping is just as important as their other tasks. In the past, new plans have been stymied by a lack of commitment and enforcement, and have eventually been abandoned. This cannot happen with the new plan, after all, nothing changes if nothing changes.
3. Dust is a major problem in Norseman's workshop, causing respiratory problems with some of the staff. The permanent solution is to replace the gravel outside the doors with concrete, but that is outside Norseman control. The alternative solution is proper housekeeping, specifically, sweeping. Sweeping stirs up dust and is labour intensive, but is necessary. By using a mechanical sweeper, sweeping can be accomplished 7 times faster without stirring up extra dust. (Karcher, 2015) It is an investment, but one that will pay off.
 4. A magnetic sweeper will make cleaning around the drill press and lathe much easier.
 5. Leaking air hoses waste energy. They should be fixed.

New Component Design

7 Opening Discs



Figure 18 – Opening Disc. Gauge wheel removed for clarity

The opening discs bolt onto the throat at a 9.5° angle and open a seed furrow as the roll through the soil. Norseman uses 15" diameter discs manufactured by Ingersoll Tillage in Canada, bolted to a custom hub made for a 204PY3 single row ball bearing. The discs are generally hard-wearing and trouble free, but occasionally do not spin true and have to be rejected. 15" diameter discs are used to match John Deere, Kinze and other major manufacturers, but farmers have expressed a need to plant deeper than 15" discs can allow. Because of this demand, Norseman has decided to move to 16" diameter discs paired with a stronger, larger bore bearing.

7.1 Current Problems

- Bearings do not have a high enough load capacity
- 15" discs are too small

7.2 Goals

- 16" disc
- M20 bore bearing
- Same diameter hub to ensure clearance on gauge wheel

7.3 Bearing Selection

The current bearing is a 5/8" bore 204PY3, specifically made for agriculture. Specialty agricultural bearing tend to have thicker, extended inner races, heavy duty seals and are made to imperial sizes. None of those bearings available fitted an M20 bolt, or were strong enough for the application, so traditional bearings were considered. Strangely, load ratings are not available for agricultural bearing so an extended dynamic load rating of 10.8kN was taken from the closest traditional bearing, a Timken 203K. (Timken, 2016)

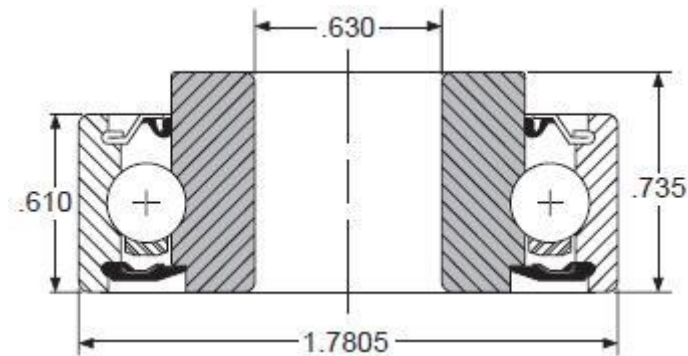


Figure 19 - 204PY3 Disc Bearing

Because of the angle the discs sit at, as well as the inconsistent nature of the soils they roll through, the bearings are not only subject to a radial load, but an axial and moment load as well. It was decided that a double row, angular contact ball bearing would be best suited to handle these loads. A 5204-2RS was chosen for its dynamic load rating of 22.6kN.

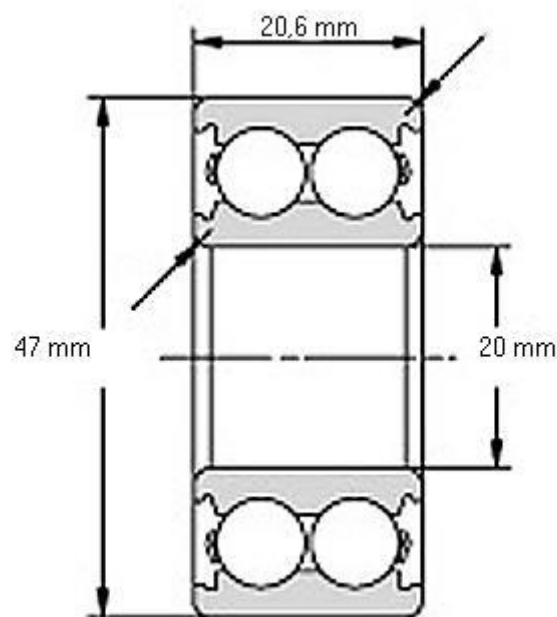


Figure 20 - 5204-2RS Bearing

7.4 Hub Design

The hub design is fairly basic as all it needs to do is encapsulate the bearing and hold a dust cap. Alternatively, a new type of hub mounted scraper was designed, which required a low profile disc hub to prevent clashing on the gauge wheel spokes. This low profile hub is recessed down into the disc and locates the bearing 4mm lower than the standard design. It does not have provision for a dust cap, but the scraper will act as a shield over the bearing.

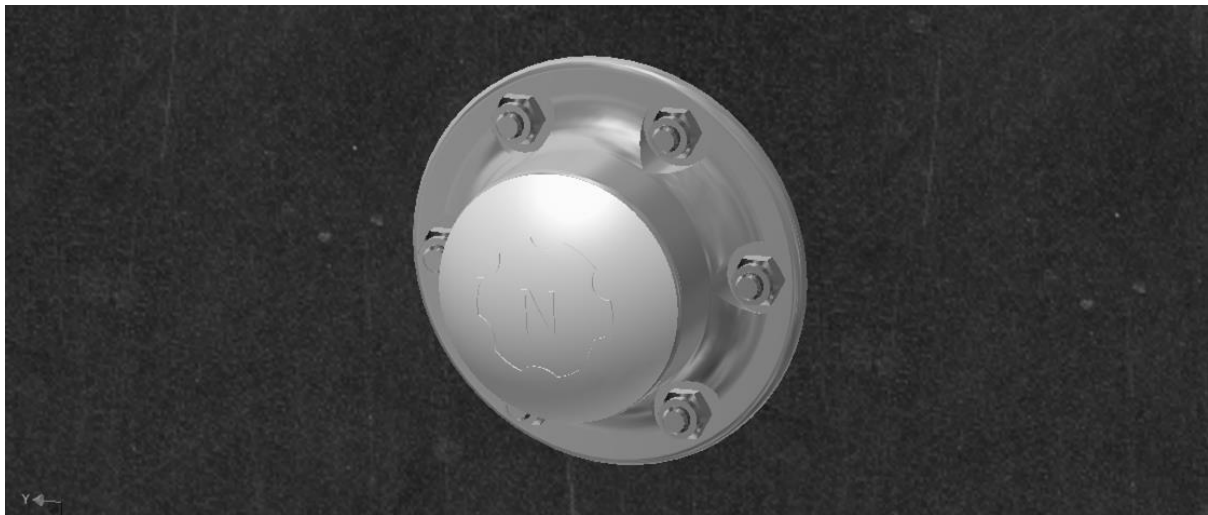


Figure 21 - Disc Hub Standard

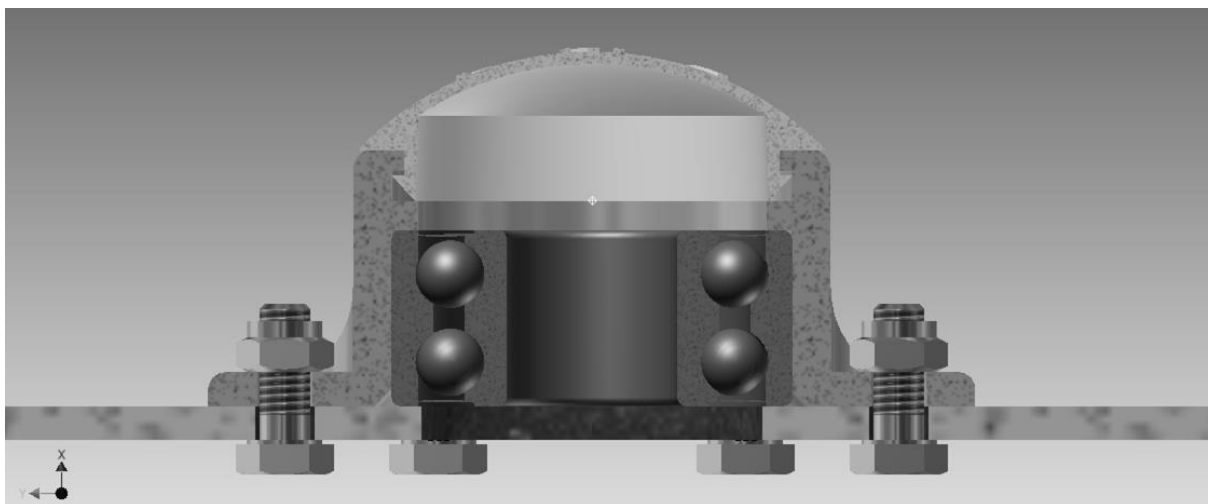


Figure 22 - Disc Hub Standard Cross Section

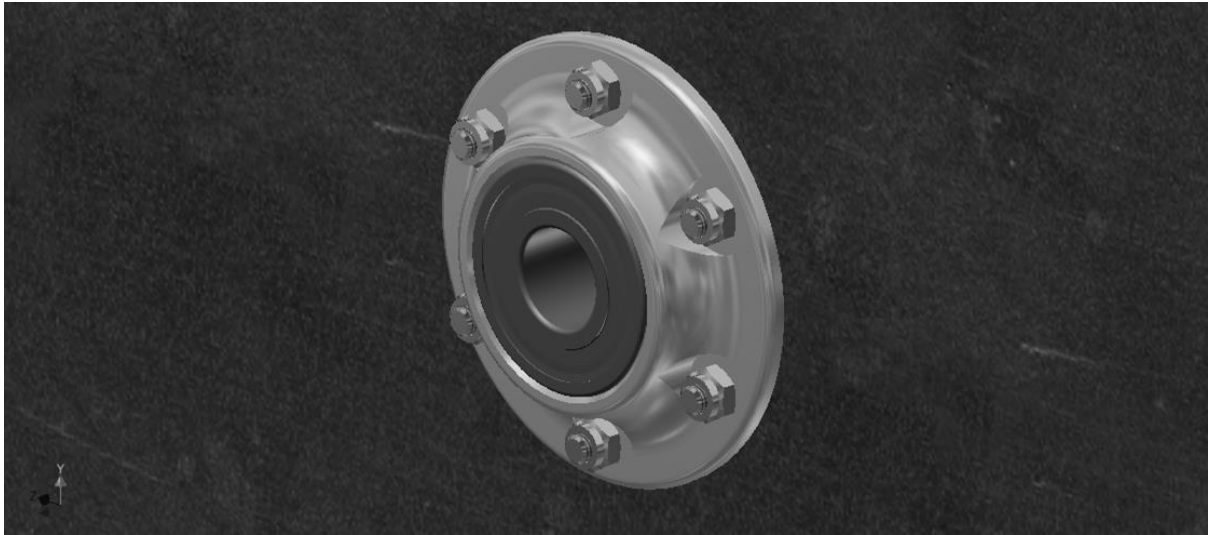


Figure 23 - Disc Hub Low Profile

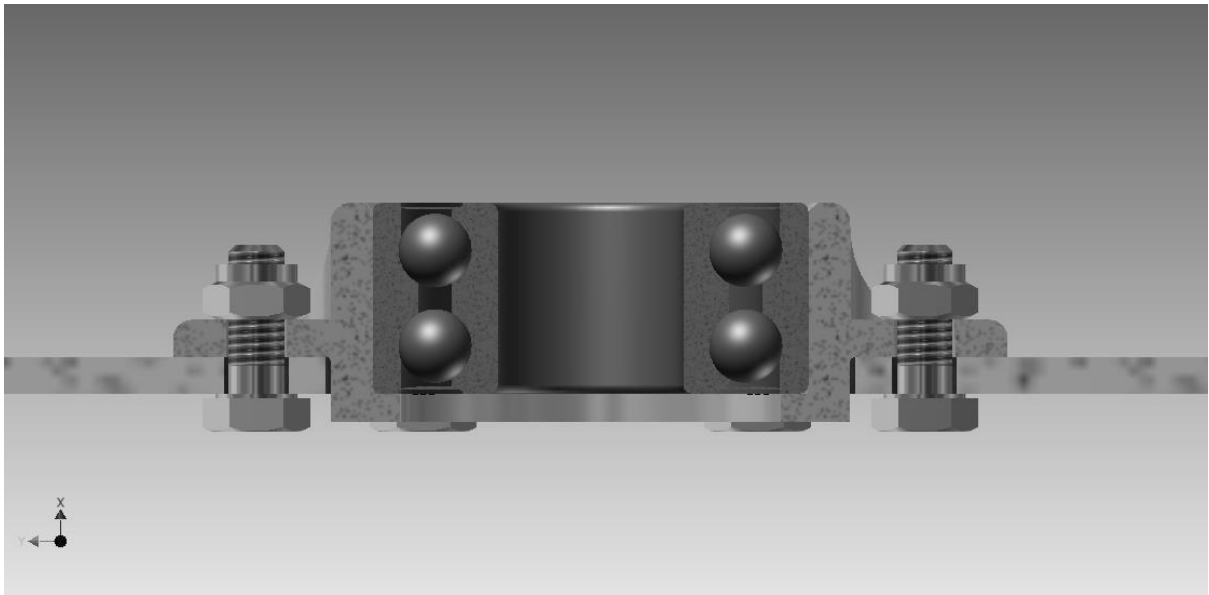


Figure 24 - Disc Hub Low Profile Cross Section

8 Gauge Wheel Arm



Figure 25 - Current gauge wheel arm on row unit

The gauge wheel arm is bolted to the shank boss and holds the gauge wheel at a certain depth via an interaction with the depth control rocker. Originally, Norseman used a modified version of a Kinze design that pivoted on an eccentric vesconite (thermoplastic) bush. As the tyre on the wheel wore, the eccentric bush was turned to change the angle of the wheel and move it closer to the disc. The changing angle overcame any inconsistencies in the shank, but the bush became clogged with dirt and wore out. In 2011 a new design was adopted that replaced the bush with a double row, angular contact bearing. This eliminated wear and dirt ingress, but revealed significant inconsistencies in the welding of the shank that led to uneven wheel placement. Also, whilst on the original design the wheels were attached with a 5/8" bolt, the new design used a 5/8" stud that was easier to assemble, but could easily be sheared off. Being manufactured in China, the overall quality and consistency of the arms were low and thousands had to be discarded.

8.1 Current Problems

- Casting inconsistencies (necessitating visual checking and manual testing)

- Inaccurate machining from manufacturer (added labour costs, bearings damaged due to undersized holes)
- Additional machining required in Australia (labour and tooling costs)
- Requires assembly (labour costs)
- The M8 bolt securing the stud is loaded in shear and is not strong enough
- Bending and twisting

8.2 Goals

- Reduce stress to below yield strength
- Simplify assembly
- Replace M8 bolt with stronger mechanism

8.3 Analysis of Current Arm

The loads placed on the arm were not predetermined, so an upwards force of 3000N, equal to the weight of the whole row unit plus the maximum down pressure, was placed on the centre of the gauge wheel bearing. An outwards force of 1000N was applied at the tyre. These values produced realistic results and were used throughout the entire analysis.

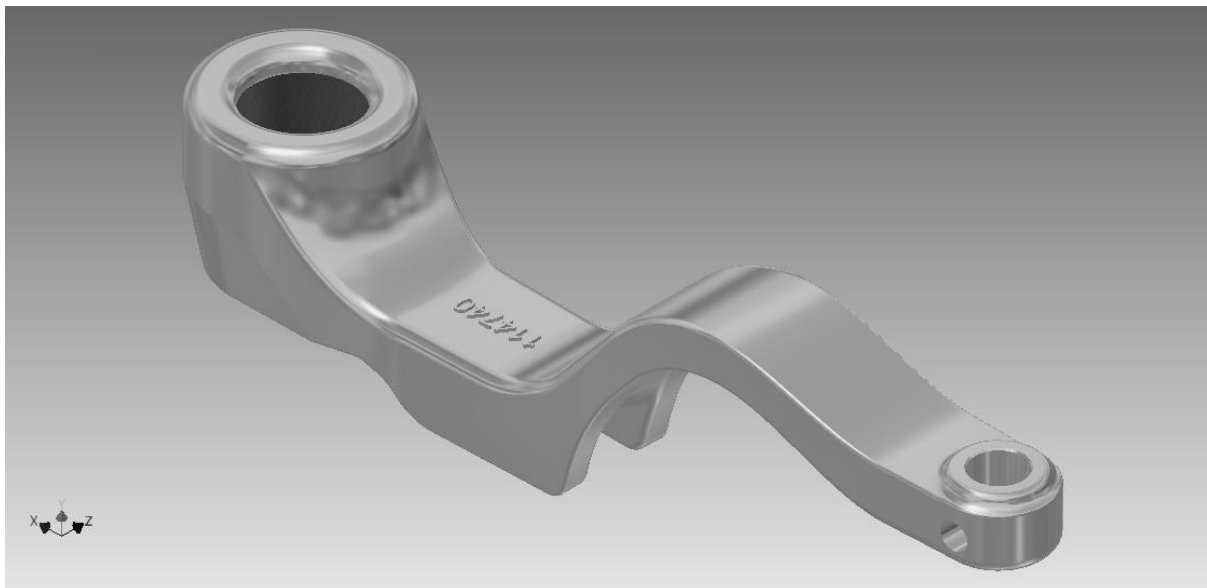


Figure 26 - Current Gauge Wheel Arm Design

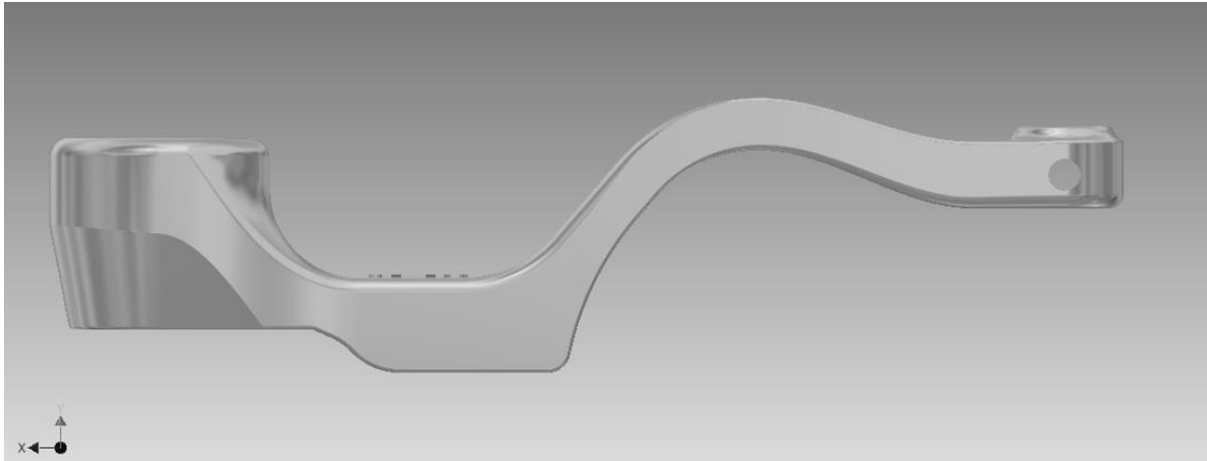


Figure 27 - Side Profile

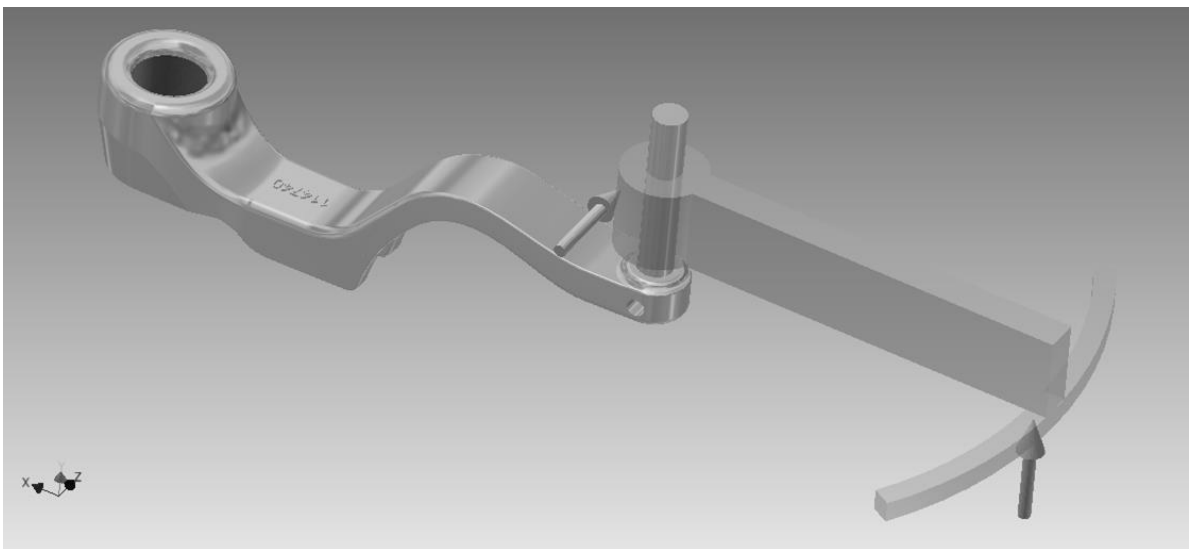


Figure 28 - Load Conditions

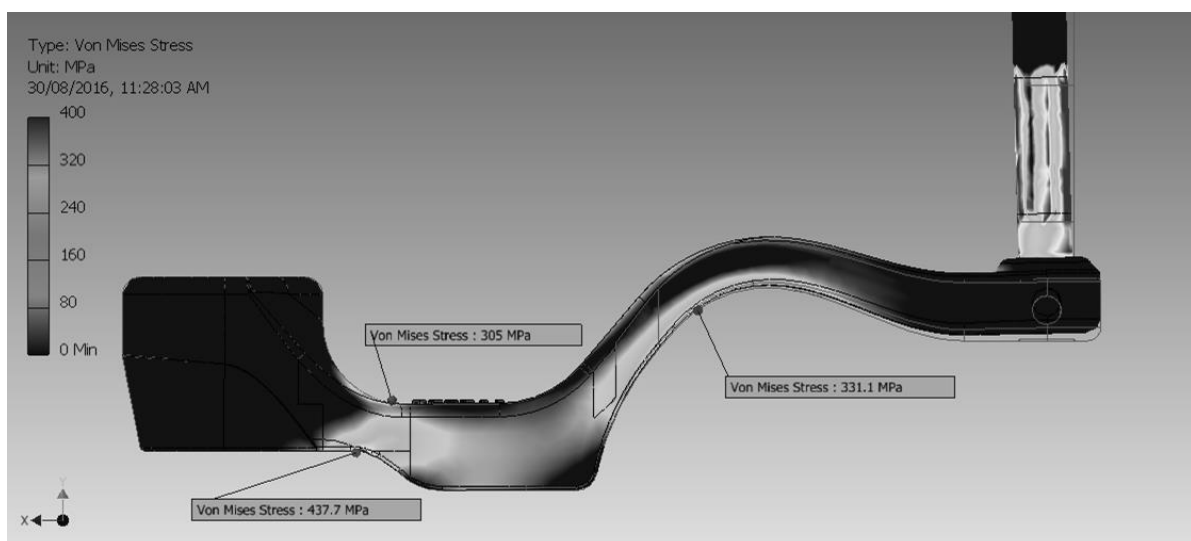


Figure 29 - Stress Analysis Side View. Note highest stress is above yield strength

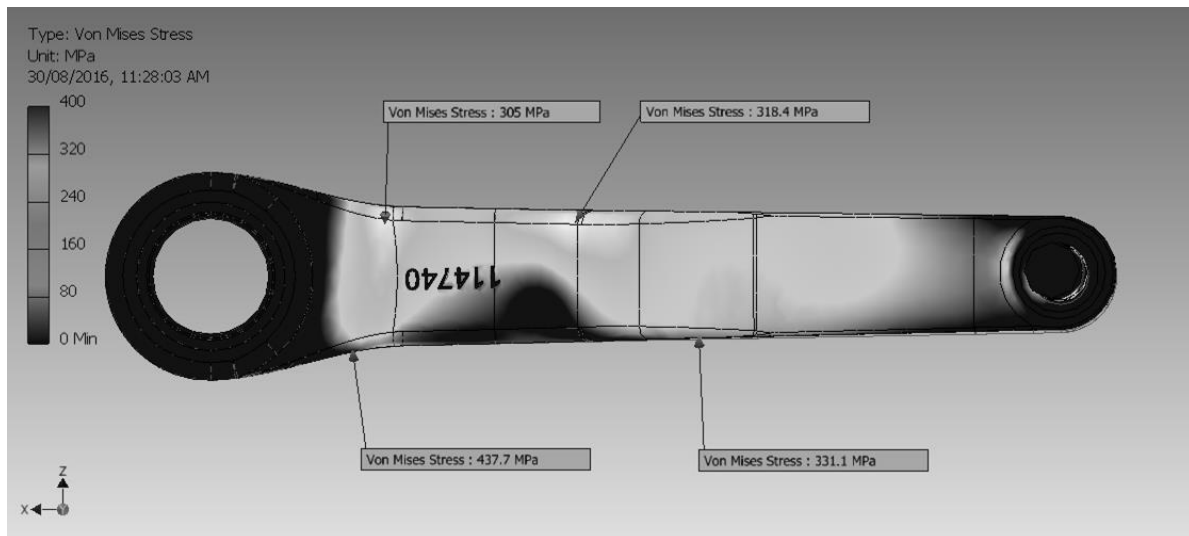


Figure 30 - Stress Analysis Top View

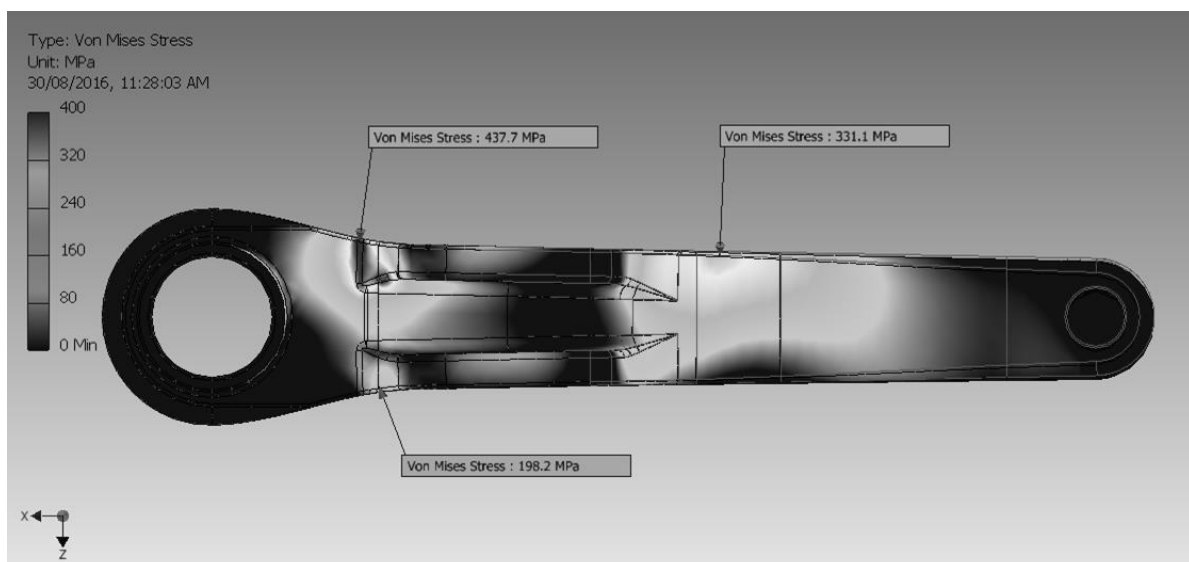


Figure 31 - Stress Analysis Bottom View

8.4 Results

Material: SG500/7 Ductile Iron

Max Stress: 437 MPa

Yield Strength: 320 MPa

Max Deformation: 2.85mm

A preliminary visual inspection revealed two likely areas of high stress, both of which were confirmed by the FEA. These areas corresponded with the weak spots identified on existing parts and were therefore the main focus of the new design.

8.5 New Design

As bending and twisting were the biggest issues with the current design, efforts were made to increase the second and polar moments of inertia. Several designs were trialled and plastic models 3D printed. Initially, the two ribs on the underside of the current arm were lengthened to run the length of the arm and sharp bends were reduced. These ribs were found to clash on the disc scrapers, so were reduced. The second version clashed on the shank and so the ribs were reduced further. Eventually, the ribs were removed entirely and a rectangular cross section was adopted.

The current stud is held in place by an 8mm bolt loaded in double shear. The new version needed to have a larger amount of material to take the load so a head was added to the stud. In order to stop the stud from spinning and hold it in place during assembly, knurling was added to the shaft. In essence, it is a wheel stud. This design eliminates two parts, reduces assembly time, and improves the strength of the arm and stud.

The arm was lengthened by 7mm to provide more clearance on the disc hub.

Quotes for manufacture were sought from a dozen suppliers in Australia, China and Taiwan and eventually Intercast & Forge in Adelaide, Australia were chosen. Thus far, their quality has far exceeded that of the previous Chinese foundry.



Figure 32 - New Gauge Wheel Arm Design

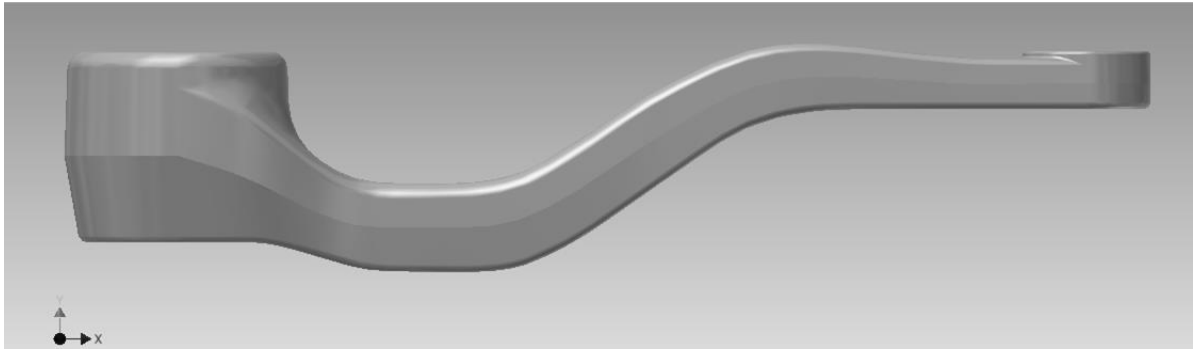


Figure 33 - New Side Profile

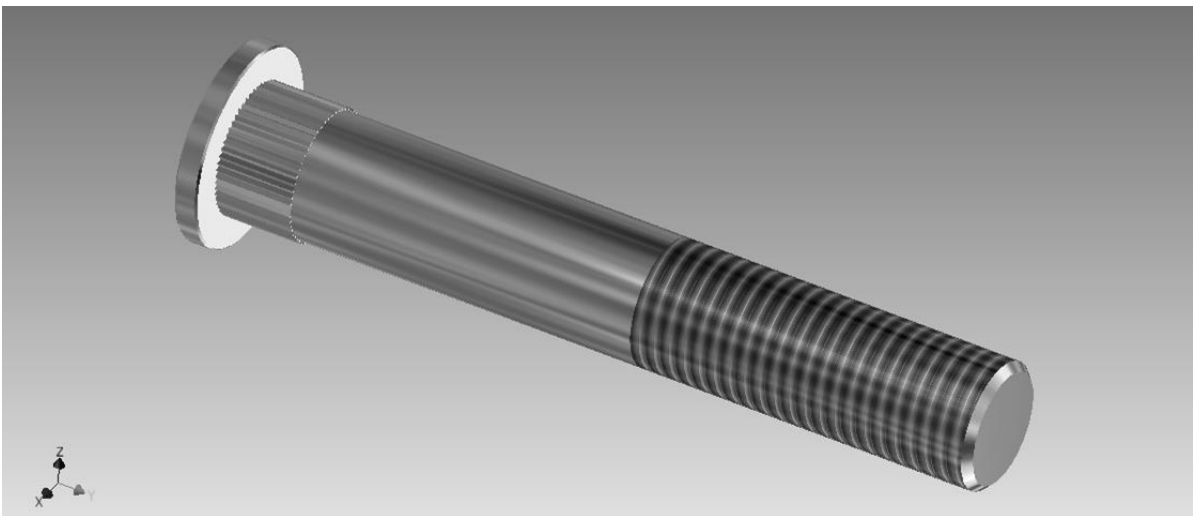


Figure 34 – Knurled Wheel Stud

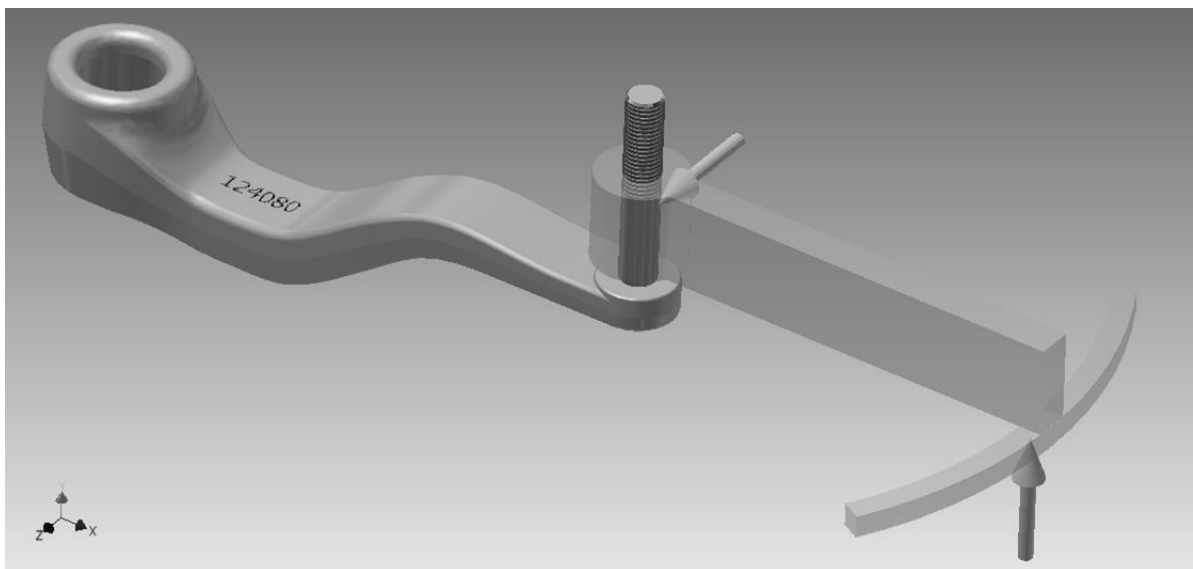


Figure 35 - New Load Conditions

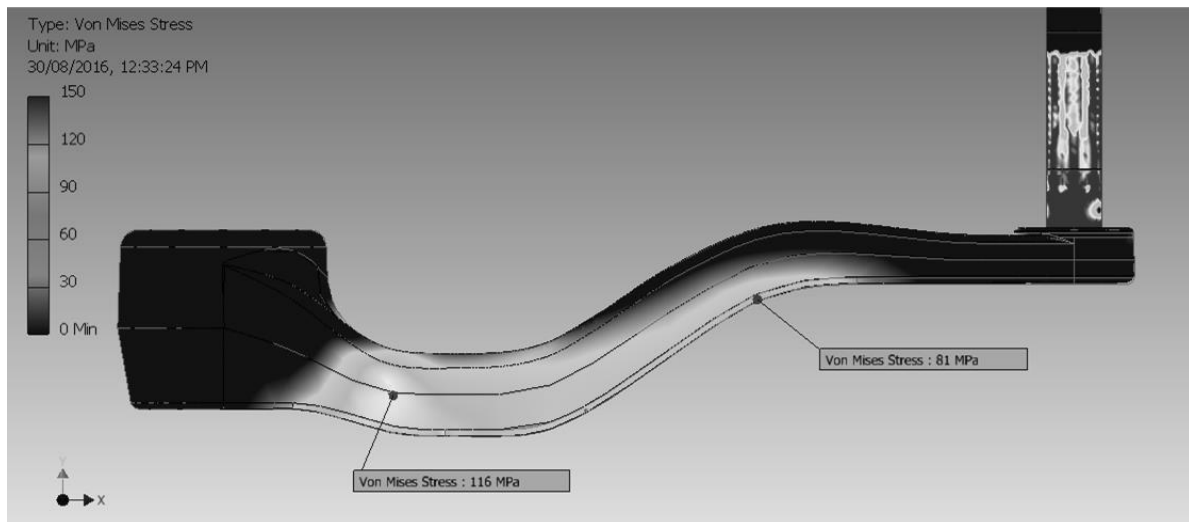


Figure 36 – New Stress Analysis Side View. Note smoother stress profile

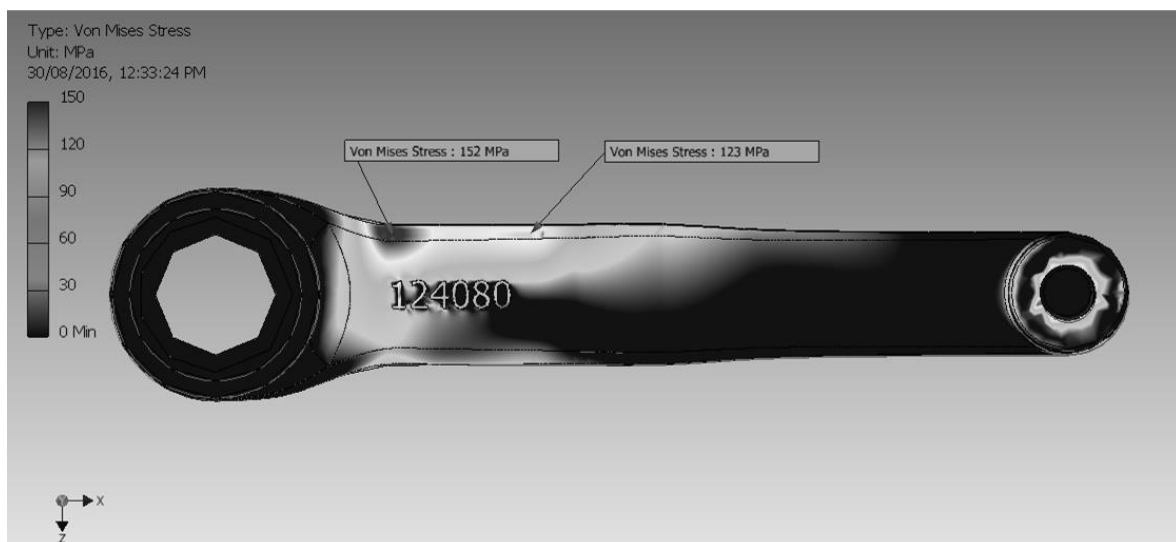


Figure 37 - New Stress Analysis Top View

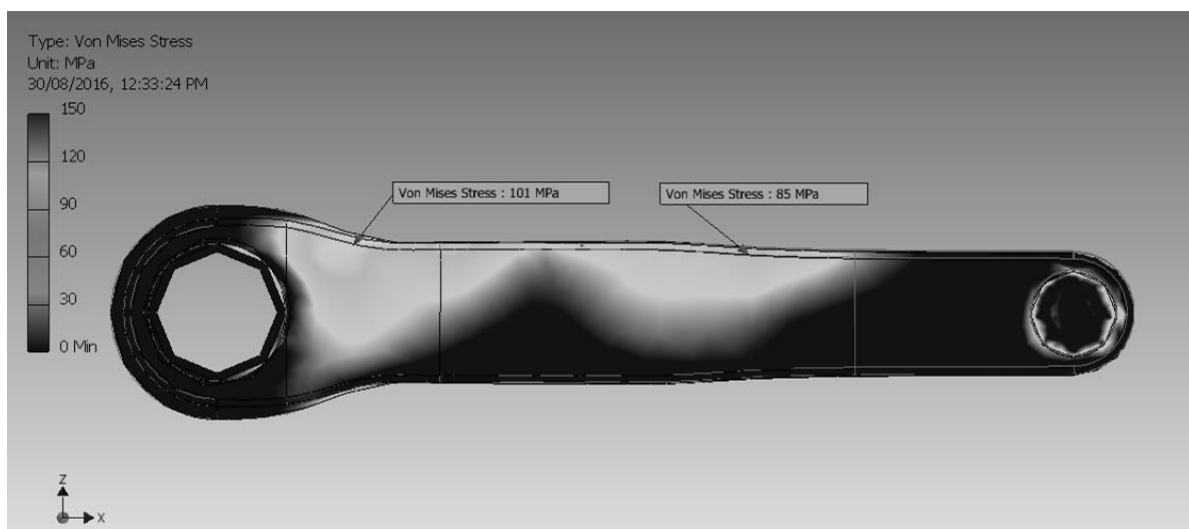


Figure 38 - New Stress Analysis Bottom View

8.6 Results

Material: SG500/7 Ductile Iron

Max Stress: 152 MPa

Yield Strength: 320 MPa

Max Deformation: 0.84mm

The maximum stress has been reduced from 437MPa to 152MPa. The stress in the thinner end of the arm has been reduced from 337MPa to 85MPa. These values are well below the yield strength of 320MPa.

8.7 Current Progress

As of writing, a production run of 1064 arms has been completed and initial orders are being fulfilled.



Figure 39 - Progress from old design (left) to new design (right)

9 Gauge Wheel



Figure 40 - Current wheel on row unit

The gauge wheel is bolted to the gauge wheel arm and floats parallel to the opening disc. Its purpose is to gauge how deep the opening discs cut into the soil and therefore how deep the seed is sown. It is made from two split rims, runs around a 5203 double row, angular contact ball bearing and holds a semi-pneumatic rubber tyre specifically made for planting applications. The bearing is press fit between two circlips. Originally, Norseman used a 3mm pressed steel rim from John Deere. These rims were economical and high quality, but lacked anywhere for mud to escape from inside the wheel. In 2011, this led to switching to a custom cast, ductile iron, 3 spoked design sourced from China. Immediately, issues arose around the quality and consistency of the castings. Substantial deformation led to unacceptable wobbling of the assembled wheels and difficulty in matching two wheel rims to form a whole. After several thousand had to be discarded, a new supplier and casting method was chosen, but strict testing and checking is still necessary.

9.1 Current Problems

- Casting inconsistencies (necessitating visual checking and manual testing)
- Needs circlips (part and labour costs, excessive force on circlip)

- Bolt holes do not match (labour cost or part rejection)
- Hex holes misaligned or full of slag (labour cost or part rejection)
- Chinese zinc electroplating is poor quality (necessitating electroplating in Australia)

9.2 Goals

- Improve consistency and dimensional stability
- Remove need for testing
- Reduce assembly time
- Reduce chance of incorrect assembly and breakage
- Reduce weight

9.3 Analysis of Current Wheel Rim

Analysing an assembled wheel was difficult due to Inventor's inability to analyse materials such as rubber, and its lack of dynamic analysis, so the rims were loaded up without a tyre and placed in the worst load scenario possible. The load placed on them, 3000N, was equivalent to the weight of a row unit and the maximum down pressure possible.

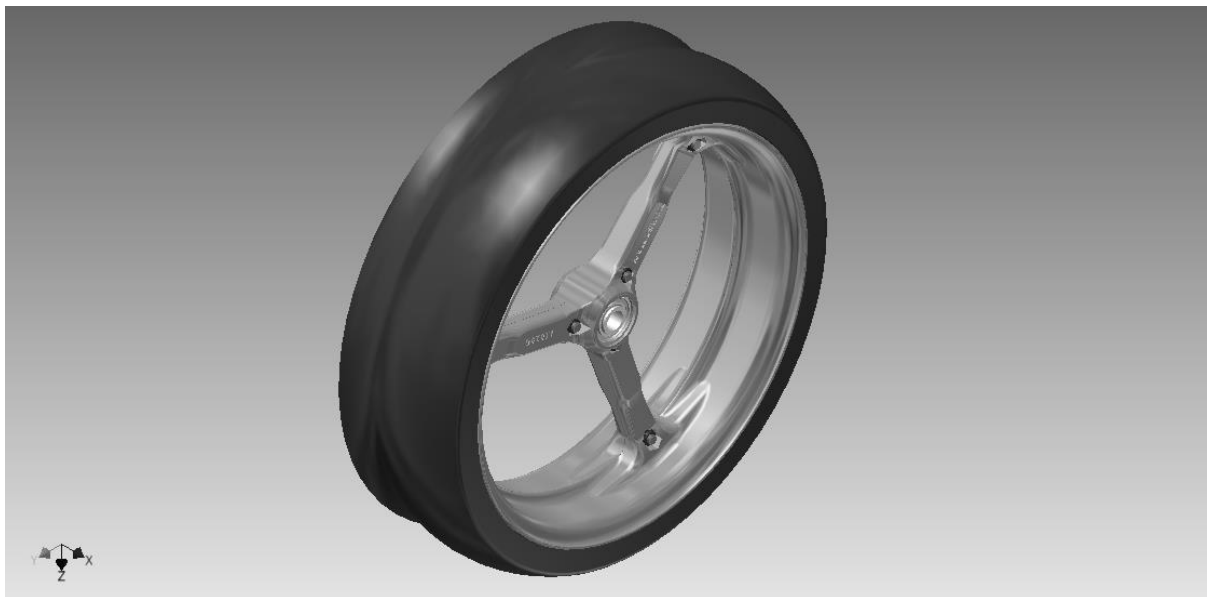


Figure 41 - Gauge Wheel Assembly

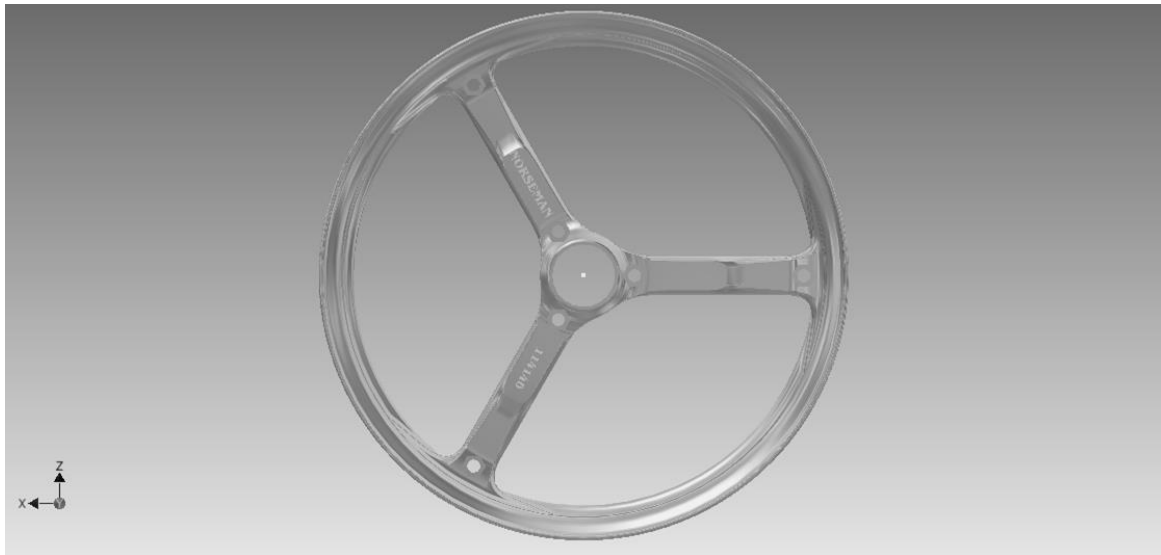


Figure 42 - Gauge Wheel Half Front View

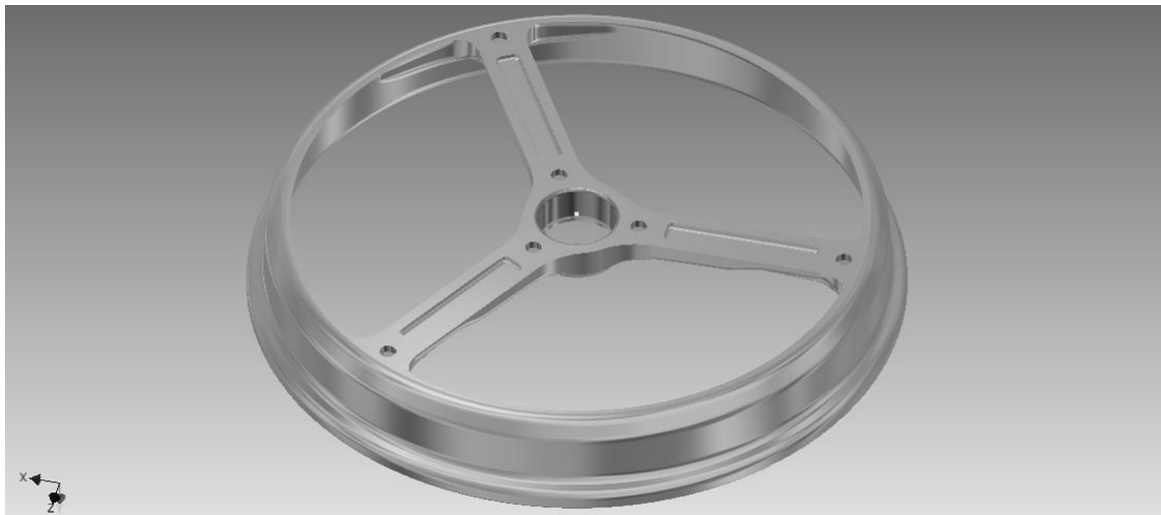


Figure 43 - Gauge Wheel Half Underside View

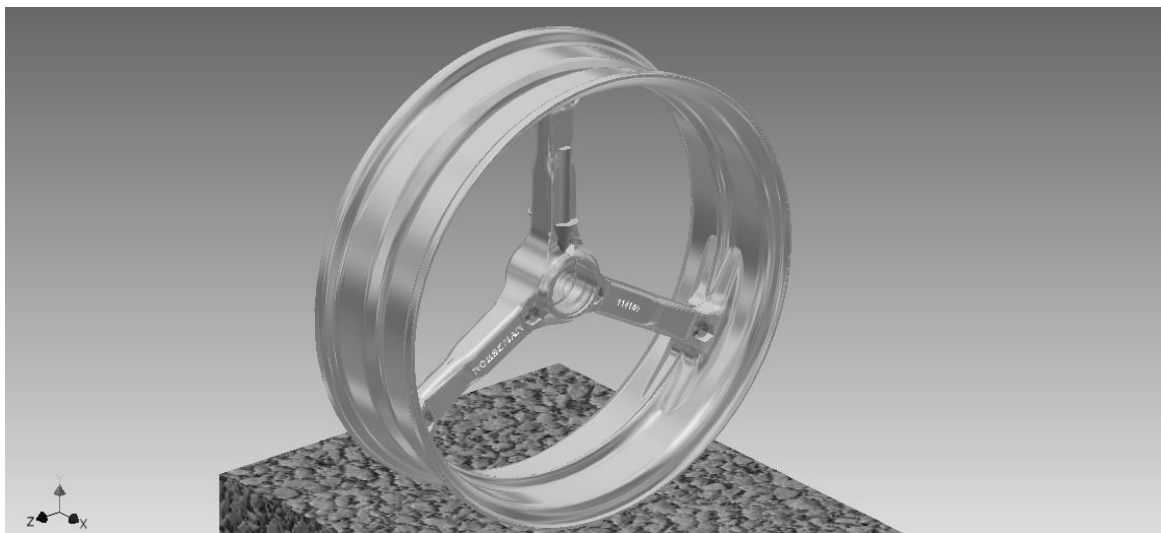


Figure 44 - Gauge Wheel Stress Conditions

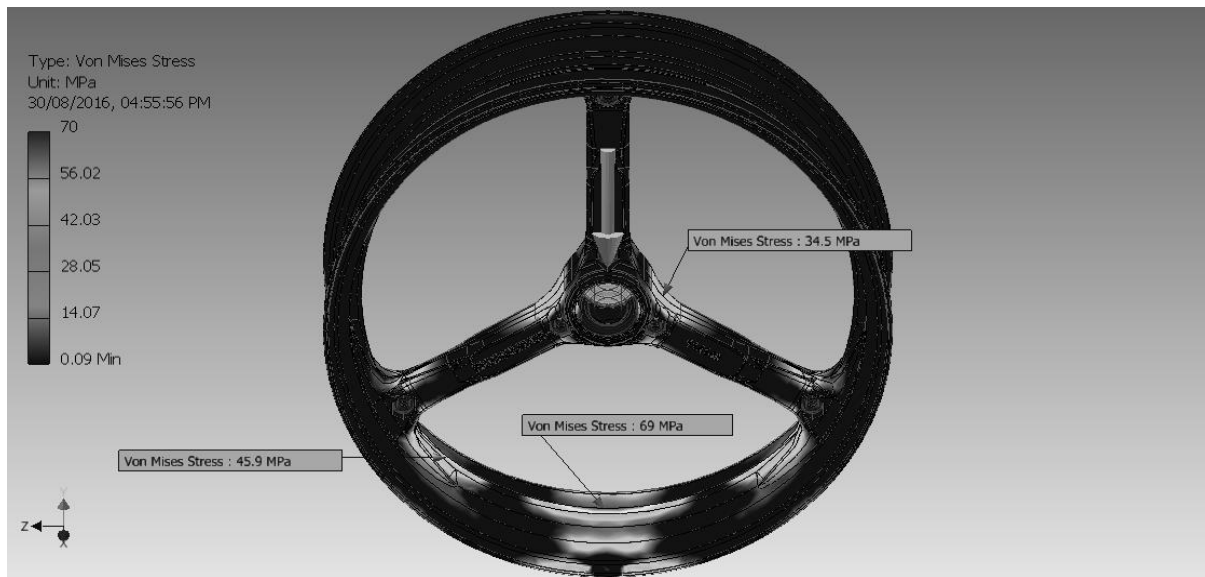


Figure 45 - Gauge Wheel Stress Analysis. Note higher stresses in bends

9.4 Results

Material: SG500/7 Ductile Iron

Mass: 3.2kg

Max Stress: 69 MPa

Yield Strength: 320 MPa

Max Deformation: 0.54mm

The stress is far below the yield strength so strength is not an issue.

9.5 New Design

The priority for the new design was to reduce assembly time. The original pressed wheel was considered as it required fewer parts and assembly operations, and was far more consistent. In that design the bearing was not pressed in, but rather clamped between the two halves. This provided accurate bearing placement, required one less pressing operation and was stronger and more efficient than using circlips to locate the bearing. The new design was modelled to be similar.

Bigger radii were chosen on the joins between the spokes and the rim to increase strength. A consistent wall thickness was applied to ensure even cooling during casting. The placement of the bearing was offset to allow more adjustment as the tyre wears.

Three methods of manufacture were considered: sheet steel pressing, ductile iron sand casting and die-casting aluminium. Quotes were gathered for each and it was found that pressing was the most expensive option at \$75 per rim and \$55000 for tooling, with sand casting also being uneconomical at ~\$40 per rim and \$9000 for tooling. Die-cast aluminium had higher tooling cost than sand casting, ~\$15000, but a lower item cost, ~\$25, as well as higher dimensional accuracy and consistency. Using aluminium also has the benefit of reducing the mass of the wheels and not requiring a surface coating.



Figure 46 - New Cast Gauge Wheel Assembly

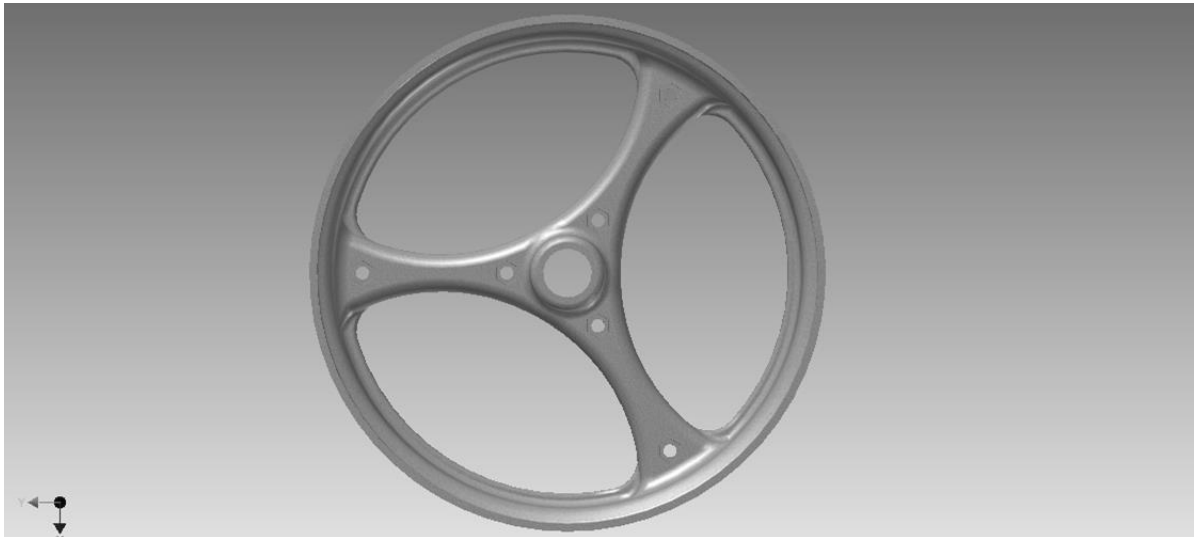


Figure 47 - New Cast Half Front View. Note increased bend radii

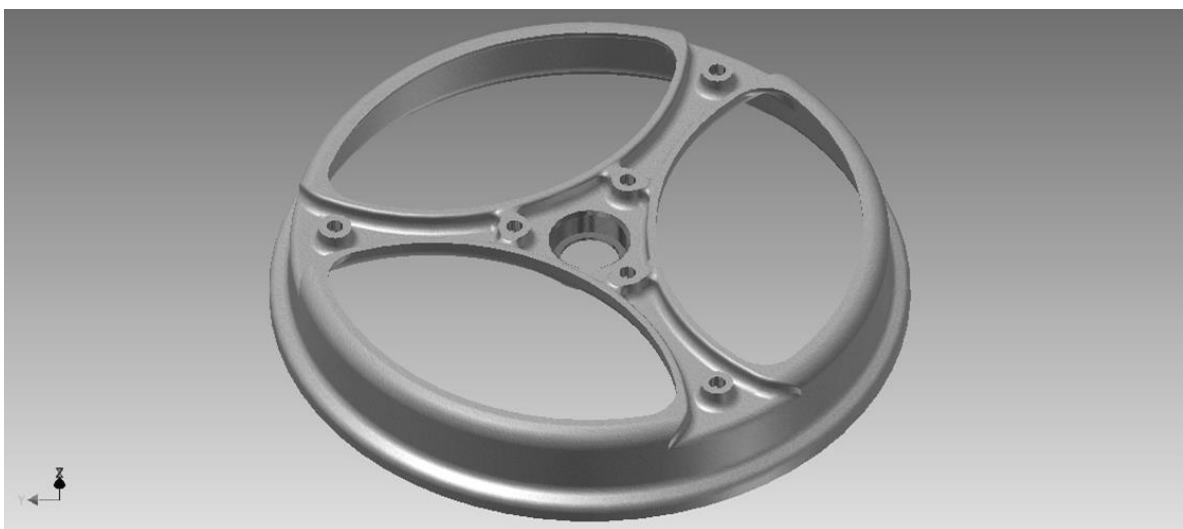


Figure 48 - New Cast Half Underside View

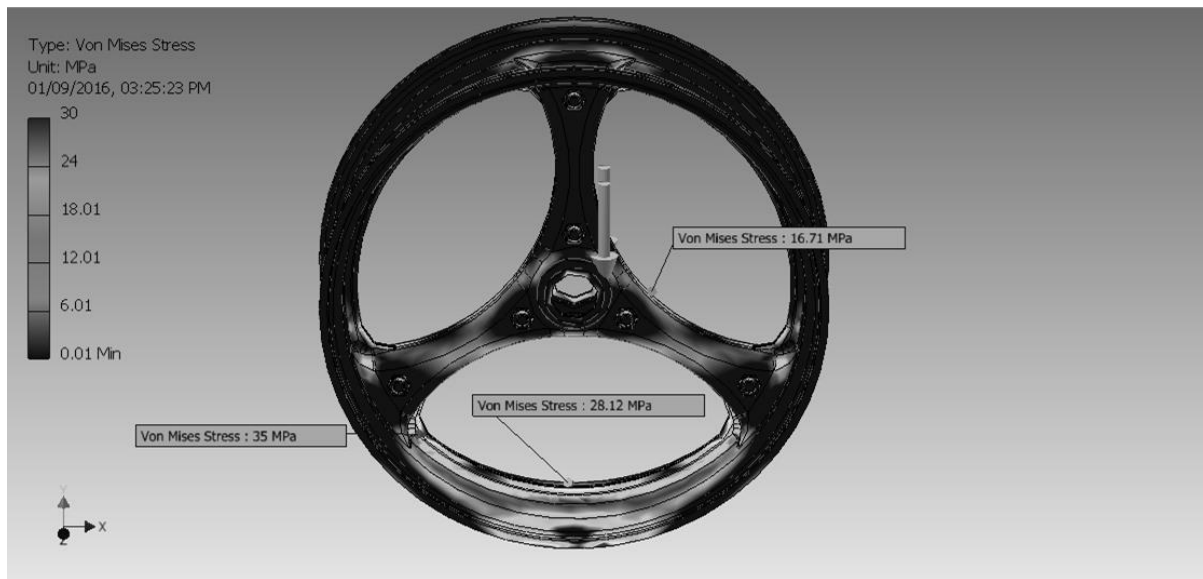


Figure 49 - New Cast Gauge Wheel Stress Analysis

9.6 Results

Material: EA401 Cast Aluminium

Mass: 1.2kg

Max Stress: 35 MPa

Yield Strength: 145 MPa

Max Deformation: 0.42mm

The maximum stress has been halved, but more importantly, the mass has been reduced by 2kg.

10 Throat



Figure 50 – Throat fitted with nonstandard seed tube guard

The throat is bolted to the front of the shank, holds the 15" diameter opening discs and hooks onto the seed tube. A cast seed tube guard attaches to the bottom of the throat with two 6mm roll pins. Originally, Norseman fabricated the throat from sheet steel but many years ago switched to a cast design. The draughtsman at that time did not understand the casting process well and tried to directly replicate the fabricated design as a cast part, even though it was unsuitable. The cast design required a core at the top and bottom of the throat, which raised the tooling and unit cost of the throat. Machining was necessary to give clearance on the bolt heads that hold the disc on. Additionally, the studs that hold the discs were replaced with bolts. This enables the discs to be replaced without removing the scrapers, but increases the difficulty of assembly. No strength issues have ever been reported.

10.1 Current Problems

- Cores required in casting (tooling and casting cost)
- Machining required to clear disc bolts
- Seed tube hook has to be welded on (fabrication cost)
- Weak seed tube guard attachment

10.2 Goals

- Remove need for cores and simplify pattern
- Include seed tube hook in casting
- Reduce machining operations
- Reduce weight whilst retaining strength
- Strengthen and simplify seed tube guard attachment
- Lengthen to enable use of 16" opening discs

10.3 Analysis of Current Throat

The throat was constrained on the top faces where they connect to the shank. The loads placed on the throat were not predetermined, so an upwards force of 3000N, equal to the weight of the whole row unit plus the maximum down pressure, was placed at the disc bolt holes. A side force of 5000N was applied at the disc bolt holes. This force is significantly higher than the normal loading on the throat and was chosen to simulate the discs hitting a rock or stump. (NSWFA, 2013) A small side load of 500N was placed on the disc bolt holes to simulate the force created as the discs roll through inconsistent soils and stubble. These values produced realistic results and were used throughout the entire analysis.



Figure 51 - Throat Assembly

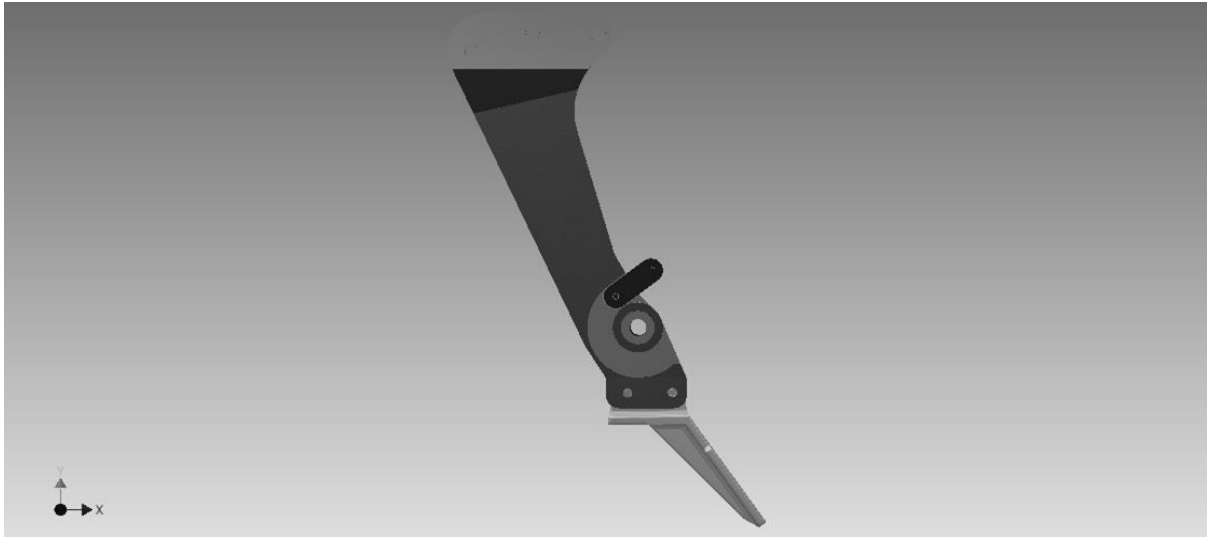


Figure 52 - Throat Assembly Side View



Figure 53 - Throat Assembly Back View

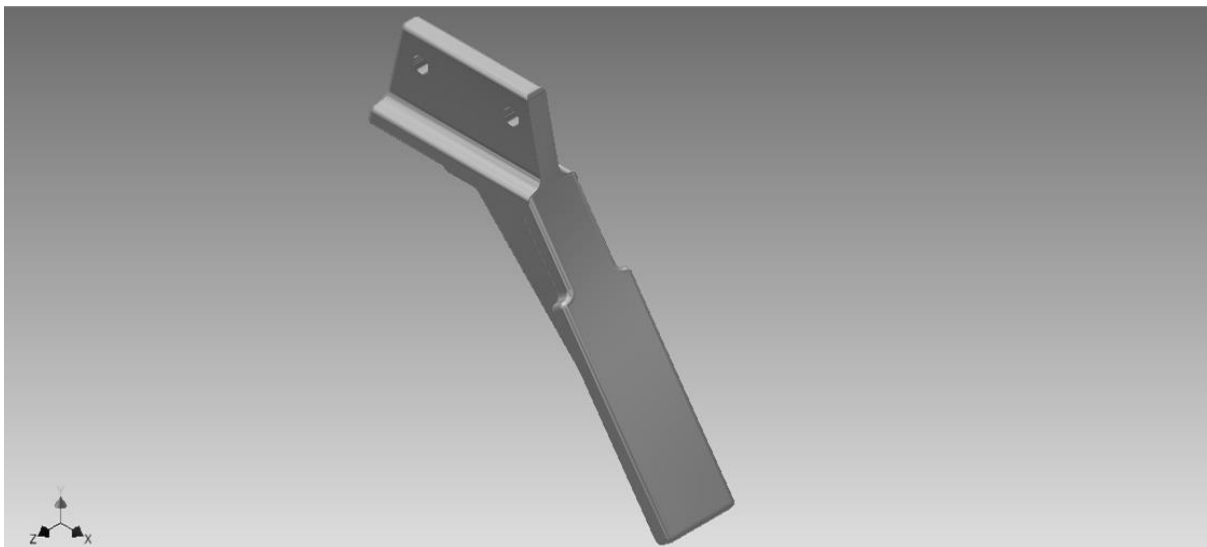


Figure 54 - Seed Tube Guard



Figure 55 - Stress Analysis Conditions

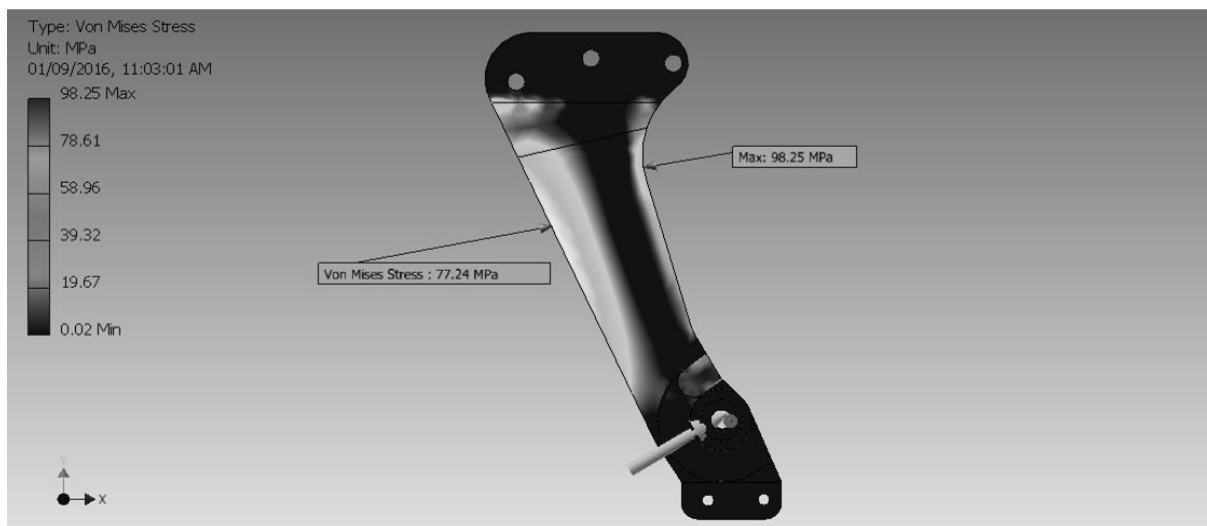


Figure 56 - Stress Analysis Results Side View

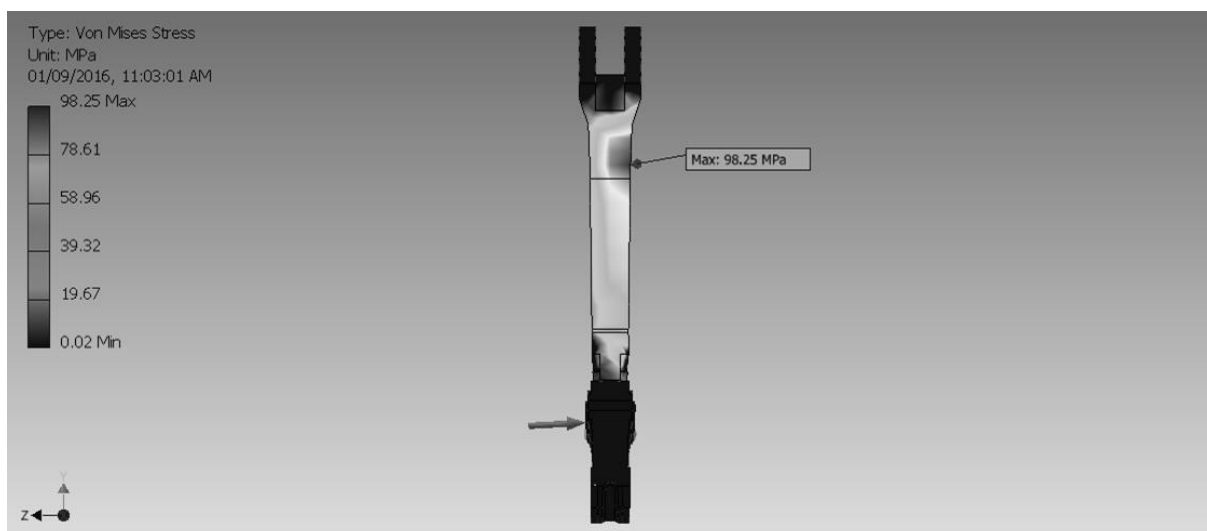


Figure 57 - Stress Analysis Back View

10.4 Results

Material: SG500/7 Ductile Iron

Mass: 3.6kg

Max Stress: 98.25 MPa

Yield Strength: 320 MPa

Max Deformation: 0.49mm

Even under the worst possible load scenario, the stresses are well below the yield strength of the material. Part strength was therefore not the priority for the new design.

10.5 New Design

The priority for the new design was reduced cost and the ability to hold 16" opening discs. The slot at the top served no purpose and so was filled in to remove the need for a core. The throat was made narrower to give clearance on the disc hub bolt heads. The attachment of the seed tube guard presented some difficulty, but a simple solution was found, as seen below.

In order to reduce cost, material was removed from the body of the throat to bring the mass down. In order to maintain similar stresses to the old design a truss and an I beam design were trialed. The truss was overcomplicated and weak, but the I beam was successful.

In order to fit the 16" discs, the bolt holes were moved 13mm lower. This caused the gauge wheels to clash on the disc hubs, so the bolt holes were moved 10mm backwards toward the gauge wheel pivot.

The seed tube hook was integrated into the casting to remove the need for fabrication.

The bolt hole was changed from 5/8" UNC to M20 to allow a bigger stronger bearing.



Figure 58 – Throat Assembly New Design



Figure 59 - Throat Side View New Design



Figure 60 - Throat Back View New Design

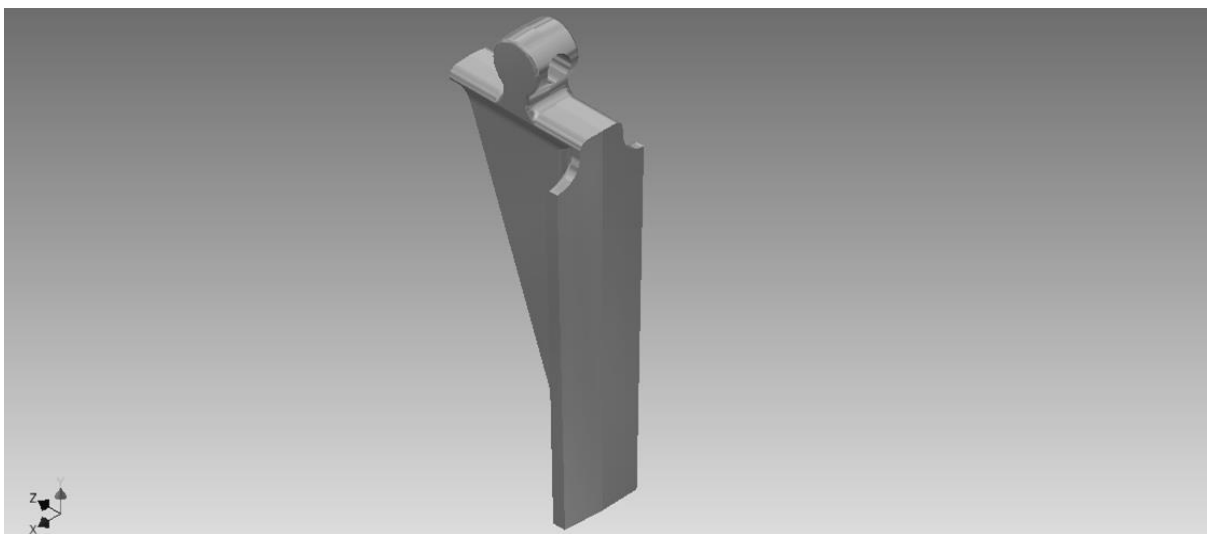


Figure 61 - Seed Tube Guard New Design

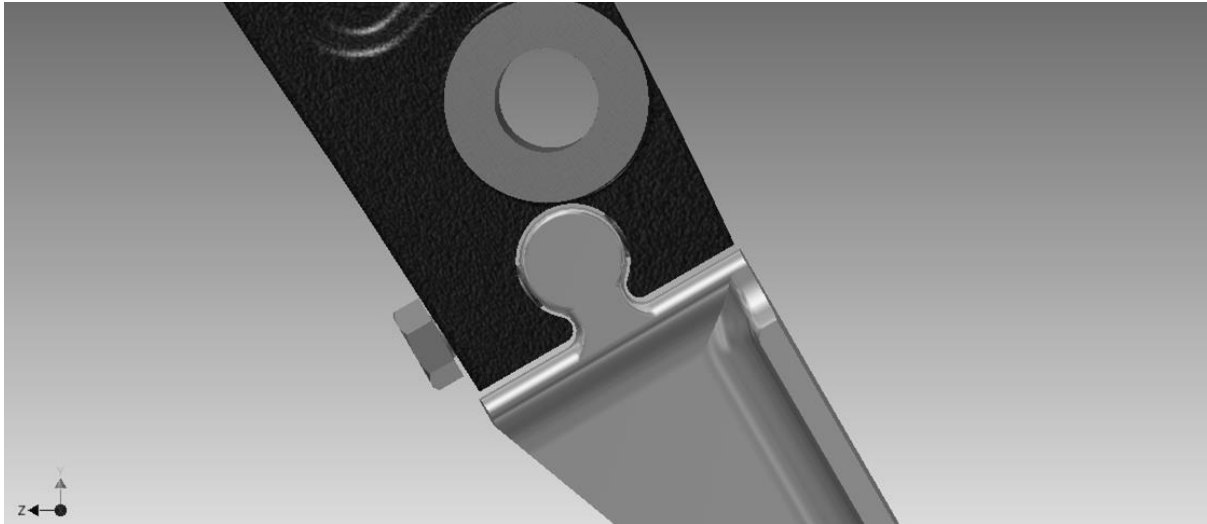


Figure 62 - Seed Tube Guard Attachment New Design

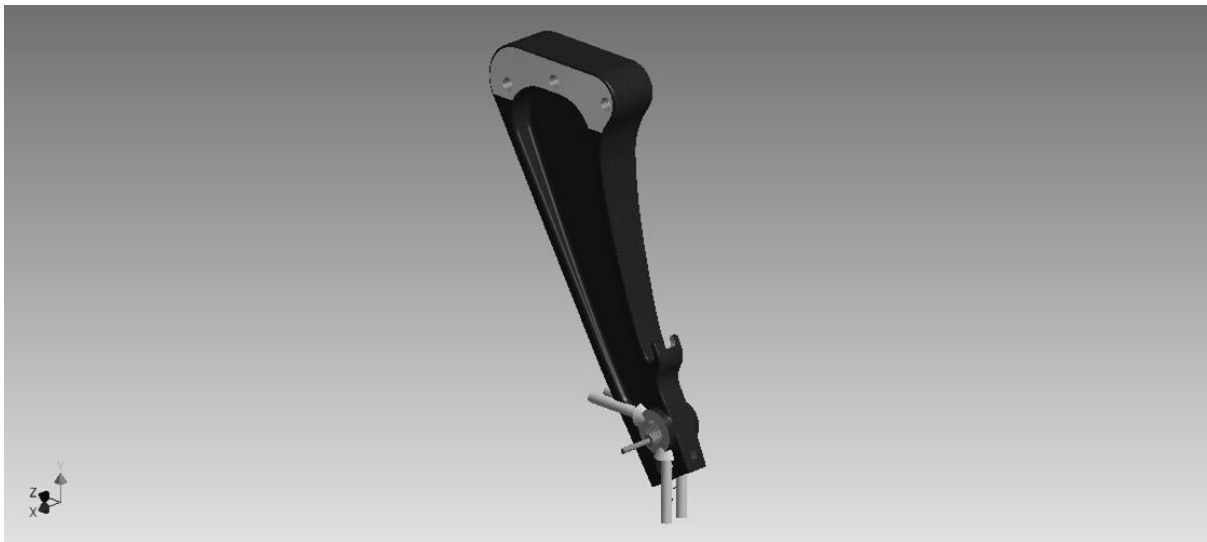


Figure 63 - Stress Analysis Conditions New Design

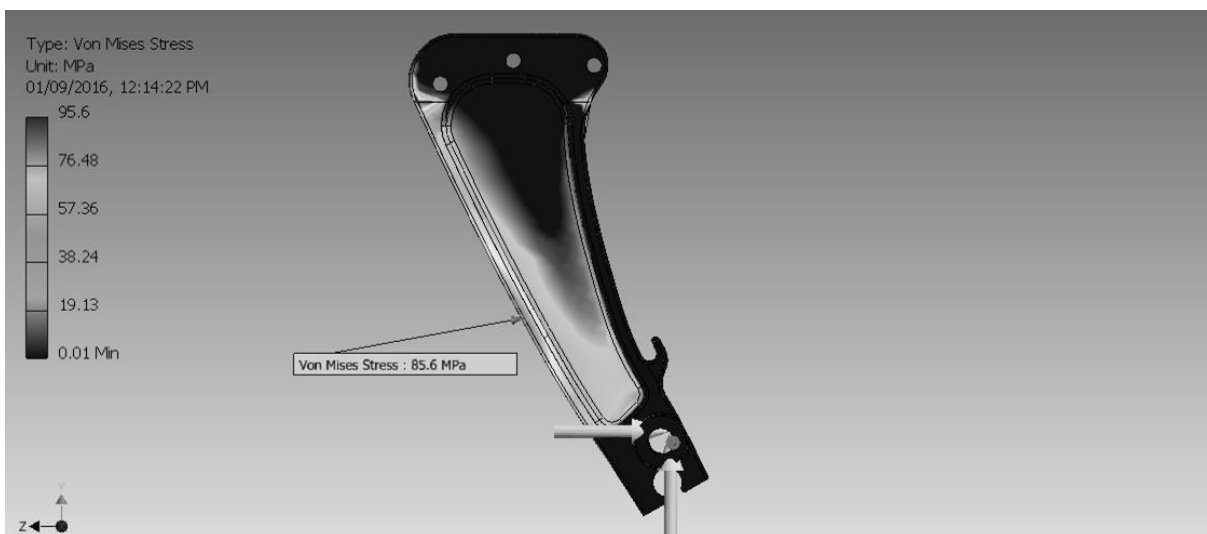


Figure 64 - Stress Analysis Side View New Design

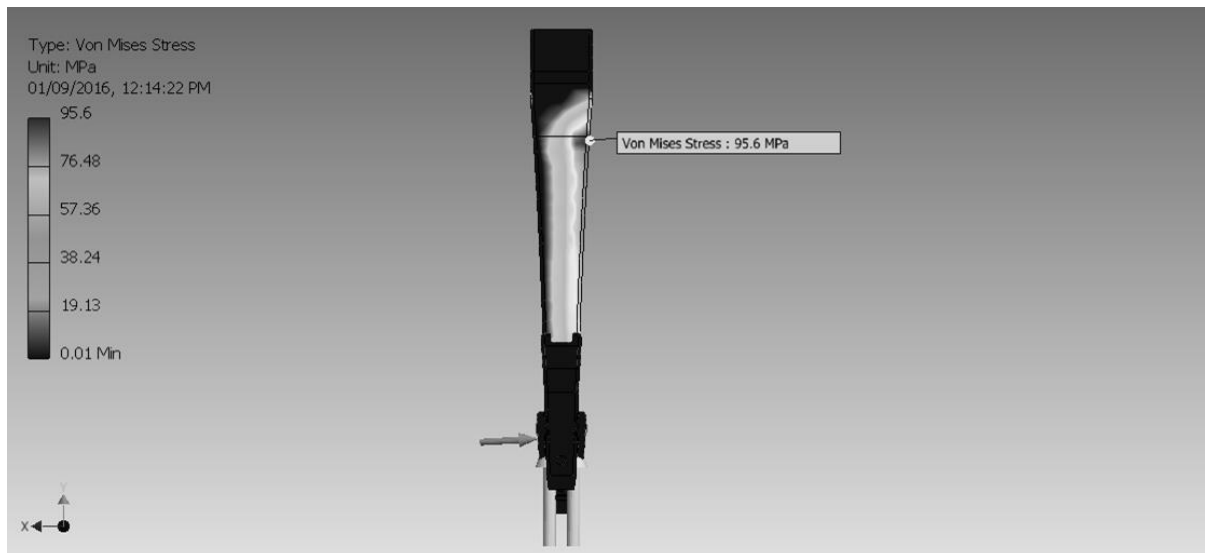


Figure 65 - Stress Analysis Back View New Design

10.6 Results

Material: SG500/7 Ductile Iron

Mass: 2.9kg

Max Stress: 95.6 MPa

Yield Strength: 320 MPa

Max Deformation: 0.58mm

The stress has remained similar with a reduction in mass of 0.7kg or 20%.

10.7 Additional Changes

Attaching a disc to the throat with a bolts enables the replacement of the disc without the removal of scrapers, but makes attaching the disc difficult and time consuming. The assembler has to balance the bolt, washer, disc and shims a locate the bolt hole that they cannot see. By changing to a stud (figure 63), assembly would be simpler and it would be harder to lose shims (an important consideration when working in the field). In order to solve the scraper issue, new scrapers were designed and are described in a later section.

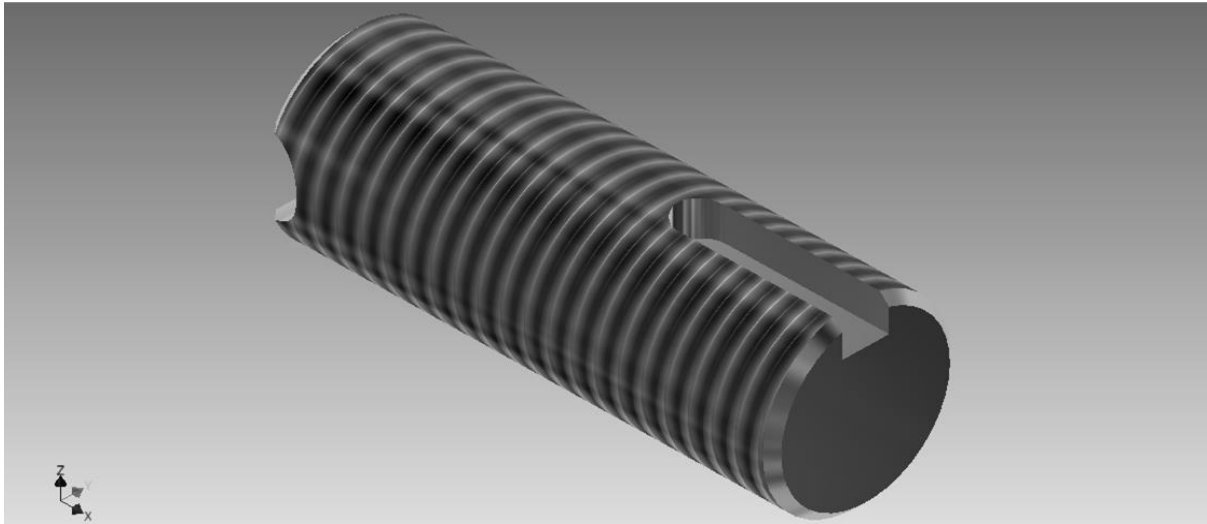


Figure 66 - Disc Stud with Slot for Scraper Location

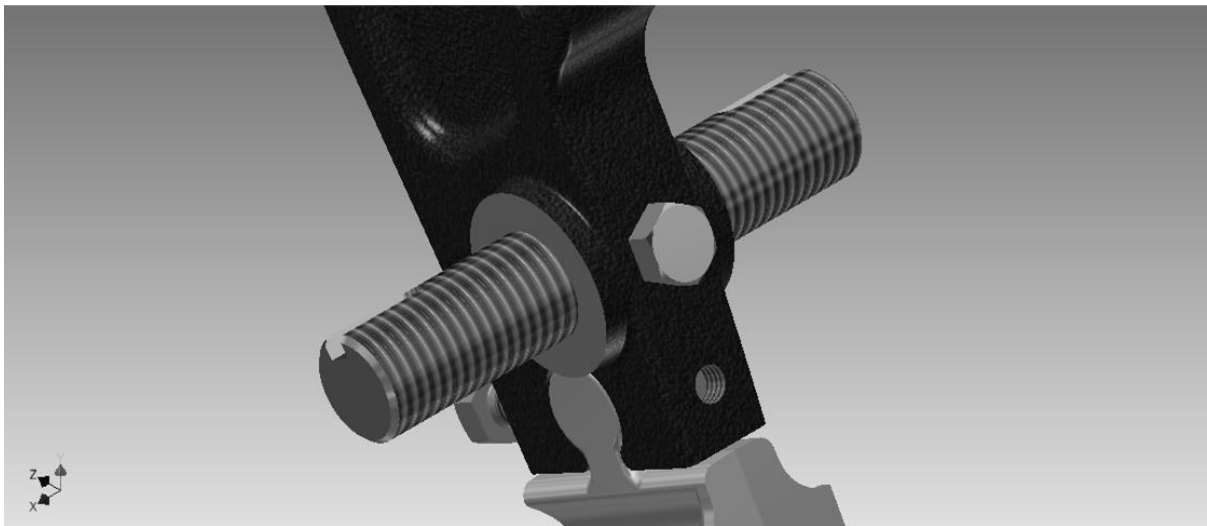


Figure 67 - Close Up of Studs

11 Tungsten Scraper



Figure 68 – Tungsten Scraper

As the opening discs roll through sticky soils, mud accumulates on the disc. (Ashworth M, 2010) This increases the downforce and draft requirements, and soil throw and can cause the disc to stop rotating. To prevent this, scrapers are used to remove mud from the discs. Norseman uses a tungsten edged scraper as well as a custom, steel blade scraper for extra muddy conditions. The tungsten scraper has three parts, a scraper blade assembly, an arm and a tapered shim. The main advantage of this design is that the hardwearing tungsten carbide edge lasts much longer than other steel designs. Unfortunately, it is time consuming to assemble, hard to adjust and does not sit flat on the disc. It sits in a very crowded area of the row unit and can clash on the gauge wheel and arm and will not work at all with 16" discs.

11.1 Current Problems

- Multiple parts
- Difficult to assemble (labour costs)
- Hard to adjust
- Sits at wrong angle

- Does not cover a large enough area
- Clashes on gauge wheels and arms

11.2 Goals

- Reduce assembly time
- Improve clearance
- Increase coverage
- Enable use on 16" discs

11.3 Current Design

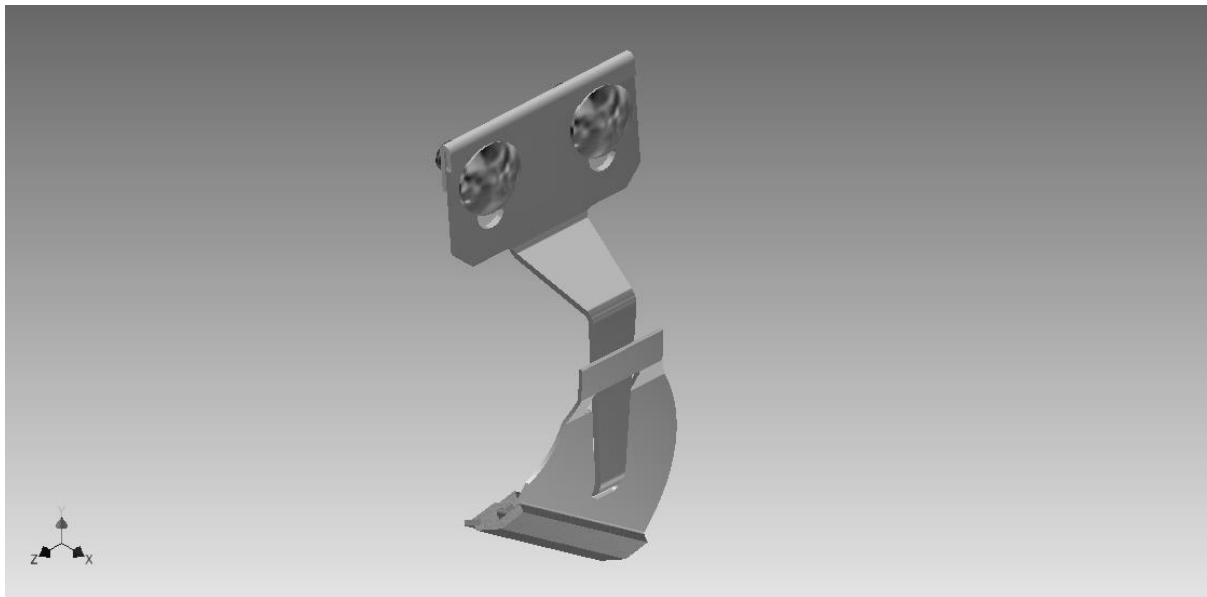


Figure 69 - Tungsten Scraper Assembly

11.4 New Design

In order to provide clearance around the scraper, the attachment point was moved from the shank to the disc hub. This enabled studs to be used, as the scrapers are removed with the discs and do not interfere with them. A keyway is machined into the disc stud to locate the scraper on the disc and the scraper and disc are locked in place by the same nut. The scraper is one unit, consisting of a tungsten carbide blade brazed to a pressed stainless steel arm. The round end of the arm is large enough to cover the bearing and protect it from damage. It involves less parts, is much faster and easier to assemble and does not clash on the gauge wheel arm or scraper.

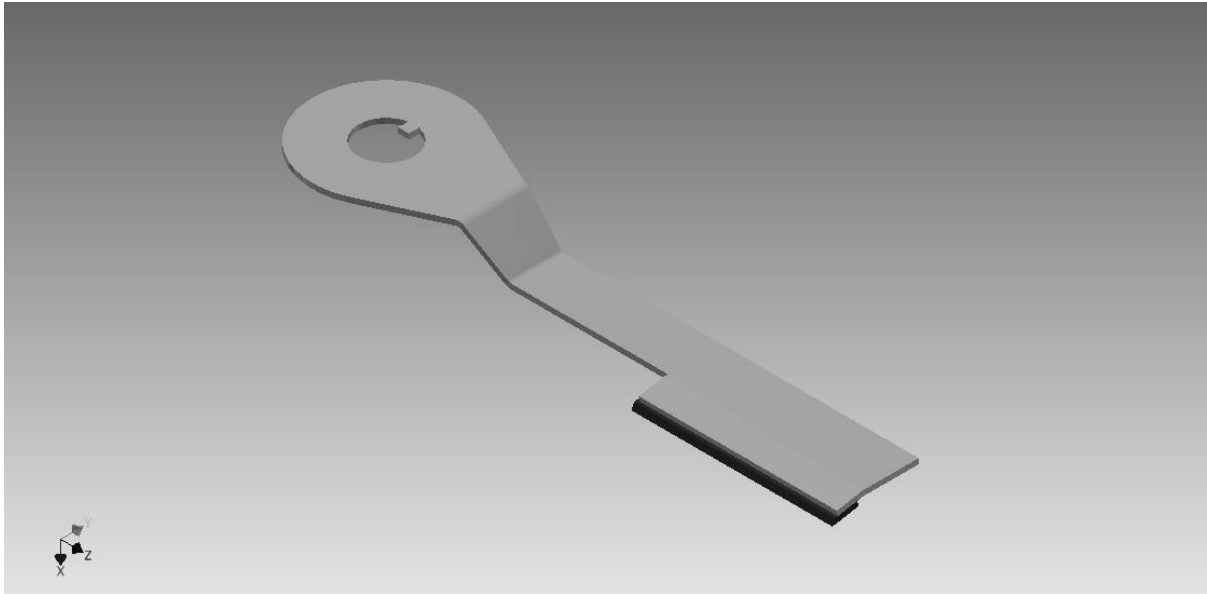


Figure 70 - New Tungsten Scraper

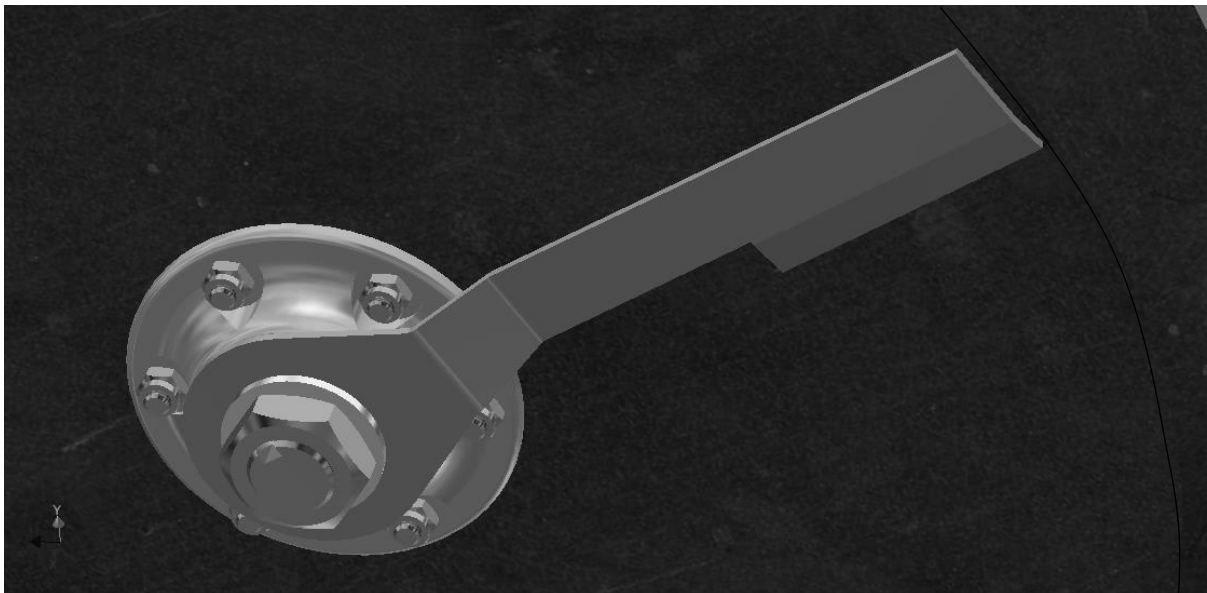


Figure 71 - New Tungsten Scraper on Row Unit

12 Conclusions

It is too early to state the benefits of all the changes recommended, but the benefits of already implemented changes and the expected benefits of future changes can be described here.

12.1 Workshop Layout

12.1.1 Existing benefits

At the point of writing, the first two stages of the new workshop layout have been implemented. The former stores area has been cleared out and the pallet racks moved to the side wall. The assembly area has been shifted and the space it occupied has been filled with small component storage and stillages.

Moving the stores area and consolidating it into a smaller area has dramatically increased the amount of free space in workshop. This allowed the pipe room to be emptied, therefore allowing the pallet racks to be cleared and filled with pallets that used to reside on the floor. Whilst moving the stores area has benefitted the workshop overall, it is too early to comment on whether it has made the stores department more efficient as the 300t press still needs to be shifted, and there has not been a full-time storeman stationed there.

Moving the component assembly area into the north-west corner of the workshop has significantly improved the ease of access and working conditions for the assembly department. By being in the main section of the workshop, travel distance has been reduced by 30m and travel times have been shortened accordingly. Completed row units can be moved directly from the unit racks to machine assembly without needing to move the unit racks. By storing parts for units close to where they are needed, there is no longer any need to pick them, saving four hours per work order and approximately 200 hours per year. Also, by storing those parts together, the travel time for assemblers is greatly reduced.

Relocating the small components and stillages gave an opportunity to assess the value of storing each component, resulting in around 200 different components being archived and removed from storage. This freed up a substantial amount of storage space and eliminated the warehousing costs associated. By creating a rack just for small components, it became possible to consolidate 15m of racking into a 6m space, reducing travel time. Removing small components from the pallet racks cleared 28 pallet spaces, removing the need to store pallets on the ground.

By storing small components on a smaller rack and storing related parts together, picking time has been reduced significantly by up to 50%. Positive feedback has been received from workshop staff and it is expected that efficiency will increase as staff become more familiar with the new system.

Moving the pallet racking from the former stores area to the south wall added an extra six pallet spaces and enabled the entire south wall to be utilised for storage.

12.1.2 Expected benefits

Moving the robot welder and 300t press towards welding bay 1 will free up space for the stores area and create a proper packing space.

By keeping the fabrication equipment together, travel time will be reduced by 15 seconds each way. Work orders of up to 100 parts are common and in those cases, up to 50 minutes of travel time will be saved and workers will not need to walk across forklift paths. Additionally, access to the drill press will be dramatically improved.

Storing welding jigs in the welding bays will be far more convenient and reduce travel time for the welders.

12.2 Production Plan

Unfortunately, not much of the production plan has been implemented at this stage. The full implementation will take place over the next year. The biggest hindrance to the success of this project will be difficulties in implementation. One aspect is the amount of time required to do tangible jobs like stocktaking and staff training. The far bigger difficulty is changing the culture of the workplace and attitude of the workers. Currently the attitude could be summed up as, “Just get the job done” with little regard to what is involved in achieving that. This disregard for proper process is the cause of the inefficiencies this project seeks to solve. If this is going to be successful, the entire company needs to undergo a culture change and adopt a mindset of, “Do the job right and do it well.” Historically, attempts to improve Norseman’s productivity have failed after a week or two because it is always easier to return to old habits and processes, than to adopt new ones. It is vital that the management takes on board the recommendations of this report and champion their implementation, for without their involvement, nothing will change. It will take months, but if the new processes are cemented in place in the first half of next year, then the company will be in a good position to handle the busy season in the second half of the year. If fully adopted, the recommendations in this project will significantly improve efficiency and productivity, reduce waste, improve working conditions and deliver a more reliable and desirable product for farmers.

12.3 Component Design

12.3.1 Existing benefits

The only component to reach production at this stage is the gauge wheel arm. A production run of 1064 was manufactured by Intericast & Forge in Adelaide. The finished price was \$14 each, one dollar cheaper than the old Chinese made arms. The main financial saving is in the increased quality and

consistency of the new arms, which removed the need to check each arm and discard any rejects. Testing of the old arms revealed distortion of up to 5mm across the length of the arm, whilst the new ones had less than 0.5mm. Assembly is also simpler and requires less parts. Positive reports have returned from farmers using the new arms, and the maintenance worker responsible for installing them on existing machines has noted the improvement in consistency and strength.

12.3.2 Expected benefits

The new gauge wheel halves are expected to significantly reduce assembly time thanks to the reduced number of operations involved, as well as not requiring the visual checks and half matching needed because of the inconsistencies of Chinese sandcasting. AF Diecasters in Melbourne quoted \$10 per wheel half, 50% less than the final cost of the current Chinese ductile iron wheel halves. At the current rate of 2000 halves per year, this represents a \$20000 annual saving in part cost alone, without taking into account the reduced assembly cost. The increased consistency should result in a better product and a smoother running wheel.

Large financial savings are expected from the new throat design. Because of the complexity of the current design, the current cost is \$70 plus some fabrication costs. Initial quotes from Interblast & Forge arrived at less than \$30 per throat. With the current demand of 500 per annum and a saving of \$40 each, an annual saving of \$20000 can be expected, as well as a saving in fabrication costs. The new seed tube guard attachment is stronger and will result in no more seed tube guards falling out during use.

Switching to a disc stud will make attaching the opening discs easier in the workshop and in the field, but more importantly, allow the use of the new radial scrapers. Assembly time for the current tungsten scrapers is around 5 minutes, but because the radial scraper attaches to an existing stud, assembly time is reduced to 5 seconds. This saves up to an hour per machine. Less parts and fasteners are involved, coverage is increased and the angle of attack has been changed to provide positive engagement on the disc.

13 Final Statements

Despite its current shortcomings, Norseman does have the capability to meet market demands and provide high quality products, at competitive prices in a timely, efficient manner. By aiming to constantly increase productivity and efficiency, whilst improving their product lines, Norseman can expand and firmly establish their position in the demanding Australian manufacturing environment.

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15 Appendix A - Project Specification

ENG4111/4112 Research Project

Project Specification

For: Andrew Reeson

Title: Improvement of Production of Double Disc Planters

Major: Mechanical

Supervisor: Ray Malpress

Enrolment: ENG 4111 – ONC S1, 2016
ENG 4112 – ONC S2, 2016

Project Aim: To redesign the Techniplant row-unit to make it better, cheaper and easier to build.
Also to formulate an improved workshop layout and production plan.

Programme: Issue A, 11th March 2016

1. Interview farmers, workers and management about improvements to be made. Compare suggestions to existing solutions.
2. Improve aspects of the production plan that has been identified as inefficient.
 - a. Develop new workshop layout to improve workflow and storage space.
 - b. Draft new stores management plan to prevent bottlenecks and inefficiencies.
3. Improve design of row unit to increase production rate, reliability and effectiveness.
 - a. Design gauge wheel arm with built in adjustment.
 - b. Design more accurate gauge wheel.
 - c. Design new row-unit.

If time permits

4. Implement new design and oversee production run of new row-units

16 Appendix B – Feedback from Interviews

16.1 Powder coaters and electroplaters

- Design parts with attachment point for hanging
- Avoid designing hard to reach places
- Ensure acid bath can drain out of parts

16.2 Machinists

- “If you make a mistake and we have to fix it, we make money”
- The more complex and time consuming components are, the more money they can charge and therefore they were not interested in helping with this project

16.3 Foundry

- Avoid thin sections
- Avoid the need for cores
- Reduce the amount of machining needed on finished components

16.4 Laser cutters

- Prefer easily tessellated shapes
- Thick materials do not cut well

16.5 Management

- Better predict lead times
- Place standing orders with suppliers
- Improve stores department
- Press shank sideplates on 300t press
- Remove need to machine shank sideplates
- Change to 16” opening discs
- Upgrade to stronger disc bearing
- Change to 8° disc angle
- Change to M20 disc bolt
- Simplify throat casting
- Strengthen gauge wheel arms
- Strengthen gauge wheel arm stud
- Put guard on press wheel carrier spring
- Change components that are copies of other manufacturers
- Increase parallelogram bolt size to M20

- Standardise to metric fasteners
- Standardise to clear zinc fasteners
- Remove unnecessary adjustability
- Improve tungsten scraper design
- Increase scraper coverage
- Remove vertical adjustment on mount plate
- Change to M20 U Bolts
- Strengthen seed tube guard attachment
- Change diffuser mount
- Change hopper support panel to allow access to meter door

16.6 Storemen

- Improve design process and reduce the amount of field testing necessary
- Clearly define roles and limit crossover
- Employ dedicated salesman
- Have list of jobs ready for workshop staff. Eliminate need for them to consult workshop staff
- Have back up jobs for staff
- Stocktake whole shed
- Keep each part in one location, not multiple
- Store related parts together
- Store common parts in easy to reach places
- Use different coloured bins for storage and picked work orders
- Use different coloured bins for different orders
- Add any changed to the back of work orders
- Do not mix second hand parts with new parts
- Organise work order listing according to location
- Purchase more parts bins

16.7 Fabricators

- Replace worn shank side plate pressing dies
- Store fabrication parts together
- Label stillages better
- Pick work orders in advance
- Order parts before they run out
- Have clearer dimensions on technical drawings

- Every worker should have their own tools
- Reduce the need to press steel plate
- Remove meter bulge in shank side plate
- Strengthen shanks
- Make gauge wheel arm attachment point more consistent
- Simplify press wheel carrier arm
- Remove robot welder
- Remove 300t press
- Install roller setup for bandsaw

16.8 Assemblers

- Make tungsten scrapers faster and easier to assemble
- Fix wobbly discs
- The seed tube guards are too wide
- The seed tube pin holes in the shank are mushroomed
- Standardise placement of heavy duty scraper
- Remove adjustability in stop block
- Ensure lower parallelogram arm width before assembly
- Pick orders in advance
- Prevent staff from raiding shelves for parts and not signing them out of stock
- Process receivals and dispatches immediately
- Build picking trolley
- Store related parts together
- Minimise double handling
- Store common parts in easy to reach places
- Have a discrete location for every part
- Reduce travel time
- Clear rack space for receivals and dispatch
- Clear rack space for picked work orders
- Do not mix second hand parts with new parts
- Store Precision Planting parts downstairs
- Have full time production manager to organise jobs and oversee production
- Order parts before they are needed