



Amazon Series 5 Bottom Blade Grinder Operation and Maintenance Manual



Hunter Grinders

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SECTION 1 - SAFETY

General Safety Precautions

WARNING! Read these safety instructions before using the equipment

- ⚠ Never use this equipment unless properly trained and authorised. Keep children away from the work area.
- ⚠ Eye protection manufactured to the current European Safety Standards must be worn when operating this equipment. Everyday glasses do not have impact resistant lenses, and are not safety glasses.
- ⚠ Always check for damage before using this equipment. Any damage should be properly repaired. Until the damage has been repaired the equipment must be isolated to prevent use.
- ⚠ Always ensure that all safety guarding is in place, and free from damage. Do not alter guarding.
- ⚠ Always ensure that adequate lighting is available. Ensure that the lighting is adjusted so that the work area is not in shadow.
- ⚠ Always use a face or dust mask if the operation is particularly dusty.
- ⚠ Always isolate the equipment from the power supply before servicing and when changing accessories.
- ⚠ Should access to the main electrical control box be required, the machine must be isolated from the mains power supply. Under no circumstances enter the control box with the power connected as this could result in electric shock.
- ⚠ Do not use the equipment in damp or wet locations or if exposed to rain.
- ⚠ Do not use if exposed to an explosive atmosphere, such as paint or solvent fumes, or flammable liquids.
- ⚠ Always keep the work area clean and clear.
- ⚠ Always wear the proper apparel. Secure loose clothing and jewellery. Wear a protective hat to contain long hair.
- ⚠ Never operate the equipment whilst under the influence of drugs, alcohol or certain medications.
- ⚠ Do not use the equipment for any other purpose than that for which it was designed.
- ⚠ Always switch off the equipment in the event of excessive vibration, and investigate the cause before proceeding.
- ⚠ Avoid prolonged contact with cooling fluids and lubricants. Wear suitable gloves or use barrier creams to limit contact. Discontinue use and seek medical advice if skin irritation is caused.
- ⚠ After switching off, always allow sufficient time for the grinding wheel to stop before touching.
- ⚠ Never place hands on or near the grinding wheel when it is rotating.

Grinding Safety Precautions

- ⚠ Eye protection manufactured to the current European Safety Standards must be worn when operating this equipment. Everyday glasses do not have impact resistant lenses, and are not safety glasses.
- ⚠ Grinding wheel dressing, truing and replacement should only be carried out by operators correctly trained in the safe use of abrasive wheels as detailed in the Provision and Use of Work Equipment Regulations 1998 (PUWER 98)
- ⚠ Always replace a cracked wheel immediately.
- ⚠ Never operate without the wheel guarding in place.
- ⚠ Do not remove the wheel guard except when replacing a wheel or carrying out maintenance.
- ⚠ Always use a grinding wheel suitable for the speed of the grinder. Replacement wheels should be approved for their purpose.
- ⚠ Do not over stress the grinding wheel.
- ⚠ After switching off, always allow sufficient time for the grinding wheel to stop before touching.
- ⚠ When grinding is complete always switch off the machine and wait until the grinding wheel has come to a complete stop before removing the cylinder or bottom blade from the machine.

Safe Operation of Machine

The machine has been designed to function in a safe manner. It can be operated with the front guard in place or elevated. Do not alter or modify the machine in any way. Never disable emergency stop buttons and always isolate the machine when entering the electrical control boxes.

SECTION 2 - GRINDING MACHINE OVERVIEW

Please note there will be a number of references/descriptions in this manual which you may not be familiar with, these are as follows.

Bottom blade: meaning Bed-knife.

Cutting unit: meaning the complete cutting head (cylinder/reel still mounted in its frame).

Hand-mower: meaning Pedestrian mower or Walk behind mower.

Description of features

Amazon Bottom Blade Grinder

The Amazon Bottom blade Grinder enables you to grind most common bottom blades/bed-knives true and accurate with the appropriate manufacturer's relief angle. When set up you can grind the top and/or front face individually or at the same time. You also have the ability to apply in-feed cuts and traverse either manually or automatically.

The base of the unit houses a one-piece cast iron bed to give strength and durability, and reduce the effects of shock and vibration. All bearing surfaces are precision machined to give exceptional accuracy.

The unit is supplied with a tank mounted coolant pump to supply coolant to the cutting area, preventing localised heating and distortion of the blade. The coolant also minimises the release of grinding dust into the atmosphere.

All Hunter grinding machines should be installed by fully qualified engineers from Hunter Grinders.

All purchasers of our machines should be trained for the safe and correct use of our grinding machines.

A full set of comprehensive instructions are provided with each machine on delivery and installation.

Handling of grinding machines: Normally carried out by Hunter Grinders. If you wish to re-site your grinding machine, contact Hunter Grinders for help or advice.

Correct use of the machine as outlined in the comprehensive instructions. In the case of any misuse of grinding machines, Hunter Grinders will NOT BE LIABLE should any accident occur.

The maintenance of the grinding machine is detailed in this document, but regular maintenance is recommended to be carried out by one of Hunter Grinders qualified service engineers. Contact Hunter Grinders: 01462 683031 for all your servicing requirements.

Training: The grinding machine must only be operated by trained personnel. Certificated training and retraining of operatives can be arranged with Hunter Grinders. If unsure of any procedures outlined in these instructions, please contact Hunter Grinders who are able to offer advice, help and training in all aspects of the equipment.

 **Always follow the safety features as outlined in the instructions.** Eye and ear protection must be worn at all times when operating the grinding machines.

For any further information or spare parts contact, Hunter Grinders.

Identification of Machine

Customer:

Machine Type: Amazon Series 5

Serial Number:

The machine to which this manual refers can be identified by the serial number plate attached to the machine.

Machine Installation Requirements

Electrical Supply: 240VAC Single Phase, Neutral and Earth
13amp 50/60Hertz
13 amp fuse required
Compressed air supply: Not required
Positioning: On a firm level floor, sited indoors

Machine Specification

The machine is designed to grind front and top edges of bottom blades.

Grinding wheel size (Taper cup): 150mm x 50mm x 31.75mm
Grinding wheel size (Square cup): 150mm x 50mm x 31.75mm
Rotational speed: 2800 Rpm
Grinding motor(s) rating: 0.75 KW
Traversing motor rating: 90 W

Please note that the details and specifications contained herein are correct at the time of going to print. Hunter Grinders reserves the right to change specifications at any time without prior notice.

SECTION 3 - OPERATING INSTRUCTIONS

Bottom blade preparation and mounting

- ⚠ Ensure that the grinding machine power is switched off to prevent accidental start-up

The bottom blade should remain attached to the sole plate used to fix it to the mower. Clean any accumulated dirt and grass from the blade, and inspect to ensure that it is not bowed or twisted.

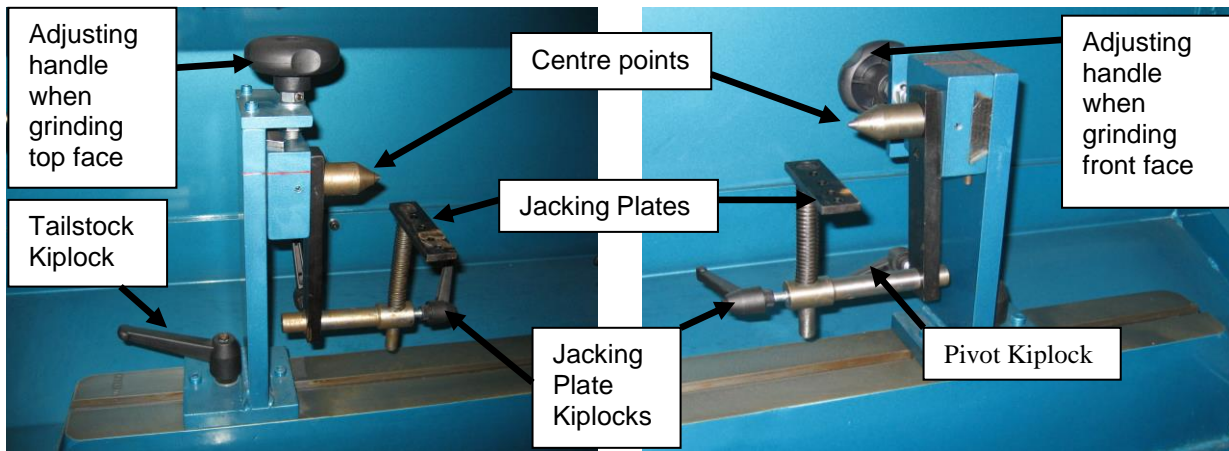


Figure 01 – Left hand Tailstock

Figure 02 – Right hand Tailstock

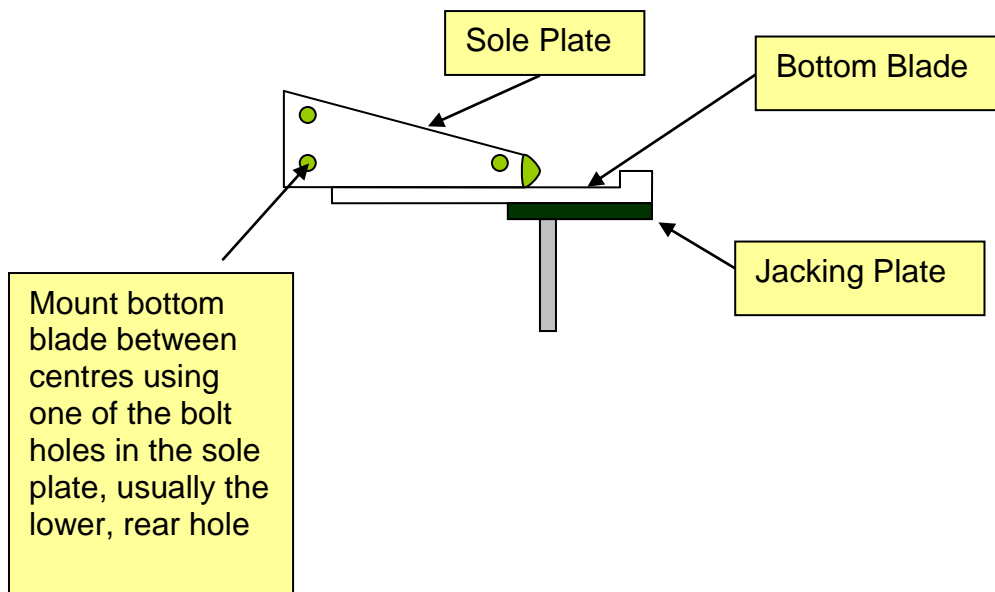


Figure 03 - Bottom Blade mounting

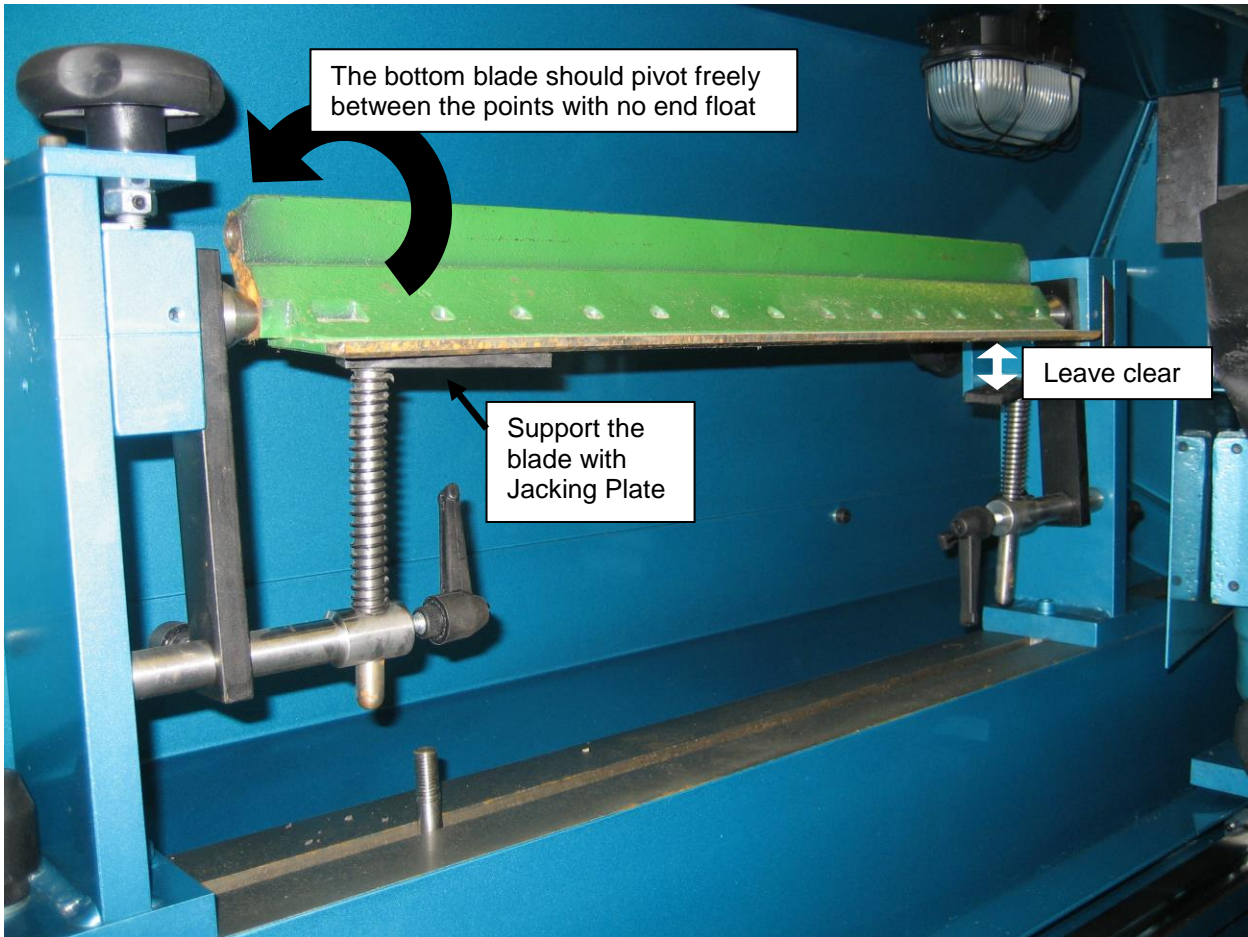


Figure 04 – Bottom Blade mounting

Depending on the manufacturer, the sole plate usually has a number of mounting holes at each end, typically one to three. Normally the lower rear bolt holes are used. Check that the chosen mounting holes are not worn out of shape and are free from burrs. Mount the bottom blade between the centre points of the tailstocks. The tailstocks should be brought together and tightened sufficiently to prevent any end play or float, but not excessively tightened which would cause blade distortion. The blade should be able to pivot up and down freely between the tailstock centres, without any end float (fig 04). Support the blade with one of the Jacking Plates, leaving the other Jacking Plate clear of the blade.

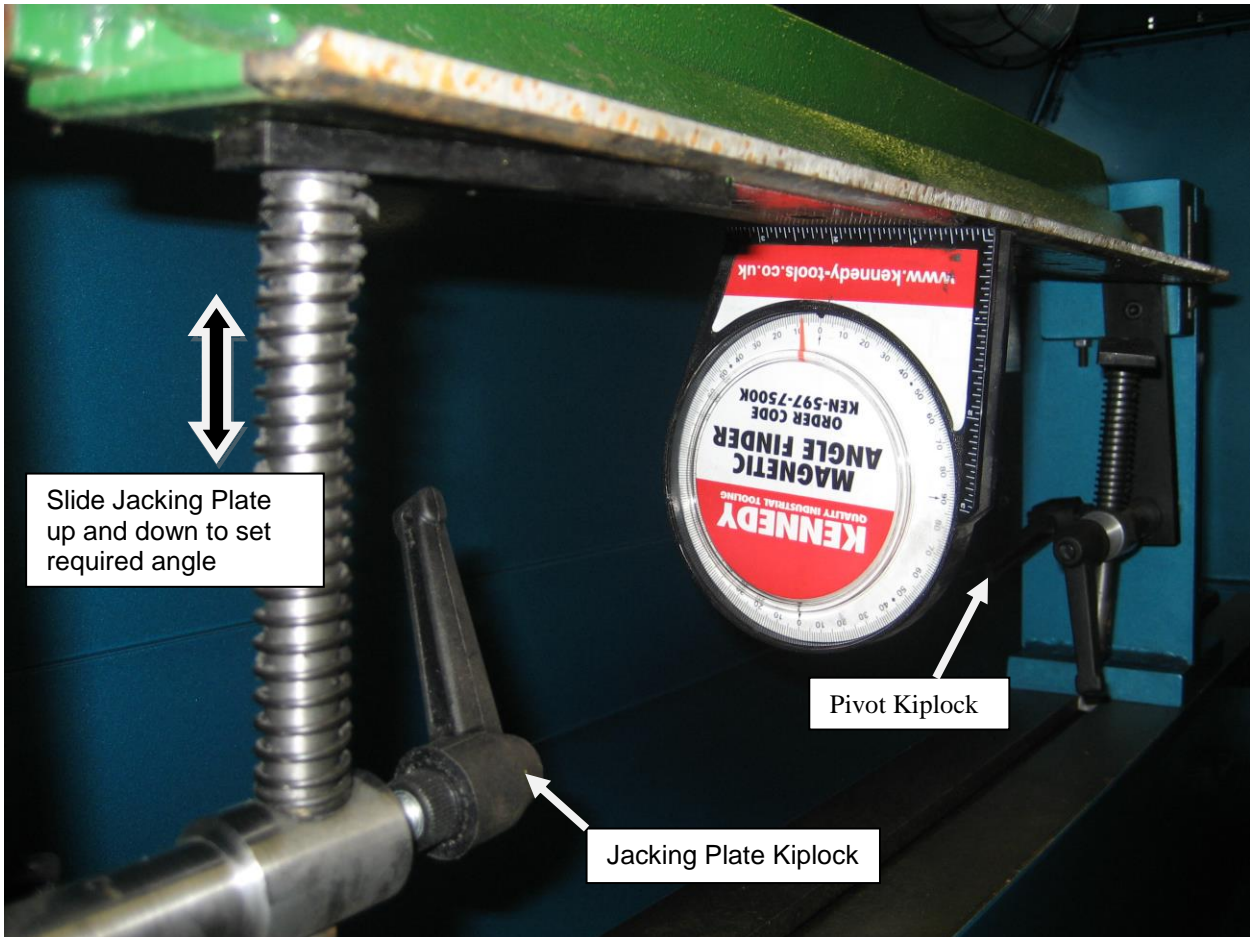


Figure 05 – Setting top face angle using Magnetic Angle Finder

Release the Jacking Plate Kiplock and carefully adjust the Jacking Plate up or down using a twisting action. Once the desired angle is achieved lock the Jacking Plate Kiplock again. With the Bottom Blade now set at the required angle release the second Jacking Plate so that it also supports the Bottom Blade. It may be necessary to release the Pivot Kiplock (see Fig 02 & 05), this enables you to swing the Jacking Plate for better support. Once the second Jacking Plate is supporting the Bottom Blade it may be necessary to check the first Jacking Plate again, this time you can also adjust the Pivot Kiplock for this Jacking Plate also if required. The Bottom Blade should now be evenly supported across both Jacking Plates at the desired angle.

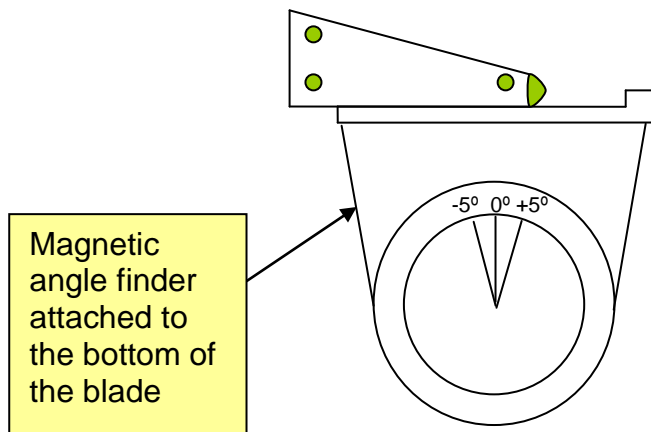


Figure 06 - Setting the correct Angle

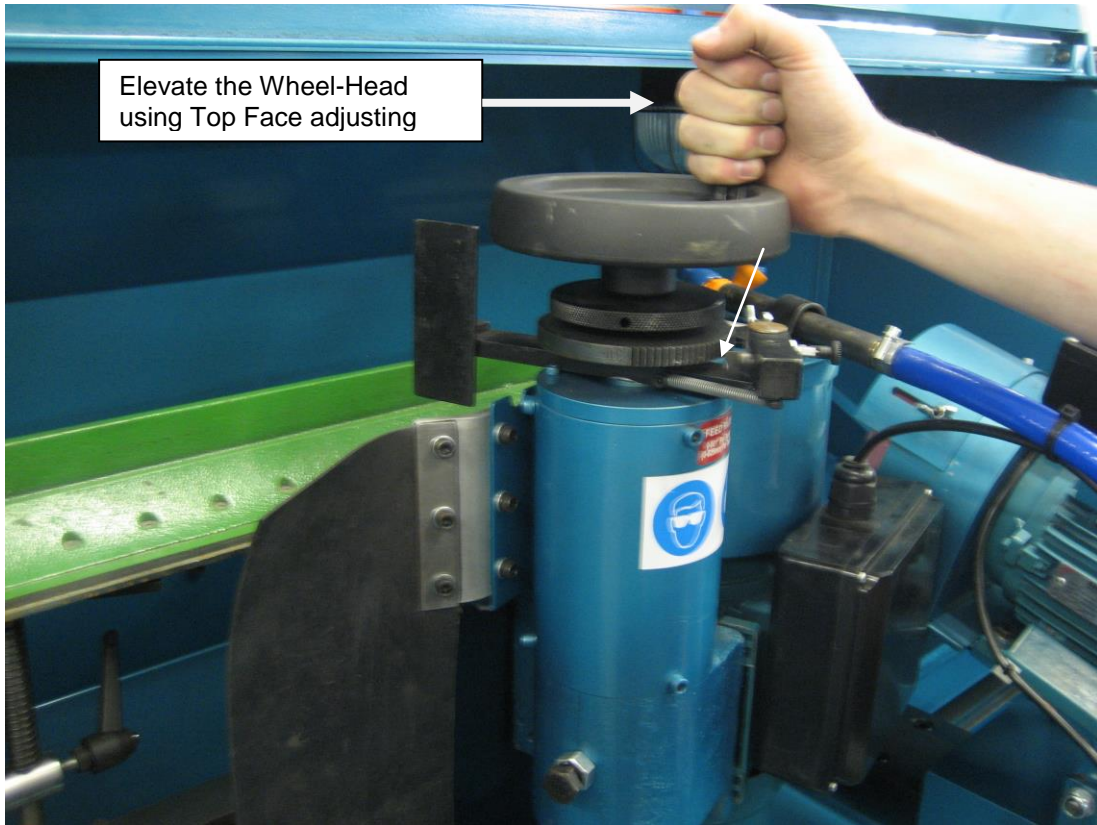


Figure 07 – Wheelhead Elevation

Elevate the Wheel-Head until the Grinding Wheel is just clear of the Bottom Blade



Figure 08

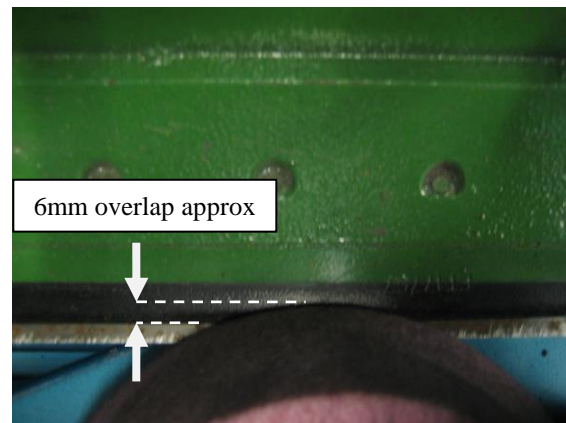


Figure 09

Using the Top Face adjusting handle and Front Face adjusting position the Grinding Wheel over the Bottom Blade so that it is just clear of the Blade and overlapping the Bottom Blade cutting face by approximately 6mm (1/4 inch). (see Fig 08/09)

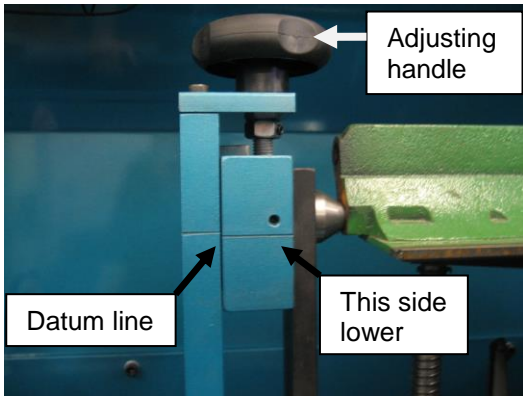


Fig 10

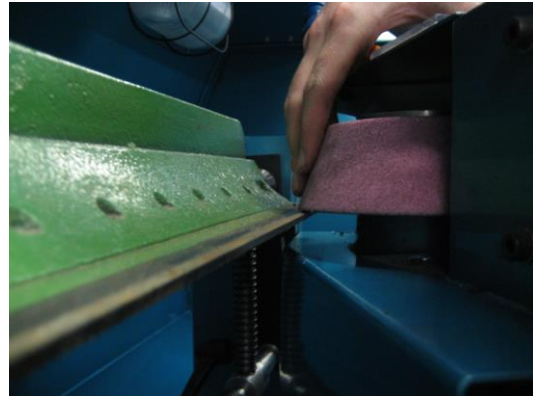


Fig 11

Using the left hand side Adjusting Handle lower the Bottom Blade so that the Bottom Blade assembly is slightly lower at the left hand side. Check datum line. (see Fig 10)

Position the Wheel-Head over the right hand side of the Bottom Blade and spin the Grinding Wheel by hand. (REMEMBER THE MACHINE MUST BE SWITCHED OFF AND ISOLATED) Adjust the Grinding Wheel down whilst still spinning it until very light contact is achieved.

Once the right hand side has been set-up traverse the Wheel-Head by hand until the Grinding Wheel is positioned over the left hand side of the Bottom Blade. Again spin the Grinding Wheel by hand but this time use the left hand Tailstock Adjusting Handle to raise or lower the Grinding Wheel until light contact is achieved between the Grinding Wheel and the Bottom Blade.

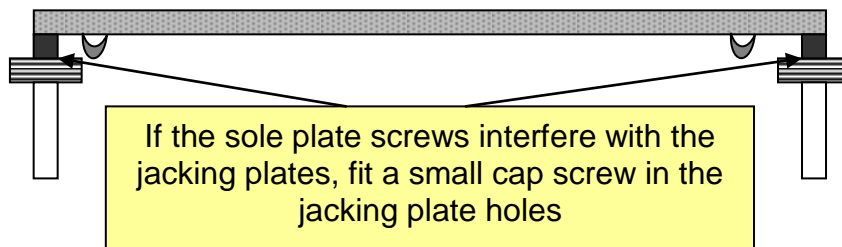
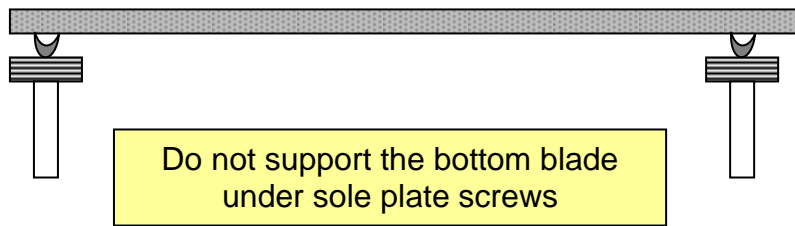
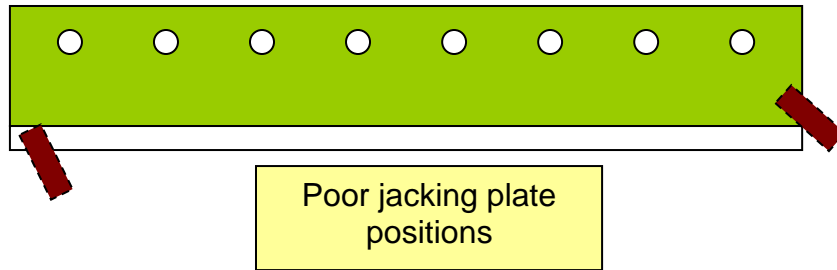
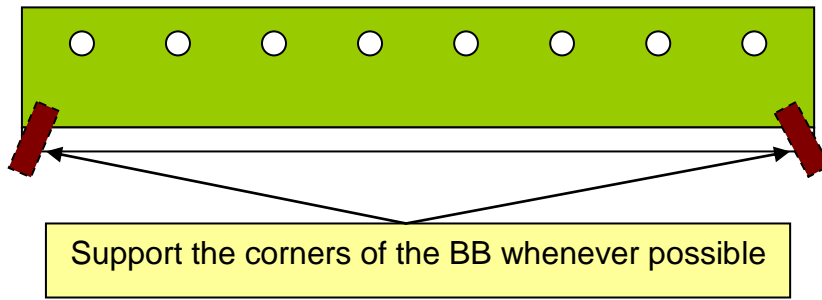


Figure 41 – Guidance on jacking plate position

Setting up the grinding head parallel to the top face of the bottom blade

Bring the grinding head to the mid point of the bottom blade and, using the front hand wheel, bring the grinding wheel over the top of the bottom blade, so that the blade is still approximately horizontal and the grinding wheel is about 1/4" (6mm) past the lip or surface of the blade which is to be ground then lock the column base locking kiplock

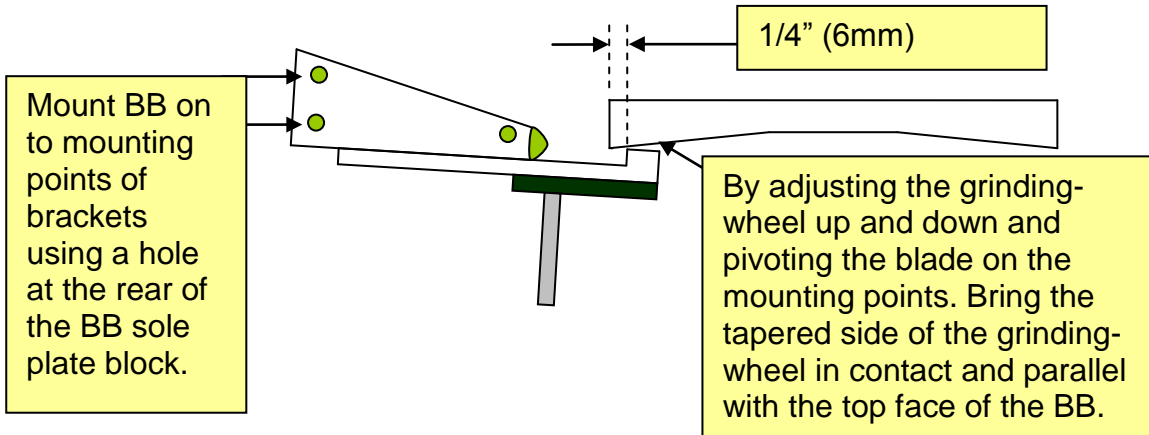


Figure 42a – position of grinding wheel over blade

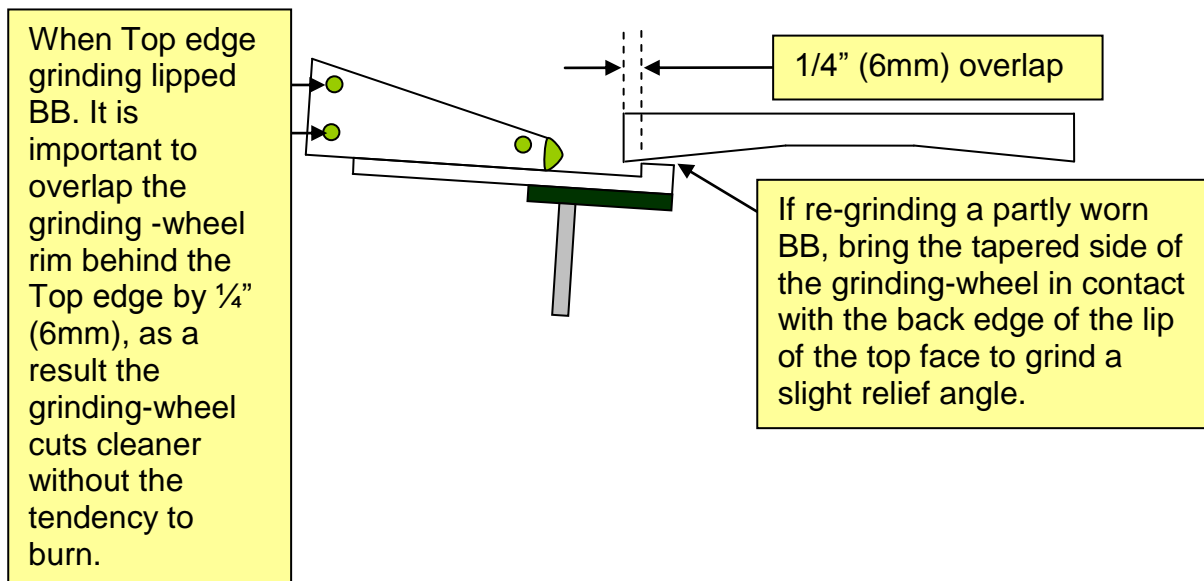


Figure 42b – position of the grinding wheel over the blade


Manually traverse the grinding wheel-head from left to right along the length of the bottom blade. Make small downward adjustments using the down-feed handle located on the top of the column (fig 43) until you have light contact across the blade (contact should only be with the left hand leading edge of the grinding wheel fig44). You will have to adjust the right hand jacking plate adjusting lever (fig35) either up or down to get the bottom blade level with the grinding wheel.

Once you are level, slightly raise the wheel-head away from the bottom blade and traverse the wheel-head across to the right hand side of the machine. You are now

ready to begin grinding. **NB** when setting the bottom blade level with the grinding head it is not always possible to have even contact across the whole of the blade. Aim to have the same amount of contact at each end of the blade and disregard any contact in the middle of the blade. If there is a significant variation along the blade which adjustments cannot remove, investigate the blade's condition for any warps or twists. Badly distorted blades cannot be ground.

TIP when setting contact at each end of the bottom blade set the wheel approx 50mm in from the ends of the blade to allow for any high spots sometimes found at the very ends of worn blades. Remember contact is only achieved with the wheels left hand leading edge of the grinding wheel (fig 44).

Grinding the top face of the bottom blade

 Ensure that the grinding machine power is switched off to prevent accidental start-up

Raise the grinding wheel away from the surface a short distance.

Switch on power and follow on screen instructions.

Switch on the coolant pump and adjust the nozzle so that an adequate flow is directed to the grinding area.

Switch on the grinding wheel motor and allow the wheel to reach its full speed.

Traverse the wheel-head from right to left and back whilst slowly lowering the grinding wheel to make a light contact with the top face of the bottom blade. Take great care not to stress the grinding wheel. Stop traversing if the grinding process becomes laboured.

Continue grinding the top face, traversing and adding small cuts until all irregularities have been ground out and the full cutting face of the blade has been machined. Take your time only applying light cuts, continue this process until you have an even grind along the full length of the blade (ground surface should be completely across the blade from left to right and front to back). Now using the automatic traverse apply several polishing cuts, traversing the grinding head without feeding the grinding head down, these polishing cuts should be very light, you may have to back the grinding wheel off by raising the wheel-head (see tip below).

When complete, park the grinding head to one side and switch off the grinding wheel motor and the coolant pump.

Remember to regularly dress the grinding wheel with the 'star wheel' dresser tool. Doing this will remove any rust or other materials clogging the surface and speed up the operation of grinding the top face and also prevent any burn marks. If burn marks persist, speed up the traverse of the grinding head from side to side, or reduce the downward feed.

TIP to aid vision when grinding the top face you can use a marker pen (black) across the full face and length of the blade. Apply the marker pen across the blade just before

the polishing cuts, any low spots will show up where the marker pen is left behind, continue traversing until all the pen is removed. You may have to apply a very light down-feed cut to achieve this.

Setting-up front face of bottom blade

Swing the bottom blade upwards and over towards the back of the machine. Unlock the jacking plates and depress them on their springs fully downwards and relock in position. Swing back the bottom blade so that it can be swung easily between the mounting bracket points.

Position the grinding head at the midpoint of the blade. Pivot the blade up and bring the grinding wheel towards the blade so that contact between the two is just achieved. At this point, the front face of the bottom blade will be aligned with the centreline of the grinding wheel.

Raise the top edge of the blade approximately 1 to 2mm above that centreline and release one of the jacking plate so that it contacts the bottom of the blade. Lock it in position. Move the grinding wheel head to one side and bring the remaining jacking plate up to the blade, locking it in position. It may be necessary to undo the Allen bolt shown in figure 39 and rotate the jacking plate to ensure a fuller contact between bottom blade and jacking plate. **NB** to ensure that the jacking plates do not foul the grinding wheel they should not protrude beyond the front face of the bottom blade.

Check that the bottom blade has good contact with both jacking plates. This can be done by tapping the front corners of the blades above the jacks with a non-metallic object. A hollow sound indicates poor contact, and a solid sound indicates good contact.

Grinding the front face of the bottom blade

Move the grinding head to the right hand end of the machine

Switch on the coolant pump and adjust the nozzle so that an adequate flow is directed to the grinding area.

Switch on the grinding wheel motor and allow the wheel to reach its full speed. Slowly bring in the wheel to make a light contact with the front face of the bottom blade and traverse the grinding head along the full length of the blade. Take great care not to stress the grinding wheel. Stop traversing if the grinding process becomes laboured.

Grind the front face, traversing left and right, adding small cuts until all irregularities have been ground out and cutting edge has been achieved along the full length of the blade. Apply two polishing cuts using the automatic traverse, without feeding the grinding wheel in.

When complete, park the grinding head to one side and switch off the grinding wheel motor and the coolant pump.

Remember to regularly dress the face of the wheel with the 'star wheel' dresser tool – Doing this will remove any rust or other materials clogging the surface and speed up the operation of grinding the top face and also prevent any burn marks. If burn marks persist, speed up the traverse of the grinding head from side to side, or reduce the inward feed.

Removing the bottom blade from the machine

Take great care when handling the bottom blade as it will be extremely sharp. Wear suitable gloves.

Loosen the left hand tailstock lock. Hold the bottom blade in both hands, avoiding contact with the sharpened edge, and push the blade and left hand tailstock to the left releasing the blade. Remove the blade to a safe place, ready for installation into the mowing machine.

Improved results can be obtained by hand grinding small chamfers at each end of the bottom blade after the edge grinding process is complete



Figure 46 – Chamfer each end of the blade

Suggested angles for bottom blades

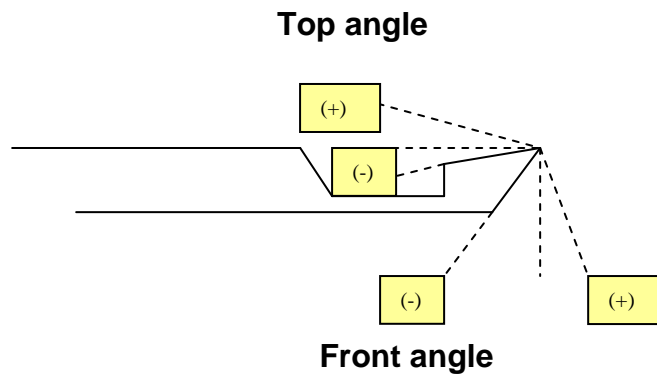


Figure 47 – Bottom blade angles

| MAKE | MODEL | TOP ANGLE (Degrees) | FRONT ANGLE (Degrees) |
|----------------------------------|------------------------------------|---------------------|-----------------------|
| Jacobsen | 19" 22" Greens Mower | -8 to -10 | 0 to -5 |
| | Blitzer F133 Fairway | +4 to +6 | 0 to -5 |
| | Greens King 418,518,422,522. | -8 to -10 | 0 to -5 |
| | Greens King 426, 526. | -8 to -10 | 0 to -5 |
| | Greens King ii, iv, iv plus, v. | -8 to -10 | 0 to -5 |
| | HF5, HM11. | +4 to +6 | 0 to -5 |
| | LF 100, 123, 128, 3810. | -8 to -10 | 0 to -5 |
| | Ranger, ST5111. | +4 to +6 | 0 to -5 |
| | Tri King 1671, 1672, 1684, 1900. | -8 to -10 | 0 to -5 |
| Trim King, Turf King ii, 76, 84. | +4 to +6 | 0 to -5 | |
| John Deer | All Models | -6.5 | -5 |
| Lesco | All Models | -6 | -5 |
| National | All Models | -5 | -5 |
| Ransomes | G-Plex 160 | -8 to -10 | 0 to -5 |
| | Fairway 250, 305, 405. | -3 | 0 |
| | Motor 180, 350D, T-Plex 185 | -3 | 0 |
| Toro | GR500, 1000, 3000, HTM175 | -5 | -15 |
| | RM5100, 5300, 6500. | -5 | -15 |
| | RM108, 216, 2300, 3500, 4500. | -5 | -15 |
| | RM5, RM7, RM11, Spartan, Turf Pro. | -5 | -15 |
| Sabo Roberine | All Models | -5 | -5 |

Note: The above table is for use as a guide only, consult the manufacturers specification for the exact angle.

SECTION 5 – GRINDING WHEEL MAINTENANCE

Dressing the side of the grinding wheel

- ⚠ Eye protection manufactured to the current European Safety Standards must be worn when operating this equipment. Everyday glasses do not have impact resistant lenses, and are not safety glasses.
- ⚠ Grinding wheel dressing, truing and replacement should only be carried out by operators correctly trained in the safe use of abrasive wheels as detailed in the Provision and Use of Work Equipment Regulations 1998 (PUWER 98).

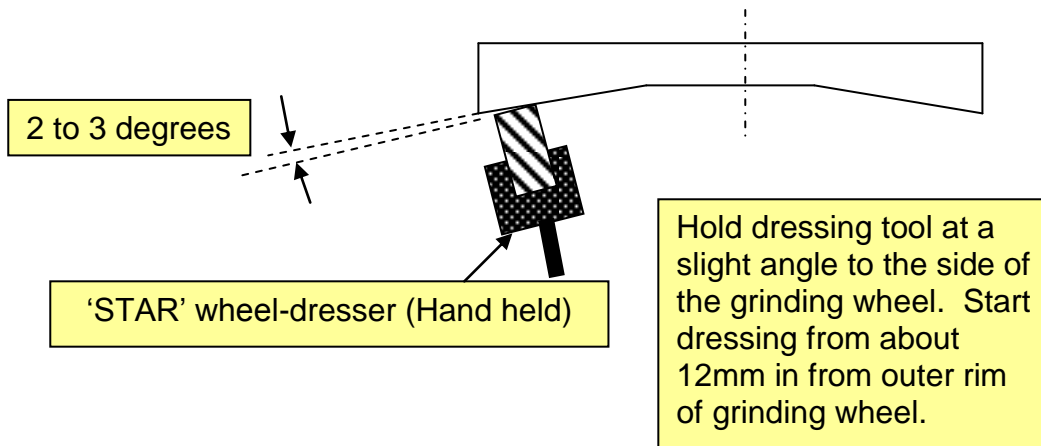


Figure 48 – Star wheel dressing

- ⚠ Dust is frequently generated when dressing wheels – use adequate dust protection.
- ⚠ Always dress the wheel above the centre of the wheel. Failure to do so will result in the cutters digging into the grinding wheel
- ⚠ Never wedge the feet of the dresser handle behind a tool rest or fixture in order to gain leverage. Rest the feet of the dresser handle on top of the tool rest and gently move the tool back and forth. Let the dresser do the work; do not apply excessive pressure
- ⚠ Always use the proper dresser for the size of grinding wheel you are dressing. Consult Hunter Grinders for guidance.

Grinding wheel replacement

Main reasons for changing:

- If the stone is worn out, the grinding process accuracy cannot be maintained.
- Peripheral speeds of the wheel will be reduced and the grinding process will take longer.
- There will be increase in risk to both the operator and the equipment.
- ⚠ Grinding wheel dressing, truing and replacement should only be carried out by operators correctly trained in the safe use of abrasive wheels as detailed in the Provision and Use of Work Equipment Regulations 1998 (PUWER 98)

Ensure that the machine is disconnected from the mains supply to prevent accidental start-up

SECTION 6 - GENERAL MACHINE MAINTENANCE.

Routine Maintenance

Correct and regular maintenance of the Jupiter grinding machine prolong the unit's life and help provide consistently accurate grinding.

Daily

Check the general condition of the machine for any damage, paying particular attention to the control panel and external wiring. Any damaged wiring must be reported immediately and the machine isolated to prevent use until repairs have been carried out.

Ensure that the emergency stop buttons are working correctly. Report any faults immediately and isolate the machine to prevent use until suitable repairs have been carried out.

⌚ Electrical repairs must only be carried out by a suitably qualified person.

After each days use, clean the machine surfaces and channels using a soft paintbrush. Gather the debris together and deposit it in a waste bin. Once most of the dirt has been removed, use the machines coolant system to wash away residues. It is important to remove as much heavy soiling as possible before washing over with coolant as this will result in excessive contamination of the coolant system. Traversing the grinding head along the machine, direct the coolant at the slideways and coolant catchment trays to wash away the dirt. Use the paintbrush to direct the coolant and dirt towards the drainage holes in the centre of the trays where it will be carried to the coolant storage tank. Wipe down all surfaces using a lint-free cloth or workshop quality paper towelling.

Apply a light coating of lubricant to the T-Slot top machined face and wipe off any excess with clean cloth. The ideal lubricant is a light grade penetrating oil which contains PTFE (Teflon) such as Fin Lube TF. Use the cloth with the excess lubricant to wipe down and clean the traverse stop rail, rear grab arm rail, grab arms shafts and spin/index motor shaft. This will help prevent oxidation of their surfaces.

Weekly (in addition to the above)

Remove the tailstocks and the spin /indexing motor assembly from the machine bed, clean the contact faces on the undersides thoroughly and apply a little of the PTFE lubricant. Wipe off excess with a clean cloth.

Whilst tailstocks and spin/indexing motor are removed, clean any build up of dirt from the T-Slot.

Check coolant level and condition. Switch off the pump and allow coolant to settle in tank. Remove the tank lid and inspect the level. It should settle between 25-75mm from the top of the tank, across all three chambers. Top up as required using correctly diluted coolant only. Contact Hunter Grinders for information on approved coolants and their use. Discard coolant mix after 3 months and replace with a fresh mix. In heavy machine use, coolant may need to be replaced at shorter intervals due to contamination. Thoroughly cleaning cylinders and cutting units before grinding will help prolong the life

of your coolant mix. Dispose of used coolant according to the recommendations contained in the coolant manufacturer's COSHH sheet.

Check condition of linear bed-rails, clean any excess dirt accumulated at the end of their travel. Check there is no build up of dirt behind the rails, particularly the rail towards the rear of the machine. Lubricate the rails with Shell Tonna S oil. Note that this lubricant is specially designed for machine slideways, especially as it resists being washed off by the system coolant. It is important to use only this approved lubricant. Contact Hunter Grinders Technical Department for additional guidance.

Monthly (in addition to the above)

Raise the wheel-head up the support column, clean the shaft and apply a thin film of anti seize oil, such as Lok-Cease.

Wind the in-feed saddle forward, clean the now exposed dovetail and lubricate using light grade oil (SAE 30). Wind the in-feed saddle back and clean the other end of the dovetail. Lubricate as before.

Remove the locking handles from the tailstocks and clean the threads. Lubricate using an anti seize oil, such as Lok-Cease.

6-12 monthly (in addition to the above)

Grease the linear bed rail bearings blocks via their grease nipples using a lithium based grease, number 2. The recommended method is to apply the grease dynamically (slowly traverse the grinding wheel-head from side to side while injecting small amounts of grease). The bearings only hold a small amount of grease so it is important not to overload them with too much. Wipe off any old and contaminated grease which will have been ejected from the bearings.

Annual (in addition to the above)

It is recommended that all medium to heavy machine users have their machines serviced on an annual basis. Light to medium uses should at least look to having their machines serviced biannually. This comprehensive service includes travel to site, checking all grinder settings, stripping down the headstock, in-feed, down-feed, traverse bearings and rails, traverse, tailstocks, checking the coolant facility, hoist (where applicable) etc. Repair and/or replace as necessary, reassemble and test. Favourable rates are offered to those customers who sign up to annual / biannual maintenance schedules. Contact Hunter Grinders for more details.

SECTION 7 - RISK ASSESSMENT

Risk categories for the design of fail safe control systems

The harmonised European Standard - 1 for the design of fail-safe control circuits outlines 5 levels of risk. It is deemed the designer's responsibility to objectively identify a risk level for a particular machine and design all safety related systems to that level.

In general, the following block diagram, figure 40, gives guidelines to the identification of design risk level, which may be used to help determine the structure of the fail safe control circuit required on a particular facility.

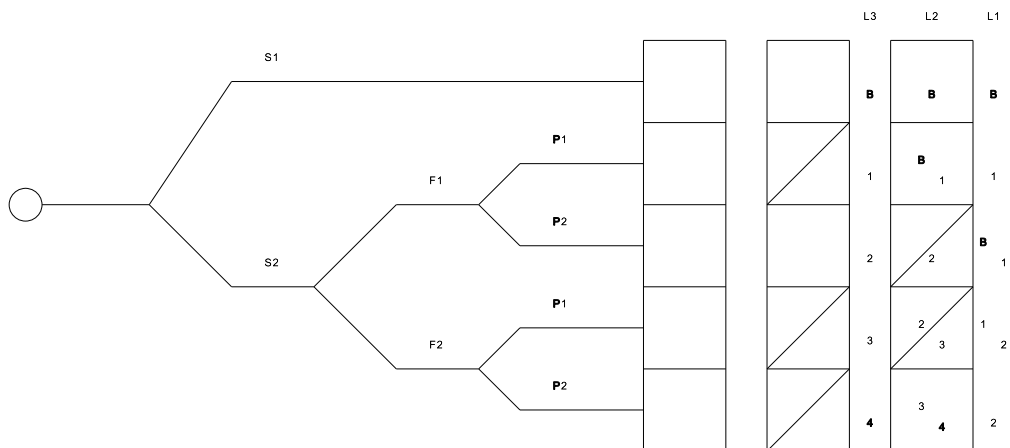


Figure: 40

S. Severity of injury

S1 - Slight injury (bruise)

S2 - Severe injury (amputation or death)

F. Frequency of exposure to hazard

F1 - Seldom

F2 - Frequent to continuous

P. Possibility of avoiding the hazard

P1 - Possible

P2 - Less possible

L. Likelihood of occurrence (if an interlock fails)

L1 - Very unlikely

L2 - Unlikely

L3 - Highly Likely

Requirements of the safety related control circuit to meet the various categories are listed in section 7 of PR EN 954 - 1, but in general their requirements are as follows :-

Category B. Safety devices and control systems as a minimum must be designed, selected and assembled to meet the operational requirements of the design limits and influence of the processed materials and other external influences. Most domestic appliances fall into this category, and providing the components are correctly specified (load, switching frequency etc), then no other special features are required.

Category 1. All conditions B apply, but the safety related system must use 'well tried' principles and components, Software or electronic logic is not considered adequate at this level.

Category 2. All conditions of B apply, but in addition the machine shall be prevented from starting if a fault is detected on power up. This suggests the use of an interface relay with redundancy and self-checking on energisation. Single channel operation is permitted providing that the input devices (Em/stop buttons, gate switches) are tested for operation on a regular basis. If regular testing cannot be guaranteed, then the designer has little choice but to opt for two channel control.

Category 3. All conditions of B apply, but the complete safety control system shall be designed so that any single fault shall not lead to the loss of the safety function and, where practical, the single fault shall be detected. This now calls for not only redundancy in the interface relay but also in the input devices pointing to dual channel systems.

Category 4. All of the conditions of B apply. In addition, any single fault must be detected at or before the next demand on the safety system, **or** an accumulation of three faults shall not lead to the loss of the safety functions. In this category single fault detection is essential, redundancy in both the input and output devices, self checking, cross monitoring and dual channel control. This level of safety is for dangerous machines where it is imperative that the safety circuit functions correctly at all times. Generally, if any input devices are connected to the safety circuit via flexible cables in vulnerable positions where damage could foresee-ably cause a number of faults, this level of two channel safety circuit should be used. Also this level of safety circuit is used where the inputs are vulnerable and are not necessarily being tested by operation of the safety circuit on a regular basis.

In general all of the above requirements can be met by applying various Pilz safety products (or equivalent safety relays) in the correct way.

Method of Stopping

When providing a risk assessment for a particular machine, it is also necessary to take into account the method of stopping required by all of the elements to be incorporated in its design. This process again allows the machine to be placed into a category indicating the method of stopping.

The following procedure is used when assessing the method of stopping required

Category 0

- a) Immediate removal of power to machine actuators or
- b) Mechanical disconnection (declutching) between the hazardous elements and their machine actuators and
- c) If necessary braking (uncontrolled stop).

Category 1

Controlled stop with power to the machine actuators available to achieve the stop and then removal of power when the stop is achieved.

Category 2

Controlled stop with power Left available to the machine actuators.

Emergency Stop Safety Circuit

The Bottom Blade Grinding Machine has been designed to operate safely. When this machine is examined, it can be seen that all areas of movement on the machine will be protected, where possible, using fixed guards. There will be Emergency Stop push-buttons situated at various points around the machine such that the operator will be able to reach at least one Unit easily.

Using Figure: 1 shown previously, it is possible to provide a risk assessment for this machine and determine the level of safety control circuit required.

Firstly, the severity of injury on this machine will be regarded as severe (S2), because of the moving carriage and the wheel-head. Either of which could cause amputation. Secondly, the frequency of exposure as been taken as continuous (F2). This helps to increase the safety factor. Thirdly, the possibility of avoiding the hazard as been taken as possible (P1). We know the operators are skilled and trained to handle this equipment. Finally, the likelihood of occurrence if an interlock fails on this machine is being taken as unlikely (L2).

When all of the moving parts on this machine are examined for the required method of stopping, it can be seen that this machine may be classed as a category 0 machine. This is due to the fact that all the movement on the machine is via electric motors and if power is removed from the motors they will cease movement very quickly.

From the above risk assessment, it can be seen that a minimum of a category 2 safety control circuit will be required on this machine. We have elected to use a Pilz PNOZ safety relay to provide better than the required category for the Emergency Stop circuit on this machine. As the machine falls within category 0 for the method of stopping, it is not necessary to provide any powered stopping procedures and simply removing the power supply from the moving parts will be adequate.