Advances in Finishing Area Technology

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We are in a time where investment casters need to improve their competitiveness against other processes. The area where the greatest savings, both financially and time, can be made is in the finishing area. This is due to the simple fact that to date very little automation or engineering has been developed in this area. Savings in the order of 70% are readily achievable. This can be compared to savings in the wax, dipping, and casting area of between 5-10%. This is due to the fact, that these areas have had considerable development in automation and engineering over many years. This paper discusses several innovative ideas that have been designed to address the automation of the finishing area

Investment Casting, like most modern manufacturing techniques, is facing new competition from new technologies and improved older ones. As investment casters, we need to look at ways to improve our process so that we can improve our throughput while incurring less cost. Equipment builders are working to come up with better designs that cut overall time or consumables to make us more efficient and therefore increase our profit. Paste wax injection, for example, has made great strides in reducing injection cycle time and reducing the need for chills in larger parts. The use of robots in the shell area has increased throughput while reducing the dependency on human labour to dip our shells. The latest induction furnaces allow us faster melt rates and precise control of the melting process. These are the areas in which we spend our capital investment dollar, but are they the right areas?

Let us look at the after-cast area. Most foundries treat the after-cast area as a necessary evil. We throw money and people at it out of necessity to get our castings out. These areas are noisy, dirty, and frankly, we all wish it would go away. Many foundries still have equipment in these areas that was designed, or is, from the early days of investment casting. The modernization process stops at the melt area. Unfortunately, the after-cast area is not going to go away. It is part of our process and it needs to be addressed just like any other area.

The good news is that the after-cast area is one of the easiest places to get a return on capital investment. There has been much advancement in technology in the after-cast area that makes the whole process less painful. We will explore advances in ingate removal. There are other developments such as automated cut-off, which we will cover in the future.

There are three main methods for automated ingate removal, plunge type grinders with a rise/fall table, reciprocating bed grinders, and rotary bed grinders. Each type fits different applications as will be explained here.

<u>PLUNGE TYPE GRINDER with Rise/Fall Table</u> (Figure No. 1)

The plunge type grinder is ideal for castings up to a few kilograms with monthly production runs of less than 5000 per month. It is the most versatile type of grinder. That makes it ideal for ingate removal in a commercial "job shop" foundry. It can handle both straight flat ingates as well as curved ingates by use of manual rotary fixtures or by adding a powered head. The powered head causes a rotational motion instead of a rise/ fall motion when the table is driven into the grind position (Figure No.2). Usually this easily attached plate fits on top of the existing table, and uses the machines hydraulic system for the rotational motion (Figure No.3). Fixtures are easily changed using either method and typically, setup from job to job is less than five minutes. There are also after market "quick change" mechanisms available. The rise/fall motion is required to remove the curvature that would be ground into the part using a straight plunge.

The rise/fall motion sweeps the parts past the contact wheel to render a flat surface. This type of grinder can also grind larger ingates using less horsepower. With this style of machine, we take advantage of something known as the "flywheel effect". The combined mass of the contact wheel, drive shaft, and motor store the rotational energy, which is dissipated when the part comes into contact with the abrasive belt. When this energy is used up, the power of the drive motor takes over. This stored energy can be as high as three times the kilowatt rating of motor, but lasts for such a small time period that it basically doubles the effective area that can be ground efficiently. Abrasive belts can be easily changed and to change a belt should take no more than two minutes.

FIGURE NO.1

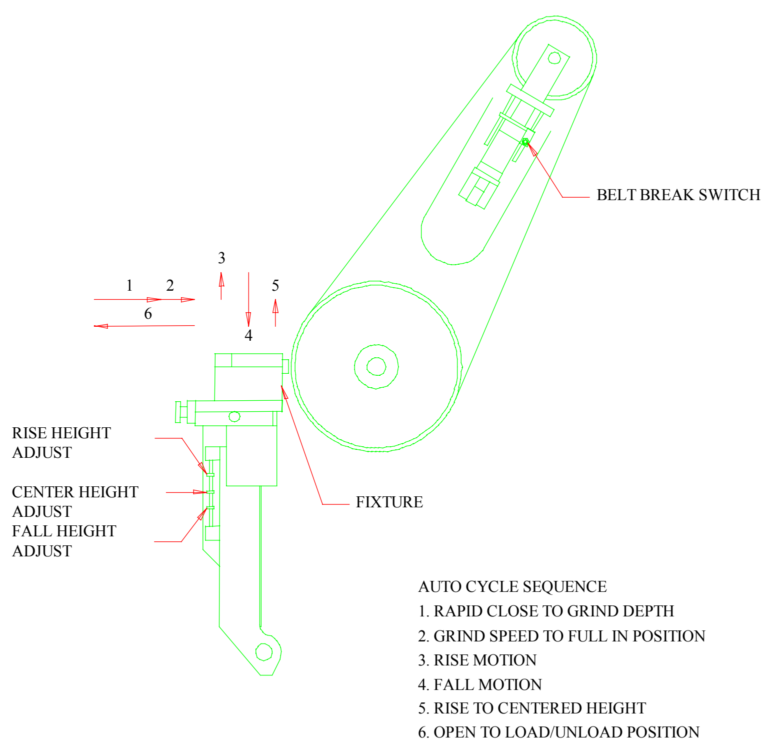


FIGURE NO.2

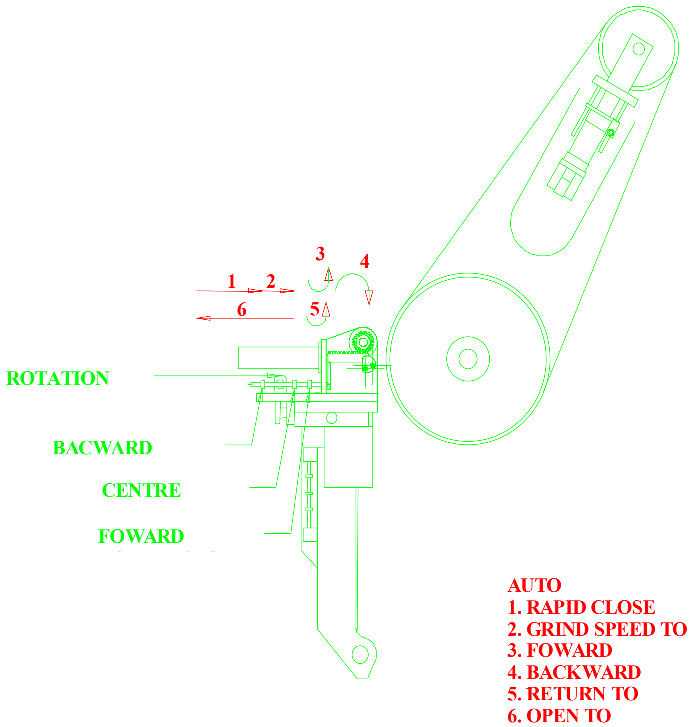
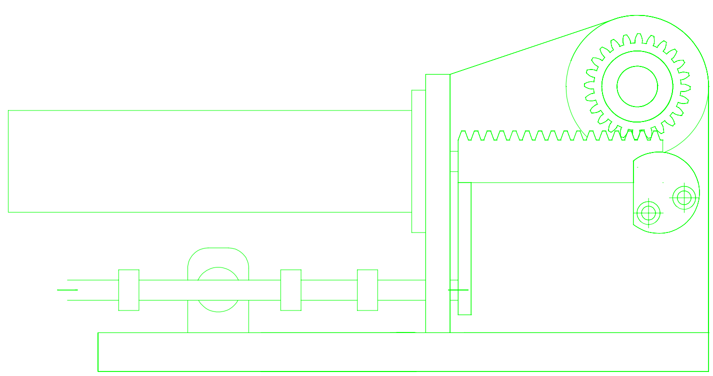


FIGURE NO.3



Changing an abrasive belt consists of:

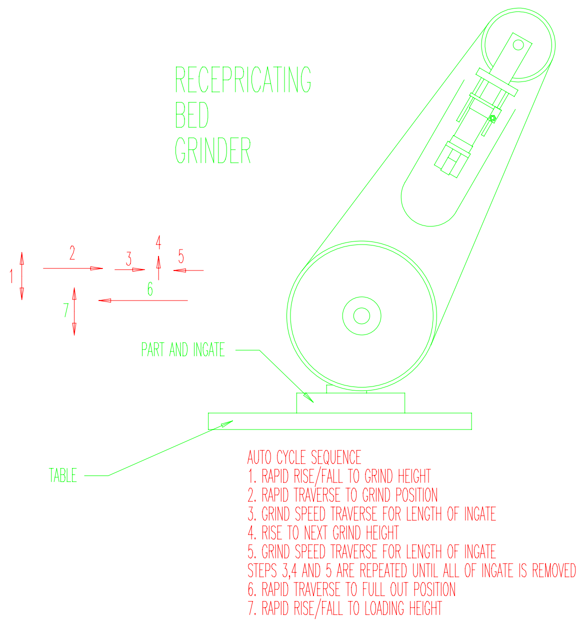
1. Turning off the drive motor (which stops quickly because of the hydraulic braking mechanism
2. Turning off the belt tension.
3. Turning off the hydraulic system, (the hydraulics will stop anyway as soon as the door guarding the belt is opened).
4. Open the guard door and replace the belt making sure to pay attention to any rotation markings from the belt manufacturer.
5. Close the door and restart hydraulic system.
6. Start drive motor and check the belt tracking to make sure that the abrasive belt is running at the proper place on the contact wheel.

This method is unchanged for all the types of grinders mentioned.

RECIPROCATING BED TYPE GRINDER (Figure No. 4)

The reciprocating bed type grinder is ideal for larger investment castings and smaller sand castings up to a combined fixture and casting weight of 90 kilograms. It is also suited to for parts that have monthly production runs of more than 5000 pieces. This type of machine (as well as the rotary type grinder) must use larger motors to grind a similar area of ingate to the plunge type because it must continue grinding after the flywheel effect has past. It is primarily designed for straight flat gates. The table is positioned by AC servomotors identical to those used in high precision machining centers, so they are very accurate and repeatable. We have been developing a method to grind large outside radii and profiles. Because the machines use AC servomotors, they already are capable of doing these motions. The problem arises in trying to enter the data, for the shape, into the machine controller. If your foundry has someone who can program in "G-code" (which is the standard language of CNC equipment), the machines are already capable of grinding shapes and contours. The system that we are developing will make it simple for any foundry to grind these shapes without the need for such programming. This type of machine also has the convenience of "masked" loading, allowing the operator to be handling other tasks while the machine is in its operating cycle.

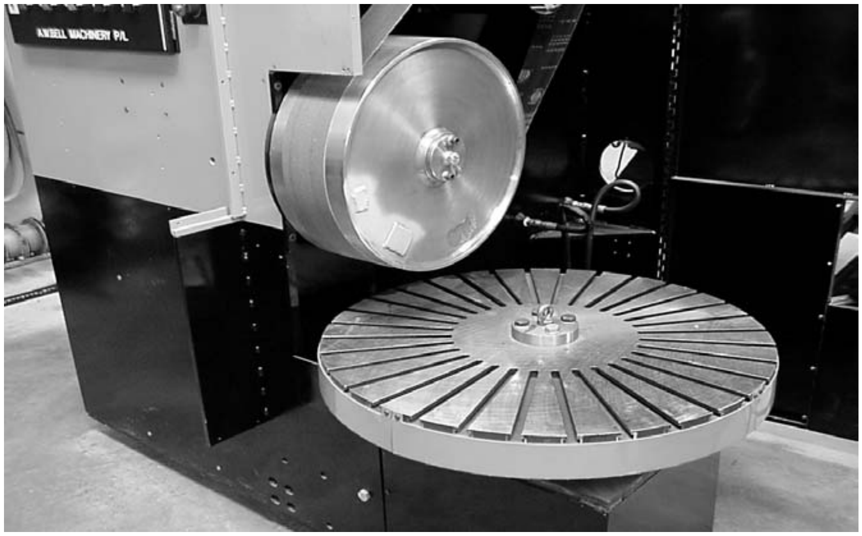
FIGURE NO.4



<u>ROTARY BED TYPE GRINDER</u> (Figure No. 5)

The rotary bed type grinder uses an adjustable speed, rotating table that runs continuously under the abrasive belt. The operator unloads a finished casting and loads an unfinished one as one operation. This type of machine differs from the previous two because it controls the speed of the operator. This type of machine uses the same frame as the plunge type with the round table instead of the plunge.

FIGURE NO.5



IDENTIFYING COSTS

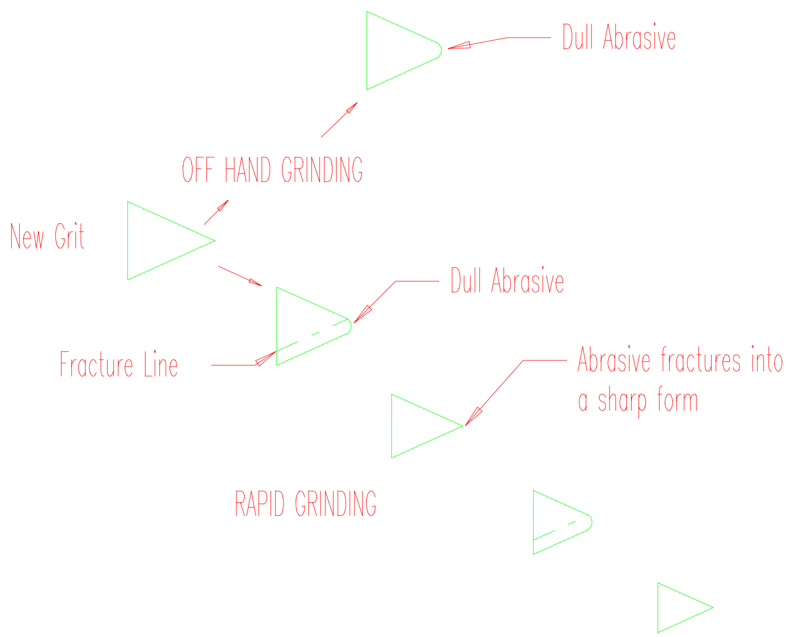
The two main costs in the finishing area are labour and consumables (abrasive belts). Rapid grinding can make a significant difference in both of these areas. First, let's look at labour costs. Rapid grinding affects labour four ways, throughput, repeatability, training, and safety. I believe it is the general opinion of most foundries that their finishing area works well. It always seems to have lots of activity. It is noisy, there are sparks flying, and it gives the impression that things are being done. Things are being done, but are they being done efficiently and could they be getting a lot more done? We have done numerous tests in our own foundry, comparing manual grinding to rapid grinding. We found that a man could grind 800 of these parts in an 8-hour workday on a manual machine.

It is important here to note that this type of test needs to be performed over an 8-hour day. Typically, if you asked someone how many parts he or she could do in one hour, the rate would be much higher because they have been given a specific task that has a clearly defined end. It is analogous to asking someone to run 100 metres as fast as they can and then trying to say that they could run 5 kilometres at the same rate. People work at a different rate first thing in the morning, when they are fresh, than half an hour before knockoff time after they have been working all day. We have to look at a rate that is sustainable. In addition, people tend to work faster if management is taking an interest in their work. We need to look at what happens during normal conditions when the boss is not standing behind them. We then tested the part on a plunge type grinder. We were able to grind 3500 per 8-hour day using a 5-part fixture. We then put the part on reciprocating bed type machine with a 60-part fixture, and could grind 22,000 parts in an 8-hour day. That equates to a 437% increase in throughput using the plunge type and a 2750% increase in throughput using the reciprocating bed. This is a significant improvement. We find these results to be common for a wide range of parts.

The machines are also repeatable. Once they are setup, they will grind the same every time. They do not get tired, they do not take breaks, and they do not take holidays. They do not grind a little more here and a little less there. This leads to a much lower scrap rate. This in itself is significant considering that a casting has approximately 80% of its value added by the time it reaches the finishing area (you not only lose the casting, you lose the wax, treeing time, dipping, etc.). We originally started to build this equipment because we had problems keeping staff in our finishing area. It was not a job that people wanted to do for long. Some foundries get lucky and get a good core staff that stays for a long time. We were not so lucky. We had to constantly train people for these positions. What was acceptable to grind, how much of a witness, etc? What we now do is to have the foreman or the leading hand setup the job and run the first few parts. When the job is operating successfully, it is turned over to an operator who now only has to load and unload the parts which is much easier to train for. This reduced our training costs dramatically. The last aspect is safety. Anyone who works on a manual abrasive belt grinding machine eventually gets too close to the belt and gets a cut or a nick. They are pushing castings into an abrasive belt with some force while at the same time trying not to grind their fingers. Using a rapid grinder, the operator is moved away from the abrasive belt altogether to a much safer area. In addition, with modern advances such as non-contact pushbuttons to start machine cycles, it is much easier to reduce or eliminate repetitive stress injuries that may occur. All of these reasons alone should get you to investigate your finishing area but the big savings comes in the reduction of abrasive belts that will be needed to do the same amount of work.

Abrasive belts are a large consumable cost for foundries. Many advances have been made in abrasive belt technology and they have become the standard for ingate removal. They now have much stronger backing materials and the abrasive media itself has gotten much tougher and longer lasting. This causes the unique problem of having the abrasive belts much tougher than the application for which they are being used. It used to be that when an abrasive belt was dulled and had to be replaced, a lot of the abrasive media had been lost due to it falling or being ripped off the backing material, and what was left was not worth saving. Today, when an abrasive belt is removed, it normally still has only been used for 20 to 30% of its life. The abrasive media is still there and it has only been dulled. Today's material is so strong that a human normally cannot break it down and only rounds off the edges. Rapid grinding machines use much higher forces and can shatter the abrasive media, keeping it sharp and allowing for full use of the abrasive belt. Figure No.7 shows what happens to the abrasive media using hand and rapid grinding processes. Typically, we now use new belts on our remaining hand grinders and then put them on to our plunge grinders when they are dull. We even know of one of our customers who buys used abrasive belts for $2.00 and then still run 300 to 500 parts on them.

FIGURE NO.7



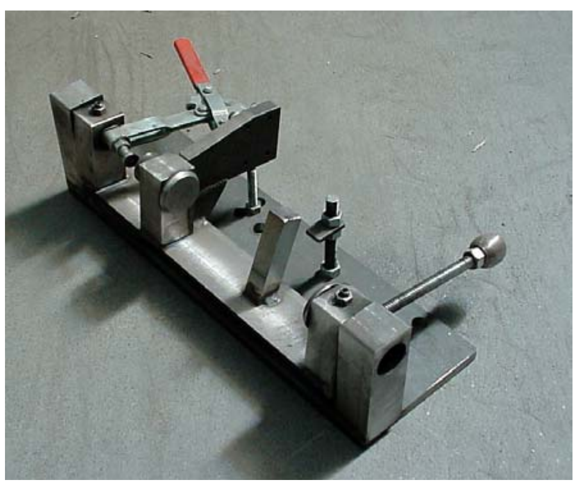
It is normal to get 4-7 times as many parts off an abrasive belt using rapid grinding over hand grinding. In the example given earlier, where the man ground 800 parts by hand and then 3500 parts using a plunge type grinder, it took six abrasive belts to do the 800 by hand. It took the same number of belts to do the 3500 parts. This demonstrates a little over 4 times the belt life on that part. We save on average $60,000.00 per year in abrasive costs using rapid grinding. An important note to make at this point, is that what ever machine you look at, it needs to have programmable belt oscillation. This important feature allows for the full use of the abrasive media because the belt is sweeping side to side at a programmed distance that changes with each part. This ensures that the entire face of the belt will be used.

FIXTURING

Fixturing for each part is the only added cost that is required for rapid grinding. A fixture must be made to hold the part(s) on the machine. Most fixtures are extremely simple and straightforward. All they need to do is hold the part firmly and not deflect when they under the grinding load. Most fixtures consist of a few welded blocks and an over-center clamp to hold them down (Figure No.8). Even most rotary fixtures for round parts are quite simple (Figure No.9). Fixtures can cost from $50 to $150 dollars on average. We treat them the same as a wax die and the fixtures are kept on the shelf using the same part number.

FIGURE NO.8

FIGURE NO.9



WHERE DO YOU SPEND YOUR MONEY?

We decided to compare our technology against one of latest technologies to re-emerge in investment casting, paste wax injection. Paste wax injection of today differs greatly from the paste methods previously available. Billets and canisters are no longer needed, greatly reducing wax handling, but what is the overall effect on part prices? We decided to compare the selling price of casting using a manual 12 tonne wax injector and a recent model automatic injector using paste wax technology, and manual grinding versus rapid grinding (Table I).

As you can see, we start with a price of $1.58 for the part that has been manually injected and ground. We then compared that to injecting the part automatically, using paste wax. It gave us a 32% reduction in cycle time, which if you check the wax injector people is about average. This allows us to drop the price to $1.55, a 1.5-percentage reduction. We then tried the same part using manual injection and rapid grinding. This allowed us a 78% reduction in the grinding cycle time and a 400% increase in belt life which allowed us to drop the price to $1.31, a 20% reduction in part price.

CONCLUSION

Investment Casting companies need to explore these developments to remain competitive. Our studies have shown that the average return on investment for one of our Model RGS 430 plunge type grinders is 6 months. The aftercast area is one of the easiest areas to get a return on investment and there are many new methods for ingate removal, which should be investigated