The NEMES Gazette

Vol 05, No 050
June-2000

The Newsletter of the New England Model Engineering Society
Ron Ginger, President, 17 Potter Road, Framingham, MA 01701, Ginger@Acunet.net
Rob McDougall, Treasurer, 357 Crescent Street, Waltham, MA 02154, RCMcDougall@MediaOne.net
Kay Fisher, Editor, 80 Fryeville Road, Orange, MA 01364, Kay.Fisher@Compaq.com

Our next meeting is at 7:00 PM on Thursday 1-Jun-2000 (first Thursday of every month) at
The Charles River Museum of Industry
154 Moody Street
Waltham, Massachusetts

Annual dues of $20 covers from Jan to Jan. Please make checks payable to NEMES and send to our treasurer. (Address in letterhead).

This Months Contents

Dues Notice

Annual dues are not due this June as has been normal. Instead everyone who is currently paid will remain paid until January 2001. Dues are now from January to January.

Dues for new members will be calculated on a quarterly basis. If someone joins in the first quarter the dues will be $20. If they join in the second quarter the dues will be $15.00. Third quarter = $10.00. Last quarter = $5.00. If you have already sent in a check for June or you already paid your dues that would have been due in June then you are paid up until January 2002.

Kay R. Fisher and Rob McDougall

Group Purchase

At the last meeting we had enough interest for a group purchase of Michael Morgan's scraper book and video. I started a list but it never made it back to me. If you think you are on the scraper list – you are not. So let's try again at the next meeting. If you can't make the next meeting and you want the book or video send me mail or email.

We won't know the exact price until the order is placed but I hope to save $5 to $10 dollars per order. For the purposes of signing up the price is $30 for the book, $25 for the video, and $55 for both. If you want in on the group purchase you must arrange for pick up of the merchandise at a meeting. Part of the group savings is based on shipping to one address. I would hope that I would have the merchandise for the July meeting. Sign up now and pay when you accept delivery.

Michael Morgan's company has been in the scraping business since 1960 and he seems to be well received by the folks on the Internet newsgroup rec.crafts.metalworking.

Kay R. Fisher

From the Editor's Desk

This newsletter has been sent out to an extended list of current members and previous members in hopes that everyone will renew their

membership. The cost of sending newsletters is high and the dues covers this cost. If your address label doesn't have you marked paid – don't expect the next issue.

Next months newsletter will be rushed out (of my hands) early because Pat and I will be on vacation visiting relatives and playing in one of the nicest of Minnesota's 10,000 lakes. So if you are contributing to the newsletter please submit your articles ASAP. I also hope to publish our first color pages.

By Kay R. Fisher

The President's Corner

By Ron Ginger

June Meeting

I have not been able to confirm a speaker yet, but I do have a couple short possibilities. I could use a few more short subjects by some members- like Ed Rogers with an update on his V8, and Dave Piper with an update on his Steamboat. And maybe we could get Max to finish up the lens grinding stuff he started in the winter. Lets go guys, we need to hear more Show and Tell talks, or I will just have to talk more!

Ron

Calendar of Events

By Bill Brackett

June 1, 2000 Thur 7PM
NEMES Monthly Club Meeting
Waltham, MA
Charles River Museum Of Industry 781-893-5410

June 3-4
Dave Dearborn's
Dearborn Homestead, Campton, NH
Call Dave Dearborn 603-726-3257

June 3-4
Hinsdale Show
Rt 119, Hinsdale, NH
Douglas Wood 802-254-6758

June 10-11
Skowhegan Show
Skowhegan State Fairgrounds-Skowhegan ME
Call: Joe Kelly 207-862-2074

June 10-11
Granby Show
Dufresne Park, Rt202, Granby, MA
Call: George Randall 413-467-9541

June 11 Owls Head
Rod & Custom Auto Show

June 15-17
Coolspring, Show
Coolspring, PA. I90 exit 13 rt 36
Call: Joyce Bashline 412-487-1464

June 17-18
Old Stone House Museum Show
Brownington, VT
Call: Bob Williams 802-525-3931

June 24-25
Orange Engine Show
Orange Airport, Orange, MA
Call: Grover Ballou Jr. 413-253-9574

June 25 Owls Head
Super 70's Auto Meet

July 1-2
Boothbay RR
Boothbay, ME
Call: 207-633-4727

July 6, 2000 Thur 7pm
NEMES Monthly Club Meeting
Waltham, MA
Charles River Museum Of Industry 781-893-5410

July 7-9
Me-Antique Tractor-Summer Festival
Windsor, ME
Call: Lynn Vernon 207-564-7001

July 9
Pepperell Show
Town Field Near Rotary On Rt. 111
Pepperell, MA
Kim Spalding 978-433-5540

July 9 Owls Head
The Fabulous ’50s & Sensational ’60s Auto Meet

July 14-16
Bangor, Pa Show
Jacktown Community Center, Bangor, PA
Call: 610-588-7466

July 15-16
Plymouth Notch Show
President Calvin Coolidge St. Historic Site VT
Call: Pat Warren 802-723-5472

July 15-16
Eastern Conn. Ant.Auto Show
Norwich Regional High School-Norwich, CT
Dick Babbit 860-376-0863

July 21-22
Sebago Days
Sebago Elementary School
Intersection Rt 114 & 11, East Sebago, ME
Call Ted Greene 207-787-2424

July 22–23 Owls Head
Trucks, Tractors & Commercial Vehicles

July 29-30
Eliot Tractor
Eliot, ME
David Raitt 207-748-1046

To add an event, please send a brief description, time, place, and a contact person to call for further information to Bill Brackett at wbracket@ultranet.com or (508) 393-6290.

Bill

Treasurer's Report

By Rob McDougall

As of 5/12/00

Balance Forward	$3,346.00
Dues Received	180.00
Less:	
Bank Service Fee	3.00
Newsletter Expense	119.86
Current Balance	$3,403.14

Note: The club's checking account has been moved from Family Bank to Boston Private Bank & Trust Company. The account earns no interest and pays no fees.

Rob

The Meeting

By Stephen C. Lovely

The Meeting, May 4, 2000

This was the first meeting after the big NAMES show in Wyandotte, and Ron says that once again it was a terrific show. George Luhrs was there, and this time he had a Cirrus engine with one-quarter inch bores. Ron still hasn't bought a Henrob torch yet either, it works magic at the show demos but Ron's worried that the magic may be in the hands using it as much as in the torch itself.

Karen LeBlanc has got things moving on the project to improve the layout of the shop area of the Museum to make it into both a more usable shop and a better exhibit for Museum Visitors. A work party will be going over the shop area on Saturday May 6 to get an idea of what the tools and machines are available and to measure the area so that a layout can be planned. Later sessions will be held to do the actual work of reorganizing the machines and getting things moved into their new locations, so if you missed this session you'll have another chance to get involved in the future.

Kay Fisher, the outgoing NEMES Treasurer and the new Editor of the Gazette, made a proposal that the dues year be shifted to run from January to December, as opposed to the current June to May. Dues will remain at $20 per year, and those who join after the year has begun will pay at a rate of $5 per quarter to put them into the same Jan to Dec cycle as everyone else. He also moved that since we have enough money to make it to January without a problem that we extend the current memberships until January. This was unanimously approved by everyone present, and Mike Boucher will be checking the bylaws to see

what we have to do to make sure that it's all legal now that NEMES is a corporation.

Kay also proposed a group purchase of a new book and video about to come out on scraping. The book and video are normally $55 a set. If we can get 10 people to each buy the pair, the cost will come down to $50 a set. There was some interest in a group purchase, and Kay will take orders for a group purchase at the June meeting.

Dave Stickler brought a set of Stuart Clone castings that he had bought. They came from Canada. They go together to make a clone of the Stuart 4, although there isn't a big "S" in the castings as there is on the actual Stuart 4. The drawings did say Stuart on them though. Aside from the fact that he hasn't made the valve gear for it yet it is done, and in the process of machining it he says he used his faceplate for the first time. He plans to put a reversing valve gear on it. It cost him about $100 Canadian for the castings and he feels they were a good buy. Mike Boucher says he has a set of the castings also and that he paid $70 US.

Tom Cross was at our meeting for the first time. He builds model airplane engines designed in the 1920s to the 1940s. "Flying and Aviation" in the 1940 period published the plans for several model airplane engines. Roger Schroeder has redrawn the plans using CAD and sells several different casting sets for them in the $30 price range.

Most of the ones Tom has made are in the .19 cubic inch size range and use an ignition coil and points to power a real spark plug to burn gasoline. A glow plug is used to ignite methanol in most model airplane engines used in the US today.

He has had problems getting the pistons to fit into the bore correctly when he makes them and asked if we had any advice on how to get things to fit correctly. What he has been doing is cutting the pistons to about 1 or 1.5 thou oversize and then lapping the piston into the bore to get the final fit by pushing it into the bore and pulling it out until all fits well. Suggestions to him were to rotate the piston rather than to just push it in and out in order to keep things round. The other suggestion was that the two parts should be lapped separately, and then thoroughly cleaned before the fit is checked.

Ron asked if the person who had shown him some aluminum model airplane engine castings, made in the dental lab he ran, was here. No one spoke up, so apparently he wasn't, but if it was you and you're reading this we'd be interested in having you give us a talk about how you cast them up.

Mike Boucher had a centering tool that he made from plans in one of Kozo's books. It's a piece of wire with a point on one end to fit into a center pop, held loosely a half inch or so from the point by a piece of metal that goes into the tool holder on your lathe. Put the piece in the chuck, center it up by eye, put the point in the center pop with the tool held by the tool holder, and the long end of the wire moves in a magnified manner to show you how the point is off center. Starrett used to make a tool similar to this but Don Strang says they don't anymore. Mike used it to cut an eccentric using his four jaw chuck. He laid out the two centers and punched them, then used the center finder to center them up and get the two circles offset just right. Roland Gaucher recommended that a sliding fixture on a faceplate is another good way to do it. Sliding the part on the flat surface of the faceplate you can be sure that the axes of the eccentric and its bearings will be parallel and the eccentric won't wobble on its shaft. If your chuck isn't perfect the two centers can be correct but not lined up with each other.

John Wasser found and interesting piece of metal while he was out for a walk at lunch one day. He kicked it and realized it seemed heavy, so he picked it up and it was heavy. He weighed it and it is 8 ounces. A similar size piece of steel he weighed was 3 ounces. There was a lot of discussion about what it might be, including the suggestion that it might glow in the dark. Someone volunteered to take a couple of filings and to have them analyzed. I'm looking forward to finding out what it might be. I know that when I held it up it sure did seem awful heavy.

Don Strang passed around another article on variable frequency drives. This one was on trouble shooting them. Now that they are coming down in price and showing up so many places people are starting to have problems with them. Most of the problems seemed to be related to misuse.

Vern Dibler has a new book out on Obelisks, listing the twelve tallest obelisks in the world. They range from 80 to 100 feet tall, and weigh hundreds of tons. An obelisk is a four-sided monolithic pillar that tapers as it rises and ends with a pyramid at the top. The ones in the list are all from ancient Egypt, made prior to 330 BC. All of them are made from syenite, a hard form of red granite, and all from the same quarry on the upper Nile.

The Obelisk in the Vatican was made about 1500 BC by the Egyptians and moved from the Quarry to Heliopolis, where it was erected. Nobody today knows how the Egyptians managed to make it, to move it down the Nile to Heliopolis, or to erect it once they got it there. When the Romans conquered Egypt they decided to bring it to Rome. They managed to lay it over on its side, moved it across the Mediterranean Sea to Rome, and then re-erected it in Rome. It weighs 361 tons, and the Romans packed it in 100 tons of wheat before rowing it from Egypt to Italy. Nobody knows the details of how the Romans did it either. It arrived in Rome in 41 BC.

In the sixteenth century when Saint Peter's was being built in Rome, the Obelisk was located behind it. In 1585 Pope Sixtus the Fifth had a competition to move it from the back of St. Peter's to the Front. At the time it was standing on a 27-foot tall base buried in fill so that it's 9 foot square base was about at ground level. Mounted on the top was a bronze ball, rumored to hold Caesar's ashes. (When it came down the bronze ball was removed. There were no ashes in it, but there were lots of dents from where various invaders had hit it with arrows - some things never change.) It didn't sit directly on its base, but on four bronze astragals, one at each corner. Each was 16 inches in diameter and cast in the shape of a crab. The front of St Peter's was 30 feet lower than the level of the fill at the back of Saint Peter's where the Obelisk had been for about 1600 years.

Domenico Fontanna won the competition to move it, and by Papal Edict he could commandeer whatever he needed to do the job, but had to pay a fair price for it. He supported it with two inch by four and a half inch wrought iron bars, and wrapped it in a protective cover to prevent any further damage to the stone. This added another 28 tons to the mass that had to be lowered. Since it was too tall to lower without hitting St Peters he had a portion of the building's wall removed so it could be laid flat. Forty capstans with three-inch diameter hemp ropes were used, which worked out to about 15,000 pounds of pull on each rope for a 300 per cent safety factor figuring the compounding of the force with the pulleys used.

Work started on April 30, and by 10 PM they had lifted it up two feet and ran into problems with unequal stress. He also found that it was 17 inches out of line and that at some point the Romans had repaired the base, which had been broken off the bottom and repaired. It was off center because the weight had squashed one of the bronze crabs. They had it on the ground May seventh. Fontanna had done a lot of work to calculate the loads and stresses involved, but didn't know about shear stresses and pulled the eyes out of several of the wrought iron bars.

After the obelisk was down they dug up the 27-foot tall base and moved it around front to put under the obelisk at its new location. It went into a 45-foot square 25-foot deep hole on top of 20 foot piles, covered with peeled chestnut planks that were covered with concrete before the base was put back into place.

New Astragals were made, with a lion's head facing out from each corner and a lion's body to each side, so there are eight bodies and four heads. Putting it back up was harder than taking it down because it had to be lifted entirely with the ropes, while coming down they had been able to lean it against a support. By September 28 it was back up, minus the bronze ball on the top.

We know how it was done in 1585 because Domenico Fontanna wrote a book about how he

did it in 1590 and included all the details. After moving the Obelisk he went on to build the dome of Saint Peter's.

Another obelisk is in New York City. It sits on a base that has a steel band holding it together. It's made of puddled steel with half a percent carbon that was made about 2000 years ago.

In all, there are about 40 obelisks known to exist in the world today, all made by the Egyptians prior to about 330 BC from the exceptionally fine and flaw free syenite in a single quarry. Cut and polished to a fine finish. Today we have no idea how they did it.

Moglice

The main speaker for the night was Dick Wagner of Mogo Rehab Inc., 193 West Avon Rd, Avon, Conn 06001, telephone/fax 860-673-5324. Dick represents Devitt Machinery Company, the exclusive United States agent for Moglice, which is the trademarked name of a filled epoxy product made in Germany by Diamant Metallplastic GmbH. So, to be correct and to keep the name from becoming a generic term like aspirin did, remember that Moglice is a brand of filled epoxy and not a general term for filled epoxy.

Moglice is something that Ron first came across on the Internet, where you can come across a lot of things that seem too good to be true. Moglice is one of those things, except that the more Ron checked it out the more it seemed that it wasn't - it's real.

I think the story that grabbed my attention about Moglice was the fish ladder. One of the large dams somewhere out west used big acme screws to move the fish ladder up and down to match the level of the water behind the dam as it went up and down depending on how much they were using to spin the generators. They were big screws with big bronze nuts on them, and because of the weight of the ladders that were being moved the nuts had a short life, wearing out in only a couple of months. Moglice was cast in place into the bored out nuts in an attempt to find an easier and cheaper way to keep the ladders functioning so the fish could get up and down the river. Moglice eliminated the problems of nut wear on the fish ladder and they had been in use for a couple of years by the time we heard about it.

Moglice got its start in 1964 when a customer who wanted a moldable low friction surface approached the owner of Diamant. Diamant came up with an epoxy filled with molybdenum disulfide. They made it into a curable putty.

Shim the carriage of a machine tool into alignment with a nice true bed, put mold release on the bed, mold it to fit so the Moglice stays attached to the carriage, and you have a perfectly aligned carriage without having to scrape anything to fit. You can do it with a new machine, or you can do it with a machine that needs to be rebuilt.

Dick Wagner goes to customer sites and trains them to do future Moglice applications while doing a needed repair or rebuilding job on their machine. An example is the nut he had with him at the meeting for a sample from a P&W Jig Bore. The bronze nut was worn, but the lead screw was okay. He bored the nut out about .120 over the major diameter of the screw, coated the screw with mold release, used alignment rings to hold the screw in alignment, and injected Moglice into the nut through a hole drilled in the side of it. Then he waited 24 hours to get a good cure. At that point if the screw turns too tight in the nut you can lap it in with a non embedding lapping compound, such as Timesaver brand.

You have about a one-hour pot life when using Moglice, followed by a 24-hour cure to bring it up to full cure and strength. Dick does not put Moglice into places where it is the sole support of something heavy, such as an unbalanced vertical slide. It's not that it isn't strong enough, it’s just that you can't be sure someone hasn't smashed it up against the stops and damaged it so that it's just barely holding on. That doesn't mean that it's not strong, just that you don't want to take chances. As an example the P&W leadscrew nut just mentioned is on it's second set of Moglice threads. Dick pushed the first set out in a press to see how much it would

take to break them. It took 14 tons, and the failure was in the bond between the Moglice and the bronze body of the nut, not in the Moglice.

If you have a ball nut that had died and you need to get back in business and can't wait two weeks for a new one to arrive, dump the balls and fill up the gap with Moglice. Then you can afford to wait ten years for the new ball nut to be delivered because the Moglice temporary repair will last that long.

The mold release for Moglice comes in a spray can and smells like furniture polish.

Moglice is good for up to 400 degrees F, but you have to allow for the fact that at higher temperatures it's not as strong. You can use it in a bearing, but you have to remember that it has limited temperature capability and doesn't conduct heat away from the journal as well as a metal babbit will, so be careful.

How much does Moglice cost per pound? Dick wasn't sure right off hand, but pointed out that it's sold by the gram, which is a clue that it's not cheap. If you put it on about a sixteenth of an inch thick, which is about how thick you usually want it to be, it will cost about $80 a square foot. That's about the same cost as PTFE (such as Teflon from Dupont), which is its major competitor.

You can use if for half nuts. It's hard to fixture it to cast the half nuts, but you can cast it as a whole nut and then cut it apart after it's cured up. It cuts nicely but is tough on cutters and will take the edge right off of a carbide tool.

Moglice comes in three viscosities. A liquid for easy injection for nuts, quills, etc., a semi liquid for carriages and such, and a putty that won't flow much at all.

The bigger the machine is, the more economical it is to repair with Moglice. Dick did a 100-ton table on a machine in New Jersey.

Is it brittle? If you whack it with a hammer you can take a chip out of it, but it'll support about 24,000 psi when it's cured.

How thin can you use it? Ten thou will do the job. If you go thinner you get problems because there isn't enough there to function properly. Sixty thou is about the optimum thickness.

You can use a scraper and adjust things if you get it on too thick. If you position things with jack screws and set them right where you want them to be before you put in the Moglice you can get it to come out just were you want it so there is no need to do any adjusting later.

Dick met one guy at a show who wanted to know if he could use it instead of line boring for the camshaft journals in a VW engine. Dick saw him two years later and he told him the engine was still running fine. Don't use it on the cylinders though as they run a lot hotter.

It comes in 100, 250, and 500-gram kits, and they don't recommend splitting kits. Mix a whole kit at once and you know it will cure up correctly. If you split a kit it might not cure right if you don't get the ratios perfect. They recommend that you use your Moglice within a year. The putty is about 41 grams per cubic inch and the thermal expansion of cured Moglice is about the same as that of aluminum.

A three-eighths hole and a quarter twenty screw could make a good lead screw combination. It could work well in a place where there isn't room for a ball screw, such as the vertical slide on the Grizzly mini mill Ron is converting to CNC.

How do you lap it if you need to free up the nut some after you've cast it? Use a non charging compound, and when your done wash it out with kerosene. Howard Gorin suggested Bon-Ami cleanser from the super market as a good choice for a non-charging compound.

If the lead screw is worn and you are molding a nut to use on it, mold it at the end where it is worn the least. You'll end up with backlash in the middle of the screw, but the nut will fit. If you cast it on the worn part of the screw it will be tight on the unworn areas of the screw and if it's worn enough it might not fit over them at all. As with all molding operations, if you

want a good result you have to have a good part to mold against. If you mess up and haven't put enough in, Moglice will stick to itself so you can add more later if you need to.

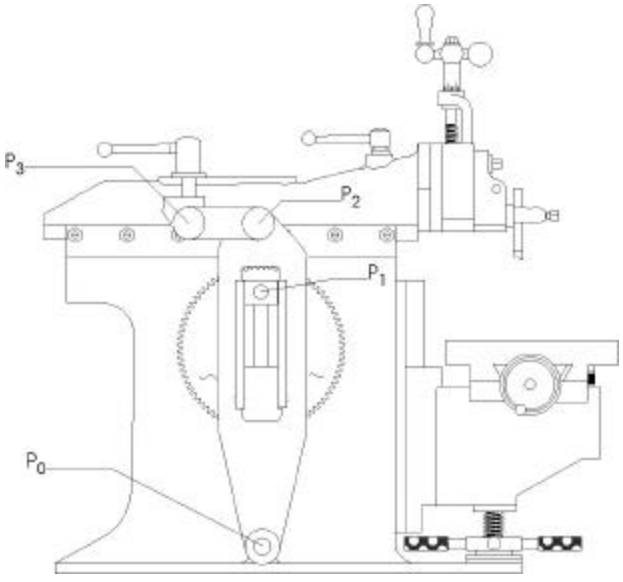
Diamant make a product called DWH, which doesn't have the MdS in it and is for static applications since it is not low friction. It's used by a German company to align the columns on their machines when they manufacture them. They line up the column and inject the DWH. It seems counterintuitive that this would be better than scraping the column in to the base, but with the DWH you get 100 per cent contact between the two parts, while with scraping you get at most about 15 per cent contact. So they feel they make a better machine by using the DWH. DWH is about half the price of Moglice, and if you can get it into the gap between the two parts it's thick enough to do the job.

Sand blasting is a good way to produce an optimum surface for Moglice to bond to.

After the meeting broke up Dick had a video of some real life Moglice applications that was shown downstairs in the little auditorium behind the old boiler.

See you at the meeting,

scl



Metal Shapers

By Kay R. Fisher

This month we will talk about another frequently asked question. Does it matter which direction the motor runs on my shaper? The short answer is yes. Most shapers that you are likely to come across in an amateur's workshop will be column shapers (like the one pictured). The motor, through a combination of belts, pulleys and gears, ultimately turns the large bull gear. Pictured in the column header we see the offset pin in the bull gear at Point P_1 pushes the rocking arm that pivots at Point P_0. By setting the position of this point you determine the length of your shaper's stroke. The top of the rocking arm at point P_2 supplies the forward and backward motion of your ram through the link to point P_3. The correct direction is for the motor to move the bull gear clockwise (in the drawing in the column header) such that the top of the bull gear is always moving towards the front of the shaper.

This motion of the eccentric pin at point P_1 will cause the ram to move forward on the cutting stroke more slowly than when it is retracting. The assumption is that you need all the power available to cut the steel but on the return stroke you can trade off power for speed and increase production. The reality is less dramatic. On modest stroke lengths there is very little difference in speed between the power stroke and the retract stroke. If you set your shaper on its lowest speed you will be hard pressed to notice the difference. But on the maximum length stroke the ram does retract noticeably faster than the power stroke.

If you run the motor backwards it still works fine. This brings up an interesting question about old machinery. Here we have a shaper that has been running for 30 years in the same direction. At the beginning of the power stroke when the tool bit first hits the steel there is one or two teeth in the bull gear that do all the work. This is the most important part of the shaper to check if you are looking at a used shaper. Make sure there are no teeth missing from the bull gear. But if we reverse the motor and run the bull gear backwards will it spread the wear out more evenly and last

longer or will it stress some poor gear tooth in a way that it had never been stressed before and cause a premature failure? Think about it and maybe we can have a show of hands at the next meeting.

Jay Stryker (one of our club members who is a shaper expert) asked the question in another way.

"Shapers were designed for slow speed cutting on cast iron. For aluminum, this is too slow. Is it OK to use a mechanical (bull-geared) shaper running in reverse to get the higher speed of the rapid retract for the forward stroke in order to cut aluminum? Would this wear the linkage or cause some mechanical problem? The advantage is that one could use the "ordinary speeds", instead of running the shaper at its highest speed." (I never imagined when I asked for questions that I would get the leading experts asking tough questions.)

I thought about it quite a bit and the short answer is no. I don't think wear would be a problem as discussed above but I don't think you would realize any speed advantage. Since the speed difference is only significant on long strokes and since the shaper slows down at the beginning and ending of each stroke the speed difference is only over a very short length in the middle of the part being machined.

And I can prove it! If you don't like math now is a good time to skip to the next article in the newsletter.

Point P_0 is the pivot point of the rocking arm and will be considered the origin for all values. Point P_1 as the bull wheel turns travels to the right and left as a function of the sine of the angle of the bull wheel. If we consider the ram stroke as the X direction and the up and down motion of the offset pin as the Y direction then point P_1 moves around in a circle and any given point will be represented as X_1 and Y_1. Point P_2 will be at X_2 and Y_2. And lastly point P_3 (which is what we really care about) will be at X_3 and Y_3.

r = the radius of the offset Pin P_1.

d_0 = the distance from P_0 to the center of the bull gear (a constant).

d_1 = the distance from P_0 to P_1.

d_2 = the distance from P_0 to P_2 (a constant).

h = the distance from P_2 to P_3 (a constant).

$X_1 = r \sin(\varpi t)$

$Y_1 = d_0 + r \cos(\varpi t)$

We also know that the point at the end of the rocking arm P_2 will be in a straight line with P_1 so the slope of the line from P_0 to P_1 is always equal to the slope of the line from P_0 to P_2. The important idea is that, since points P_0, P_1, and P_2 are always in a straight line, we know that:

$\frac{x_1}{d_1} = \frac{x_2}{d_2}$ Solving for x_2 we get $x_2 = \frac{d_2 x_1}{d_1}$

Both ratios are equal to the sine of the angle that the arm makes with the vertical (if that helps).

d_1 is the hypotenuse of the right triangle from point P_0 to P_1 with the bull gear centered to P_1 with the bull gear turned to any angle. Using the Pythagorean theorem we get:

$$d_1 = \sqrt{x_1^2 + y_1^2}$$

Substituting in the values for x1 and y1 earlier we get:

$$d_1 = \sqrt{(r\sin(wt))^2 + (d_0 + r\cos(wt))^2}$$

Squaring both terms we get:

$$d_1 = \sqrt{r^2\sin^2(wt) + d_0^2 + 2d_0 r\cos(wt) + r^2\cos^2(wt)}$$

Moving the two r^2 terms to the left we get

$$d_1 = \sqrt{r^2\sin^2(wt) + r^2\cos^2(wt) + d_0^2 + 2d_0 r\cos(wt)}$$

We factor r^2 out of the two terms on the left to become:

$$d_1 = \sqrt{r^2(\sin^2(wt) + \cos^2(wt)) + d_0^2 + 2d_0 r\cos(wt)}$$

Using the trigonometric identity:

$$\sin^2 + \cos^2 = 1$$

We can simplify the equation to:

$$d_1 = \sqrt{r^2(1) + d_0^2 + 2d_0 r\cos(wt)}$$

Or simply

$$d_1 = \sqrt{r^2 + d_0^2 + 2 d_0 r \cos(w t)}$$

Our original formula for x_2 was:

$$x_2 = \frac{d_2 x_1}{d_1}$$

Now substituting the value for d_1 above and the value for x_1 that we had long ago we get:

$$x_2 = \frac{d_2 r \sin(w t)}{\sqrt{r^2 + d_0^2 + 2 r d_0 \cos(w t)}}$$

This gives the position of P_2, not P_3 as desired. But it turns out that they are almost identical in their relative X position when calculated.

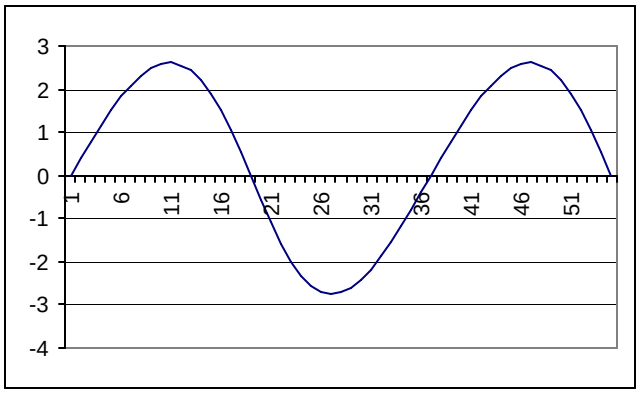
However, we can get the exact answer, since we know that:

$$h = \sqrt{(x_2 - x_3)^2 + (y_2 - y_3)^2}$$

$$x_3 = \frac{d_2 r \sin(w t)}{\sqrt{d_0^2 + r^2 + 2 d_0 r \cos(w t)}}$$

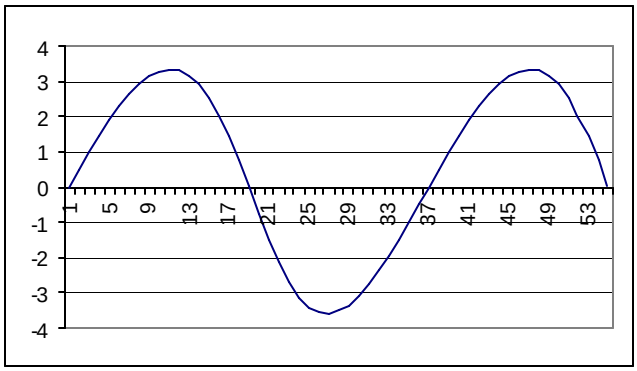
$$- \sqrt{h^2 - d_2^2 \left(\frac{d_0 + r \cos(w t)}{\sqrt{d_0^2 + r^2 + 2 d_0 r \cos(w t)}} - 1 \right)^2}$$

Substituting in known values and varying ϖt for one cycle we can plot the tool bit travel in X over time as follows:

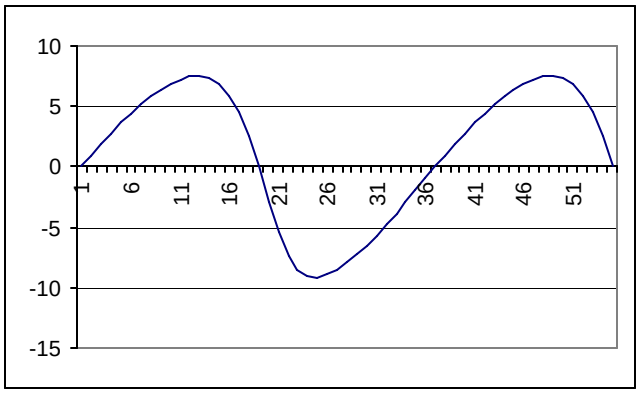


This was using data from my 7 inch Rhodes shaper with d_0 = 10", d_2 = 16.6", and r = 1.625" giving a stroke of 5".

You will notice that it looks almost symmetrical. This shows that the retract cycle is nearly equal to the power stroke. If I increases the radius of the eccentric pin on the bull gear to 2.1" the plot of the tool becomes slightly distorted to reflect the slow forward motion and rapid retract as follows:



Unfortunately it is still difficult to see any real change and this is currently at a 7-inch stroke – the max my poor little Rhodes can handle. However the software doesn't know the real diameter of my bull gear so here is what it would look like if I could increase the radius of the offset pin to 5 inches giving a stroke of 19 inches:



This exaggerated view shows slow power stroke and the rapid retract. The slope of the waveform at any point represents the velocity.

I knew that the tool path was following a sine function but to allow for the extra geometry of the rocking arm and the link I had to enlist the aid of

my friend, colleague, and math mentor Michael Tsuk. Michael developed the formulas and led me thru the proofs and helped me simplify the steps to bite size pieces that I could understand. In addition he entered the data into Mathematica and had prototype waveforms proving the validity before I created a Microsoft Excel spreadsheet from which I captured the above graphs.

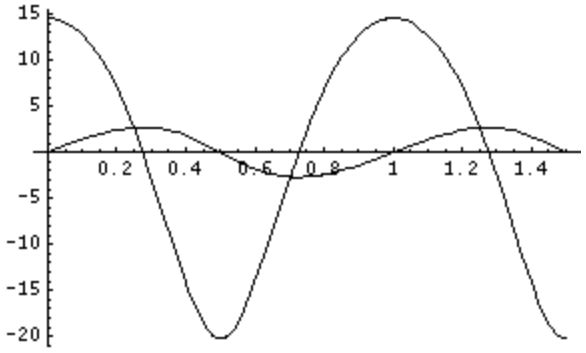
The next step (Oh no there's more!) is to recognize that what we really care about is not the X position over time but the velocity of the tool, which is the slope of the plot. To see this we could take little bites of the X and Y values from the spreadsheet and make a graph of the values of all the individual slopes. This would give us relative velocities but not in any measurable units. To accurately graph the actual velocity of the tool path in real units we need to find the derivative of the previous formula. For this we need to leave Excel and go into Mathematica.

The formula for derivative of the tool position over time gives us the answer to tool velocity in inches per second.

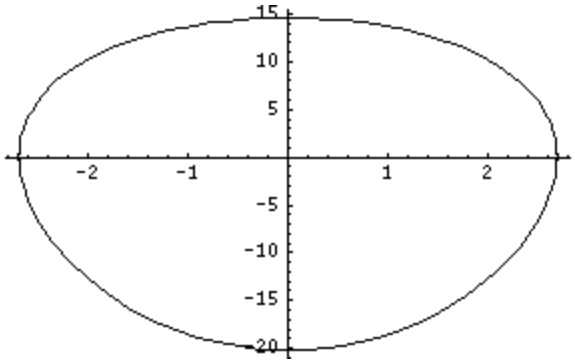
$$dx/dt = \frac{r^2 w\, d_0 \sin^2(w\,t)}{\left(r^2 + 2\cos(w\,t) d_0 r + d_0^2\right)^{3/2}}$$

$$+ \frac{rw\cos(w\,t) d_2}{\sqrt{r^2 + 2\cos(w\,t) d_0 r + d_0^2}}$$

This yields the following graph where the large sine wave is the velocity of the tool in inches per second and the small sine wave is the previously plotted tool position varying from plus and minus 2.5 inches for a 5 inch stroke. We are assuming here a shaper speed of 1 stroke per second. If you were running at 2 strokes per second you could simply double the velocity values.



What we would like to know from the above graph is specific values of velocity at specific positions on the tool position. For instance we would like to know the velocity at the center of the work piece and at each end. It is a little difficult to see on this scale but if we create a parametric plot from Mathematica we get the following:



Now we are getting close to the truth. The top of the plot is the power stroke with a maximum velocity of 14.5 inches per second. The bottom shows the return stroke at 20 inches per second. With a 7 inch shaper set up with a 5 inch stroke on a 4.5 inch work piece the velocity near the end of the work piece at the –2 and +2 inch marks would be approximately 10.5 inches per second on the power stroke and approximately 12 inches per second on the return stroke.

So if you run your motor backwards although the speed would increase from 14.5 to 20 inches per second in the center of the work piece it would only increase from 10.5 to 12 inches per second near the ends of the work piece. Not enough change to expect for any increase in finish quality.

If you were to increase the stroke to the maximum (7 inches in this case) you would have even less gain in tool speed near the ends of the work piece.

OK – I promise – no more shaper math ☺

Keep sending letters and email with questions and interesting shaper stories.

For some of us the acquisition of a new tool is the best part. If it is a used tool that just makes the acquisition turn into another interesting and rewarding project. There is no greater feeling than turning the object of a rust hunt back into a shinny tool that works as good as new. Next month we will have part one of a shaper acquisition story.

My mailing address is at the top of the newsletter and my email address is Kay.Fisher@Compaq.com

Kay

Next Months Gazette

- Ron Ginger's NAMES trip to Michigan.
- Bill Bracket's Work Bench Storage
- Rob McDougall's Shaper Story
- Steve Cushman's Sheldon Lathe Project
- Web Sites of Interest

The NEMES Gazette

Newsletter of The New England Model Engineering Society

c/o Rob McDougall (Treasurer)

357 Crescent Street

Waltham, MA 02154