troubles caused by the hob going out of pitch in hardening may be eliminated, and wheels cut with such a hob as this probably comes as near to perfection as can be obtained on any wheel cutting machines.

Disadvantages of Hobbing Principle.

Nevertheless, there are certain disadvantages of the hobbing principle. In the first place, owing to the spiral twist of the blades a section of the blade normal to the axis of the blank is not a perfectly true rack and in consequence the points of the teeth are very slightly too thick. Secondly, while the blank rotates continuously the cutting is intermittent, and after one tooth of the hob has taken a cut a small piece of metal escapes before the next tooth comes into action. If a hobbed wheel is examined it will be seen that the sides of the teeth show a series of small flats. Bv increasing the number of teeth in the hob, the flats are made smaller, and if there were an infinite number of teeth in the hob it would generate a smooth curve.

Grinding Teeth of Gears Advocated.

Of recent years there has been a great tendency towards grinding the teeth of the change gears for motor cars. At first the wheels were run in with emery and grease. This was found to take off as much metal from the parts that were correct as from those that were incorrect, and while some wheels ran much better after this treatment others were decidedly worse. However, something in the way of grinding has long been requisite, and about two years ago a machine was made by Messrs. Reinecker on the same principle as the machine used in the Fellows' gear-shaper system, for grinding the involute teeth of the cutters. The machine carries an emery wheel bevelled on each side to the shape of a rack-tooth with sides inclined at an angle of 29°. This wheel revolves at about 2,000 revolutions per minute. At the same time it moves bodily up and down through the space of tooth whilst the blank rolls under the restraint of two steel tapes, as in the Bilgram bevel gear planer. A few thousandths of an inch are left on the teeth for grinding, and the teeth are generated to the true involute form. One tooth is finished at a time and then the blank automatically moves forward to the next space. The amount of wear on the emery wheel is said to be small and the wheel can be trued up in its place. Gears ground by these machines show a great improvement over those which have not been ground. Nevertheless, owing to the gradual wear of the emery wheel there is a difference between the first and the last tooth finished in this way.

The author has devised a machine for grinding the involute teeth of gear wheels, which works on the principle of the hobbing machine. The teeth are generated simultaneously so that distortion due to the heating of the blank is eliminated, and, as the downward feed of the abrasive wheel is very rapid, the wear is practically negligible. For purposes of experiment an ordinary 22-inch gear hobbing machine made by the author's firm was chosen. In place of the hob was substituted a cylinder of corundum, Grit 50 and Grade M, 10 inches in diameter and 7 inches long, having a continuous thread of 7 pitch cut upon it. The sides of the thread are straight and inclined at an angle of 30°, which is the exact shape of the thread of the hobbing cutter. The thickness of the thread on the pitch line is however made rather less than the correct thickness for a 7 pitch tooth. This corundum worm practically amounts to a hobbing cutter having an infinite number of teeth. The thread was roughed out in a lathe with Huntingdon dressers in seven hours, and finished by grinding on a Greenfield universal tool grinder with a carborundum wheel in 21 hours. It is thought it may be possible to save much time in the manufacture by moulding the thread roughly into shape. In place of driving the corundum worm through the gear box and vertical shaft of the machine, a pulley is fixed directly on the spindle of the corundum worm itself. By this means the effects of the torsion of the shafts are got rid of. The corundum worm is revolved at a speed of 2,400 revolutions per minute, and it is geared up to the work table through change wheels as in a hobbing machine. A rapid downward feed is provided for, and the driving belt is led horizontally to the driving pulley to permit this.

The author has ground up several cast-iron wheels of 7 pitch on the experimental machine. The wheels are first hobbed, but the hob is not put into the full depth, so that a few thousandths of an inch are left on the sides of the teeth for grinding off. Before the wheels are ground the bottoms of the teeth are cut to the full depth with a special formed cutter. It would of course be far better to hob the teeth in one operation with a hob having teeth that are slightly too thin. The wheel is then put on the work mandler and the corundum worm moved down by hand until its centre is level with the top of the wheel to be ground. The corundum worm is then adjusted endwise by means of a screw turned by a worm and worm wheel by which a very fine cut can be put on, so that one side of the thread touches one side of the teeth in the wheel. Owing to the thread on the corundum worm being thin, as has been explained, the other side of the thread is not in contact with the teeth. The corundum worm is then allowed to feed down automatically, grinding up one side of all the teeth and generating them truly. The machine is then stopped, the corundum worm raised by hand, and a finishing cut taken. The other sides of the teeth are ground and finished in the same way. A stream of lubricant consisting of water, soda and oil is kept running on the wheel to prevent glazing.

In the best results obtained so far a cast-iron wheel of 70 teeth 7 pitch and 1¼ inches face was completely ground in eight minutes.

The wear on the corundum worm appears to be very slight, about 1-1000 inch in the worst part, but in the finished machine it is proposed to provide a carborundum wheel for touching up the corundum worm after each cut. The author has found that when he grinds 1-1000 inch off the corundum worm to true it up, the carborundum wheel which grinds it shows only 1-4000 inch of wear. The author has also found that the corundum worm is only worn on three threads for about one-third of their circumference. In the finished machine an arrangement will be provided for traversing the wheel that is being ground across the face of the corundum worm, like a wheel meshing with a rack, thereby wearing the corundum worm evenly. To compensate for this traversing motion, a differential gear will have to be provided like that of of the Reinecker machine when cutting worm wheels with a taper hob. The results obtained with the experimental machine have been so good that with these improvements there is every prospect of the success of a future machine

All Wheels Should Be Ground.

The author's idea is that not case-hardened wheels only should be ground on this machine, but every kind of metal should be ground in the soft state, no matter for what purpose the wheels are required. The wheels would be roughed out rapidly in the gear hobbing machine with no attempt at finish, and then sent to the grinding machine to be finished, just as all lathe work that is required to be both accurate and cheaply produced, is first roughed out in the lathe and then finished on the universal grinder.