Mechanics.

PUTTING UP SHAFTING.

The writer once had the putting up of considerable shafting, and the following are some of the data respecting the same, the rules and formulas found in text-books being insufficient to form a correct opinion by. The writer found that 800 pounds, acting on the end of a 12-inch lever, would twist off a wrought-iron shaft one inch in diameter. The *length* of the shaft had no influence on the breaking or twisting-off force, or torsional strength of the shaft, though on the length depended the torsional elasticity. The speed of a shaft controls its size, that is, if a one-inch shaft is large enough to transmit a given force at 50 revolutions per minute, a shaft running at 100 revolutions per minute will transmit the same force, its *area* being one-half of the one-inch shaft. This is plain enough when one remembers that the surface of a pulley on the smaller shaft travels *twice* as far in the same time that a similar surface on a similar pulley on the lower shaft travels, and hence needs transmit but half the force, to equal the force through half the distance.

Suppose we have a factor of safety of 4, this will allow of our continuing a force of 200 lbs. ($800 \div 4 = 200$) on the end of our 12-inch lever. That is, 200 will be a safe load. Now, if we wish to find the *area* of a shaft, to transmit 10 H. P. at a speed of 300 revolutions per minute, over a 24-inch pulley, we multiply 33,000 feet (one H. P.) by 10 H. P., obtaining 330,000, which, divided by the number of feet the run of the pulley passes through per minute (6.28 ft. + 300 revolutions), will equal the strain on the end of a lever equal to the radius of the pulley. In the case supposed, the radius of the pulley equals 12 inches, the size of the one for comparison. If it had not it would have been necessary to reduce it to 12 inches, that is, the effect the force would have at 12 inches. This force, whatever it may be, then being divided by 200 (the safe load on a one-inch shaft) will equal the area of the needed shaft, that is, it will equal the area in units of the area of a round shaft one inch in diameter—7,854-10,000ths of a square inch.

To reduce the radius of the pulley, whatever it may be, to the standard of the unit of comparison—12 inches—suppose the pulley was 40 inches in diameter, the radius is 20 inches. If the force as found were 50 lbs., we would multiply the 20 inches by 50, and divide the product by the length of our standard lever, 12 inches. The result being the weight necessary at the end of a 12-inch lever that would be equal to the force or strain on the belt over the pulley. For instance, let us take the conditions of the case given: Number of feet raised one foot high in *one* H. P. $\times$ 10 = 330,000. Circumference of pulley = 6.28 feet, which multiplied by 300 = 1,884 feet per minute, that the rim of the pulley moves through; $300{,}000 \div 1{,}884 = 175.15$, that is 175.15 lbs. is the constant strain on the belt, because 175.15 lbs. through 1,884 feet = 10 H. P. = 330,000.

This steam is transmitted to the pulley which acts as a lever, equal to the radius of the pulley, tending to twist off the shaft. The radius of the lever in this cone is 12 inches, which happens to be the same as our lever of comparison.

Thus we have a force of 175.15 lbs. acting on the end of a 12-inch lever; 200 lbs. on the end of a 12-inch lever was, as previously stated, a safe load for a one-inch round shaft; $175.15 \div 200 = .875 = \frac{7}{8}$ of the area of a shaft one inch in diameter = .6872 of a square inch, and would be a trifle over nine-tenths of an inch in diameter.

Thus, so far as torsional strength is concerned, a one-inch round iron shaft will transmit with safety 10 H. P.; but there is another feature of the question to be looked after, and that is the lateral stiffness of the shaft.

A one-inch shaft, five feet between hangers, will be deflected from a straight line 9-64ths of an inch by a pull of 28 pounds midway between hangers, while a pull of 56 pounds will cause a deflection of $\frac{1}{4}$ of an inch. However, there are few shafts of two inches and under that are not constantly deflected $\frac{1}{4}$ when transmitting power, especially if the pulley is midway between the hangers. The deflection of shafting is approximately represented by the general law that deflection increases as the cube of the length, and inversely as the cube of the diameter. Thus, if we should leave but $2\frac{1}{2}$ feet between hangers, the deflection would be $(2\frac{1}{2})^3 = 15.6$ and $5^3 = 125$, and $125 \div 15.6 = 8$, therefore the deflection at $2\frac{1}{2}$ feet between hangers would be 8 times less than it would be 5 feet between hangers. A $1\frac{1}{2}$-inch round shaft, 10 feet between hangers, will be deflected 9-16ths at the center by 56 pounds.

A three-inch shaft, 10 feet between centres, would be deflected a trifle more than 1-16th at the centre by a pull of 56 pounds. The remedy for deflection is more bearings, setting the pulleys as close as possible to bearings, and speeding the shaft up. Small shafting will not break, nor twist off when put up in accordance with the above data.

Many dollars have been thrown away in putting up large and slow-running shafting, which is so expensive at first cost, liable to break for want of alignment and excessive weight. The lighter shafting is by far the most economical in every respect—first cost is less, expense of putting up and keeping up is less, and has a longer life, and runs with less friction.

How many of your readers would be surprised to see a two-inch shaft taking off 1000 indicated H. P.? A great many, I think. Still, I have in mine just such a shaft, which has been doing the above amount of work for eleven years, and which was put in to take the place of a four-inch shaft, which had broken repeatedly. I believe I am correct in saying that there is no necessity for a line shaft larger than two, or two and one-half inches in any shop or manufactory in the United States. The shaft mentioned above as taking off 100 H. P. made less, I think, than 200 revolutions per minute. The shaft might easily be reduced in area one-half and more by doubling the speed. There are a great many shops, now running with three and four-inch shafting, that might make a few dollars by selling the same and replacing it with one and three-fourth and two-inch shafting. It will be well to remember the following: Never put up a slow-revolving shaft when a fast one will do as well (and that is nine cases out of ten). Increase the bearings, as such increase does not affect the friction, and increases the life of the shafting.—*V. Hook in American Machinist.*

HARDENING AND TEMPERING AT ONE OPERATION.

Steel hardens when suddenly cooled from a red heat, and whether the heat be extracted by immersion in water or other matter, is of no consequence, so long as it is extracted with sufficient rapidity to effect the hardness. The degree of hardness depends first upon the temperature to which the heated steel is raised; and, secondly, upon the rapidity with which the heat is extracted. Water is the medium mostly used for this purpose, but it is a well-known fact that if water of a sufficient degree of soapiness is not employed, the steel will not harden.

It is obvious, however, that the degree of soapiness may be so varied as to either prevent the steel from hardening or to have no practical effect upon the hardening. It is also obvious that it is possible to obtain a degree of soapiness that shall give to the steel any required degree of temper, and thus temper the tool without having to harden it at one operation and temper it at another, which would dispense with the hardening process and thus save both time and fuel, as well as oil or other material ordinarily used for the tempering. That tempering processes will ultimately be based upon this principle there can be no doubt, the difficulties (which will be explained presently) being so slight as to be easily overcome.

In my last communication I described one method of tempering at one operation, and I have now to describe another method which has been employed by the Monitor Sewing Machine Company to temper their small spiral springs.

In this process the steel is heated to the usual degree and cooled in a mixture of milk and water. The proper proportions of milk to water would undoubtedly vary with the quality of the milk, hence it must be arrived at by trial. The more milk the lower the temper, all other things being equal, and conversely the less milk (in a given quantity of water) the higher the temper. The proper mixture once attained, the tempering can be carried on very expeditiously, but it is apparent that such a process is more suitable for tempering in quantities than for single pieces, especially when the grades of steel may be variable.

The difficulty in obtaining uniform results lies in the difficulty of heating the pieces to an exactly equal temperature before dipping them, for it is found that a very small difference in the heat of the steel makes a wide difference in the degree of temper obtained, but it may be stated positively that with a uniformity of heat the best of spring tempering may be obtained.

In this connection, there arises the question whether a good spring temper may not be obtained by heating the steel to a low red heat and mixing a lesser quantity of milk therein (the requisite quantity to be determined by experiment). If such is the case, as seems highly probable, the process is expedient in the heating part of it. This would leave the steel tougher, while, at the same time, it would obviate the liability of burning the steel.