Sixty per cent betterment attained on forged Oldsmobile shafts by use of a new automatic machine that makes a cycle in forty-seven seconds

Fig. 1. Diagram showing how fillet rollers are applied to the fillets of crankpins and main journals of Oldsmobile crankshafts. Work rollers set at an angle apply heavy pressure against fillets. Backup rollers take the reaction of work rollers.

Fig. 2. Two work roller units at left and two backup roller units at right. The wider ones are applied to crankpins, and the narrower ones to main journals.

Fillet where crankpins and main bearings join the faces of the throws of forged automobile engine crankshafts are critical areas that must be ground and polished if high fatigue life in service is to be realized. Only in recent years, however, has it been appreciated generally that a marked increase in both fatigue life and in bending moment can be attained in crankshafts by subjecting fillets to suitable rolling action after grinding and polishing (article entitled "Fillet-Rolling Diesel-Engine Crankshafts" was published in November, 1960, Machinery).

European manufacturers of automobile engines have employed German type Hegenscheidt machines for fillet rolling. In such applications, however, the fillets have been of an undercut type that is not popular in American crankshaft design. Oldsmobile engineers and production specialists believed, however, that such fillet rolling would yield similar results on forged crankshafts having fillets that are not undercut, provided that suitable procedures were developed. Accordingly, work was undertaken by Oldsmobile with this objective in an experimental lathe setup.

Tests made with this machine proved that the results anticipated could be attained on conventional Oldsmobile crankshafts identical with those already in production and having fillets not undercut. This naturally required the development of rollers of suit-
able contour and hardness, along with roller holders properly designed and constructed.

It then remained to design and build production machines capable of rolling fillets at a rate compatible with that of other production equipment already in use. Rolling is now done on crankshafts of the V-8 type (designated "645"). The crankshaft design was not altered to enable fillet rolling, and SAE 1049 medium forging steel is used as before. Specifications for heat-treating and for grinding and polishing are the same as previously. Fillet rolling was merely added to the conventional procedures.

Although the added operation has increased crankshaft costs somewhat, the increase in fatigue life and in bending moment fully justifies the added expense, including the cost of new machines that had to be developed. Farrel-Birmingham Inc. has built several machines to Oldsmobile specifications. They embody the experience of the Hegenscheidt, Farrel-Birmingham, and Oldsmobile companies.

Rollers that bear against the fillets are made of M-2 tool steel and measure 0.620 inch in outside diameter. They are 0.280 inch thick at the hub but are thinned out gradually until side faces merge with an 0.063-inch radius at the periphery to correspond with the radius of the fillet to be rolled. After the rollers are rough-turned on an engine lathe, they are hardened to 58 Rockwell C and then are ground to the specified diameter and periphery. Side faces are given a 5-degree relief to clear crank-arm checks. The design and arrangement of rollers are indicated in Fig. 1 where the fillet rollers are seen at A, a work roller support at B, and a backup roller at C.

Grinding results in a 10-microinch smoothness. Hand polishing with 400-grit carbide paper follows grinding, and then crocus cloth and rouge are applied by hand to obtain a 3- to 4-microinch smoothness. Work rollers are used in pairs on each crankpin and on each main bearing journal. Work rollers are set at a 43-degree angle in relation to the axis of the crankpin or journal. A bronze cage provided for each roller permits it to float and be self-centering.

Each pair of cages is attached to a holder, as seen at the left in Fig. 2, that spaces and positions the rollers so that one bears against a corresponding fillet of the crankpin or main journal. As the rollers float in their cages and do not bear in them or in the
Fig. 3. Oldsmobile V-8 crankshaft resting in brackets of the Farrel-Birmingham machine, ready to be rocked backward on roller supports of the open machine.

Fig. 4. Fillet-rolling machine with a crankshaft held in rolling position. Tooling for main journals remains fixed but that for crankpins reciprocates.

holder itself, roller reaction has to be taken by backup rolls arranged in holders as seen at the right in Fig. 2. The backup rollers are supported on needle bearings whose cages fit into and are locked in recesses of the carrier blocks. The backup rollers are hardened to 60-62 Rockwell C and then are finish-ground and polished. They have annular grooves that bear against the work rollers that take the reaction of pressure that is applied hydraulically to the rollers.

Fillet rolling takes place when the crankshaft is rotated slowly (60 rpm) and pressure is applied to the work rollers. As the latter roll against the fillets, pressure causes the fillets to be work hardened. As a result, the strength of each fillet is increased and it takes on a planished surface.

In the fillet-rolling machine, the squeeze pressure applied by the hydraulic fluid is 624 psi, but as the area of work rollers in contact with the fillets is quite small, the specific pressure on the fillets is very high. It is calculated to be on the order of 385,000 psi. This pressure, in conjunction with the rolling action, produces whatever slight metal flow occurs in the crankshaft fillets and improves physical properties, as mentioned.

In the operation of the machines, a light hoist is employed to transfer each crankshaft into a cradle loader, as shown in the heading illustration and in Fig. 3. This cradle initially positions the shaft axially so that the four main bearing journals are opposite to, but at a lower level than, the floating main bearing backup rollers of the machine. When the cradle is rocked upward, it transfers the shaft so that its journals rest upon backup rollers, as seen in Fig. 4, with the main journals and crankpins located between corresponding upper and lower tooling.

There are, of course, eight sets of backup rollers below the crankpins and journals, and eight pairs of work rollers above, the sets being separated, as shown in Fig. 3, during loading and unloading. The backup rollers take the load imposed by the work rollers when the latter are forced against fillets with the rolling force of 385,000 psi. This load is applied against each fillet when the machine is closed for rolling all sixteen fillets at the same time, as seen in Fig. 4.

Rolling pressure is applied by hydraulic plunger systems that do not act directly but through scissors linkages at the back of the machine to provide a fulcrum point for each tool assembly. Tooling above each bearing includes a central mandrel, a series of needle bearings, and an outer work-roll shell. Two annular work-roll grooves are form-ground in each work roller support, after which the groove radii are heat-treated to a 62-63 Rockwell C hardness.

Bottom work-shoes each include four centering mandrels, four sets of needle bearings, and four backup rollers, as illustrated in Fig. 1. Riding in contact with each pair of backup rollers is another roller of about 1/2-inch diameter that bears tangentially against the two work rollers at two points and against a crankshaft journal at one point. Thus, the bottom shoes provide two supports for each crankpin and for each main journal.

After a crankshaft is set into the machine, the machine oper-
ator presses a button to start a cycle. The upper tooling assemblies are brought down so that each closes against a crankpin or against a main journal. The crankshaft then starts to rotate, turning against lower tooling, much as if the crankshaft were rotating in fixed main bearings of an engine. The upper and lower tooling for the crankpins rotates with them.

After a few revolutions, the hydraulic pressure is increased, causing the work rollers to rotate under a given maximum pressure against the sixteen fillets. When a set time elapses, the machine stops, the pressure is released, the machine opens, and the crankshaft is rocked forward for removal by means of the motor-operated hoist.

During the rolling operation, lubricant is applied to all bearing surfaces under pressure, the lubricant being the same light oil that is used in the hydraulic system. For the first five revolutions of the crankshaft at 60 rpm in the machine, pressure is light but is increased slowly in the 2-inch hydraulic cylinders until it reaches 624 psi. This load is continued for ten to twelve revolutions and then is released, after which the machine stops and opens and the crankshaft is unloaded. As the hydraulic pressure is balanced by internal reactions and the setup is self-aligning, no distortion of the crankshaft as a whole occurs.

Total cycle time is forty-seven seconds, including loading and unloading. Once started by a control button, the cycle is automatic but can be stopped by simply pressing a button. During operation, both front and rear windows of the machine are closed to prevent loss of lubricant.

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