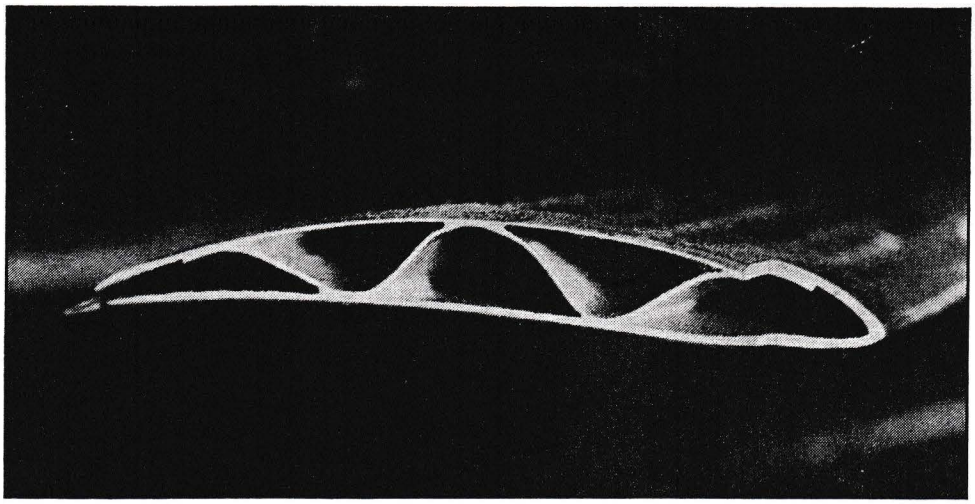


End view of a finished Iroquois stator blade showing reinforcement baffle between outer skins.

HARD METAL FABRICATORS

How One Small Canadian Industry Helped Cut Weight and Costs for Orenda's Iroquois

A SMALL, relatively unknown Canadian company—Hard Metal Fabricators Ltd.—has made a major contribution to the development of Orenda's mighty Iroquois turbojet. As a result, the production Iroquois should be a lighter, less costly engine.

The contribution: the development of a method of mass producing compressor stator blades by stamping them out of stainless steel sheet in the cold state, to the extremely fine tolerance of .003 in. Such tolerances are commonly associated only with machined parts, and are practically unheard of in the precision sheet metal stamping field.

In making such a success of this program, Hard Metal Fabricators proved once again that there are very few areas of technical product development in which Canadian small industry cannot compete with better than satisfactory results to the principals concerned.

Hard Metal Fabricators is, perhaps, typical of Canadian small industry. Formed in 1948, in Toronto, it originally had two employees besides the founding partners, Graydon E. Anderson and W. H. Walley. Mr. Walley is president of the firm, while Mr. Anderson, under whose personal guidance the Iroquois blade program was carried out, is vice president and general manager.

During the first years of the company's existence, operations were conducted from a 3000 sq. ft. former garage. About five years later, a move was made to larger quarters (9000 sq. ft.) at the present location, and in 1956 these quarters were expanded to 24,000 sq. ft. Staff normally averages about 90.

According to Graydon Anderson, the ability to organize themselves to carry out specialized segments of major programs is the key to successful participation by small industry in the development of technical products like the Iroquois. In effect, the small company must be prepared to organize itself to act virtually along the lines of a department of the prime contractor for which it is working.

Flexibility: The small organization's intrinsic flexibility is particularly advantageous in this regard. This same flexibility is also helpful in the actual carrying out of any development work which a small company may undertake, enabling it to switch quickly when necesasry from one line of development to another, more promising one.

The very fact that the prime contractor is risking, at best, a serious delay in an important program by placing such seemingly unbounded faith in the capabilities of the small specialist firm, is such a formidable challenge that it almost guarantees success. Says Graydon Anderson of his company's Iroquois work: "When Mr. Earle K. Brownridge of Orenda placed such confidence in us, we just couldn't afford to fall down."

The participation of Hard Metal Fabricators in the Iroquois development program can be traced back indirectly to the design philosophy behind the big turbojet, which visualized the engine as combining high power with minimum weight. A thrust/weight ratio of 5:1 or better was the aim, and this has in fact been achieved.

Uncharted Waters: To realize this in many ways seemingly contradictory combination, it was necessary for Orenda to develop many new techniques and to introduce a variety of new materials.

In the quest for lightness without sacrifice of other essential qualities, the introduction of titanium as a replacement for steel in some of the forged stator and rotor blades has been a big step forward. However, insofar as blading is concerned, it has long been obvious there could be no really significant savings in weight until a satisfactory hollow blade had been developed. It follows, of course, that many other gas turbine manufacturers besides Orenda have for some time been working towards the development of hollow stator and rotor blades for application in both compressor and turbine sections.

There are a variety of ways in which such blades can, and on a short-run basis have been made. Of these, the idea of stamping them out of sheet metal has been the most attractive, though posing the most formidable production problems. Not only would a stamped sheet metal blade save weight, but it could produce substantial cost reductions.

Not Unknown: Hollow blades

stamped from stainless steel sheet were not unknown elsewhere when Orenda decided to go for this technique in producing the 11 stages of stator blades for the Iroquois compressor section. At the same time, only limited success had been met in developing a method of mass producing such blades.

As part of its experimental program directed towards the development of a technique of mass producing stamped blades, Orenda began casting around for outside assistance from some organization wise in the ways of precision stamping. U.S. firms were approached, but the lowest bid on the job from this source made the Malton engine manufacturer hesitate.

It was at this time that the name of Hard Metal Fabricators was suggested to Orenda as possibly being an organization capable of finding the answer to the problem of developing methods to produce a precision stamped stator blade. Orenda investigated, found that though Hard Metal Fabricators was best known among manufacturers in the automotive, electronic, and appliance fields, it had previously done some work for several aircraft industry companies, including Canadian Pratt & Whitney (tooling only) and Lucas-Rotax, as well as Orenda itself. Among the items it had produced were noses by the millions for shells, and by the thousands for Heller rockets, under sub-contract to the DDP.

Second Stage Try-out: Orenda decided to let Hard Metal Fabricators have a crack at developing production tooling for, as a starter, the second stage of compressor stator blades.

It is of interest to note that Hard Metal Fabricators undertook the job on a firm price basis, and, further, at a price that was, it was later learned, only about 50% of the lowest American bid.

This was in November, 1956. Within 90 days the first blades were coming off the tools. Though these initial blades were not within the required tolerance, they proved that the basic approach was sound. By July, 1957, progress was such that Orenda was firmly convinced that Hard Metal Fabricators had the main problems licked, and, accordingly, released the remaining ten stages of compressor stators to the tooling and stamping firm.

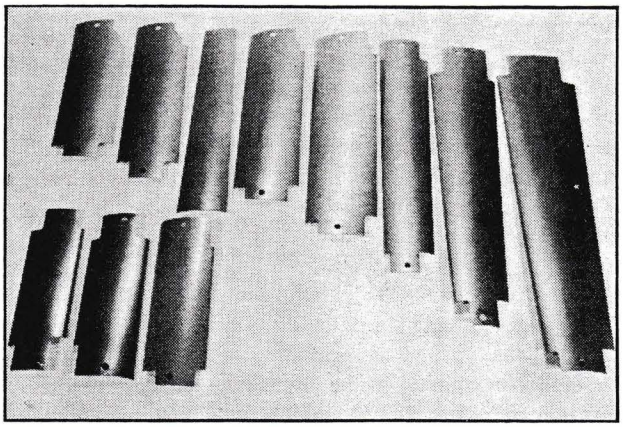
With these ten stages, as with the first on which the company cut its teeth, all it had as a starting point were the vinyl drawings, the material specification, and the dates of delivery required by Orenda.

Three Pieces: Each blade, insofar as Hard Metal Fabricators was concerned, was comprised of three pieces—upper airfoil, lower airfoil, and internal baffle. Actual assembly of the blades, which involved welding the three pieces together and other finishing operations, was to be carried out by Orenda. (All phases of blade manufacture will ultimately be turned over to Orenda, Hard Metal Fabricators' principal job being to develop the method and produce blade parts until Orenda is ready to take over).

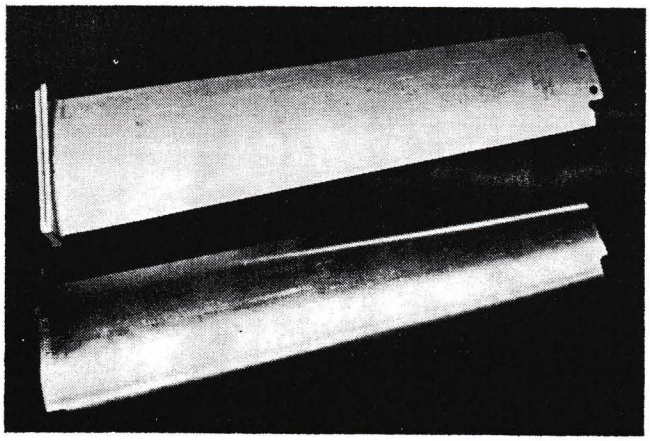
A typical blade, as represented by a second stage stator, required some 11 tools (two stretchform dies, eight trim dies, and a notching die).

There was nothing haphazard about the way Hard Metal Fabricators approached its assignment. During the early months of the project, a system of program control was developed and introduced, which was such that at any time Hard Metal Fabricators could tell the exact status of any individual tool (and over 425 tools and gauges were finally accepted by Orenda). If a tool was behind schedule, the records indicated precisely why it was lagging.

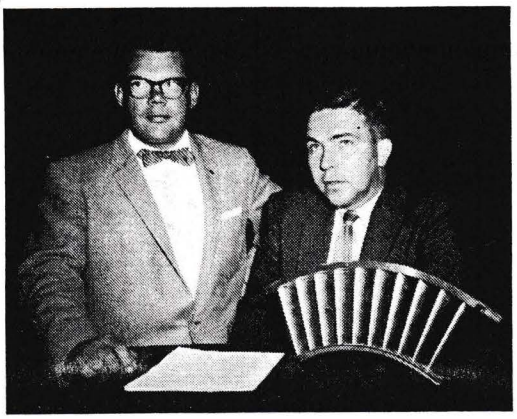
This "fingertip control" was achieved by breaking the production of each tool down into five phases: (1) Engineering, (2) Purchasing, (3) Models, (4) Manufacturing, and (5) Tool Proving. Color coding provided instant visual presentation of the status



A set of blade skins, each one representative of one of the eleven stator stages of the Iroquois, laid out to show relative size.



At left is a comparison of Iroquois stator blades made by different processes and of different materials. Top, forged titanium blade; bottom, stamped sheet metal blade.



The founding partners of Hard Metal Fabricators, left, W. H. Walley, president; right, Graydon Anderson, vice pres.

of each of these phases: red for behind schedule; green for ahead of schedule; blue for on schedule.

Up to Date: The color code schedule charts were brought up to date every half week. Close watch was kept on the progress of each part of every tool program. If part of a program was running consistently ahead, then some pressure was taken off of it, and an attempt would be made to use the reserve capacity thus gained on another part that was running behind.

Extremely close track was kept of costs at all times, so that Hard Metal Fabricators was able to supply Orenda with a detailed cost breakdown of every major phase—labor, materials, overtime, engineering, models, manufacturing—of production of the blade tools and gauges.

In addition, graphic presentations were prepared at regular, frequent intervals for briefing Orenda engineers on the progress that was being made towards getting the blades coming off the stampings within the .003 tolerance. Each graph showed how close to the tolerance a blade from current production was at 23 different check points.

No Distortion: As Hard Metal Fabricators summed it up, the problem faced in the ultimate manufacture of the blades appeared "to be the necessity of producing a part which will lie in the free state on a master model and be in positive contact at all stations; that is, eliminate all distortion in forming.

"Our aim was to make no allowance for spring-back or distortion, as this could become uncontrollable. It would be best to eliminate all strain at the cold working stage."

The blades kept coming off the tools closer and closer to the required tolerance, and finally they were being produced within the .003 in. limit. However, Hard Metal Fabricators showed that it was trying to do more than simply meet the customer's minimum requirements (even though these in themselves were unusually demanding) when it reported to Orenda that . . . "We are not satisfied with this blade, as we are using all the tolerances of the finished blade, and have absolutely nothing left for the other operations to be performed at Orenda."

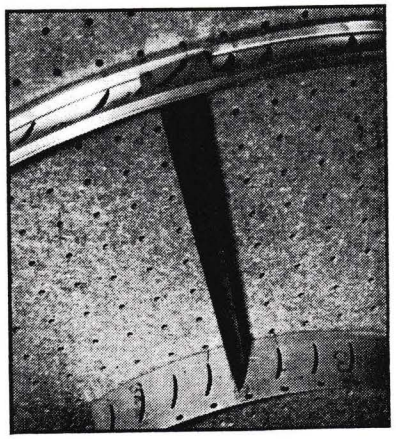
At last blades were being produced that satisfied the requirements of all concerned. A final report from Hard Metal Fabricators to Orenda stated that "from the present run of 300 blades being produced, and checked on a 100% basis, we have no blades that are outside the tolerance. This has proved conclusively that these airfoil shapes can be produced in the cold state well within your present tolerance requirements."

Objective Achieved: By July, 1958, finis had been written to the development of blade tooling capable of turning out 8000 blades per day, and all the tools and gauges necessary to produce 11 stages of compressor stator blades had been accepted by Orenda production. Using this tooling, Hard Metal Fabricators has produced some 30,000 stampings for Orenda to date.

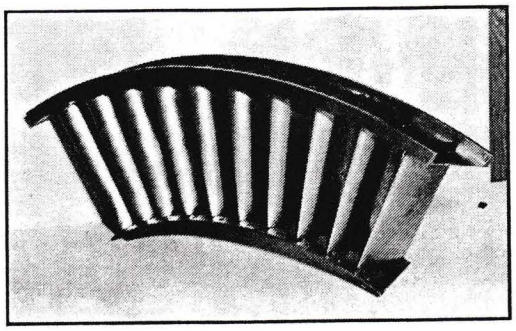
Though a total of 21 months elapsed from the time Hard Metal Fabricators first entered the picture, till the last tools, gauges and blade parts were accepted by Orenda, there was a five-month period when the program was virtually suspended, for reasons over which Hard Metal Fabricators had no control. Thus the actual period involved in developing the stamping technique and proving the tools, as well as producing a substantial number of blades for pre-production Iroquois engines, was only about 16 months.

A breakdown of the program shows that the first two months were spent with Orenda engineers discussing the problems involved, getting a clear picture of just what was expected of the units Hard Metal Fabricators was being asked to produce. The next four months were spent in building and developing tools to the point where they were ready for the production of blades well within the required tolerance. At this point came the five-month delay before the go-ahead was received; then there was a period of ten months from the actual start of production until final acceptance by Orenda of tools and gauges and deliveries of first blade parts.

In all, the blade program involved 64,000 hours of program work (at peak, about 55 were employed on the project) on the 11 stages of blades and six stages of shrouds. All this work was completed without Hard Metal Fabricators being late on one schedule.



Close-up of finished stator blade with cap, fitted to inner and outer shroud.



This is an Iroquois stator segment with blades tack welded before the brazing operation.