CRAFTS TECHNOLOGY

A HYPERION MATERIALS & TECHNOLOGIES COMPANY

WHITE PAPER

COUNTERSINK DRILLING

Modular Composite Countersink Drilling for Aerospace and Automotive Applications: *Optimizing Cost per Hole*

ABSTRACT

Countersink tools are used to produce holes that allow fasteners to sit flush to the surface on advanced composite and aluminum applications in the aerospace and automotive industries. Integral countersink drills consist of a single piece that is used to produce a countersink hole. Cost conscientious manufacturers have opened the door for modular composite countersink drilling technologies. By implementing a modular engineered system, tooling costs were dramatically reduced for a major aerospace company. Modular designs include a holder, insert, and drill. Modular composite countersink drilling parameters and prototype assemblies were provided to confirm each component worked seamlessly as a complete solution. By incorporating a modular versus integral design, significant cost per hole savings were experienced with no adverse effect on performance. Modular custom countersink drilling solutions have revolutionized countersinking applications for composite materials.

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KEY TAKEAWAYS

- Holistic engineering disruptions move countersinking technologies forward
- The most technologically advanced companies from Silicon Valley to the largest airplane producers in the world use modular countersink tooling
- Modular composite countersink drilling is appropriate for CFRP (carbon-fiber-reinforced polymers), CFRP stacked, and aluminum materials
- The modular component consists of three pieces a drill, insert, and holder
- Scalability and cost per hole play a critical role in engineering design
- Cost per hole is reduced through systematic refurbishing of the countersink inserts and PCD drills
- Large-volume countersink drilling operations can be retrofitted with a tailored modular system
- Converting existing product specified drill tips to straight shanks within a modular system maintains the validation process
- Modular countersink drills achieve near-perfect run-out as a complete assembly
- Innovative design negates coolant feed leaking concerns
- Cost benefits increase with scale

INTRODUCTION

Countersink tools bevel the rim of a drilled hole so that a fastener can be inserted flush with the surface on various advanced composite and aluminum applications in the aerospace and automotive industries. Forms of this technology have been used for 100's of years. Over time the process has evolved, with today's engineers using countersinking for complex applications in various industries. Integrally designed drills require extended changeover time, cannot be remanufactured, and are expensive. Today's dynamic and cost conscientious manufacture is committed to improving efficiencies without compromising quality, which provides an opportunity for modular composite countersink drilling technologies.

BACKGROUND

In the past, integral countersink drills were the accepted option for specific composite applications because they were simple and effective. An integral countersink drill consists of a single piece that is used to produce a countersink hole. This solution is expensive due to the amount of carbide removed when fabricating the tooling. The cost of tooling and waste motivated engineers to develop alternatives. Initial modular countersink drill designs were challenged with run-out, potential coolant leaks, and cost issues. Questions and concerns formed a barrier to entry for modular alternatives compared to integral options, which were the product of choice when producing high-volume fastener holes in CFRP and aluminum.

SOLUTION

While practicing continuous improvement philosophies, the opportunity to optimize the manufacturing process using countersinking solutions became apparent. By creating a modular design consisting of a holder, insert, and drill (see figure 1), the cost to produce tooling was substantially reduced for a major aerospace company.

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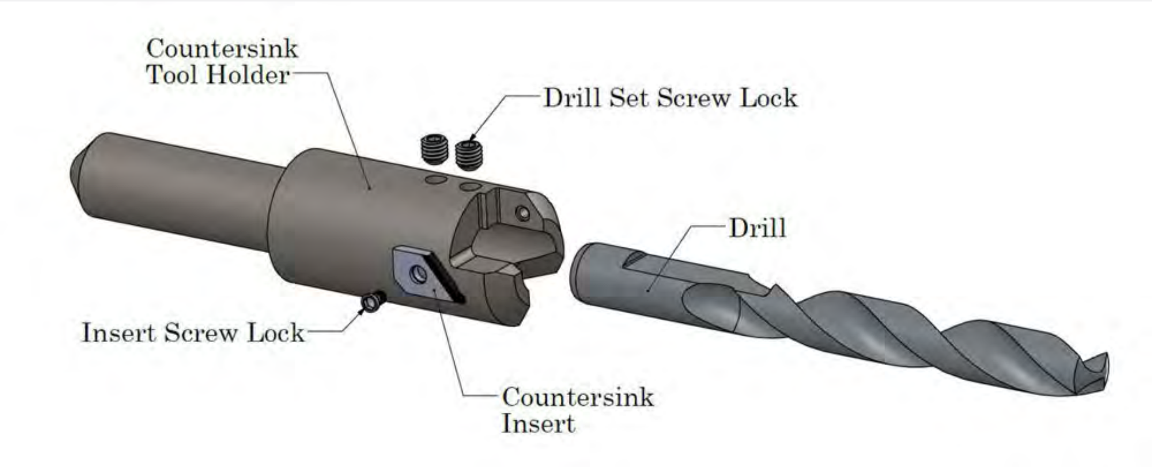

Figure 1: Crafts Technology Modular Countersink Drill

A modularly designed system allows for replacing individual drills and countersink inserts at a dramatically reduced life-cycle cost compared to integral designs. Holders are developed per application using customer specifications and the highest quality materials. The modular design allows users to harness current drill solutions without changing engineering/production specifications.

ADVANTAGES OF MODULAR COMPOSITE COUNTERSINK DRILLING

- Moving from an integral to modular approach allows for a 50% reduction in consumable cost
- By implementing a systematic regrind program, inserts can be used 5+ times before end of life, further reducing consumable costs
- The design includes the ability to incorporate any commercial (off-the-shelf) drill as a straight shank offering
- A proprietary design feeds coolant directly to the drill tip
- Components are designed with tight tolerances to achieve near-perfect run-out (less than .0002”/.05mm)
- Countersink inserts are designed using superhard materials such as tungsten carbide and polycrystalline diamond (PCD), the preferred choice for fabrication of composites, for the machining of carbon-fiber-reinforced composite
- Countersink tool holders can be designed to fit any off-the-shelf holding technology (HSK, MT, etc.)
- Holders can be produced with built-in holding technologies to further enhance the overall system run-out and reduce total CapEx tooling costs.

Modular engineered systems allow for a dramatic cost improvement over integral (solid/single piece) designs by offering the seamless replacement of inserts and drills. Modular composite countersink drilling parameters (see appendix) and prototype assemblies are provided to confirm each component works seamlessly as a complete solution.

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COST PER HOLE SAVINGS

Using a tailored setup to separate the countersinking insert significantly reduces consumable costs. By selecting polycrystalline diamond (PCD) materials, an optimal combination of countersink surface finish and tool life is achieved, increasing typical tool life by more than four times that of tungsten carbide. By incorporating a modular versus integral design, significant cost per hole savings can be experienced with no negative effect on performance.

CASE STUDY: MODULAR COUNTERSINK VS. INTERGRAL COST PER HOLE

WC Coated Integral Drill
(Startup Cost = $0)

- Life = 30,000 holes
- Cost = $1,200 each

Modular
(Startup Cost = $1,000)

WC Coated Drill

- Life = 30,000
- Cost = $500 each

PCD Insert

- Life = 90,000
- Cost= $125 each
- Regrind = $75 each (3x)

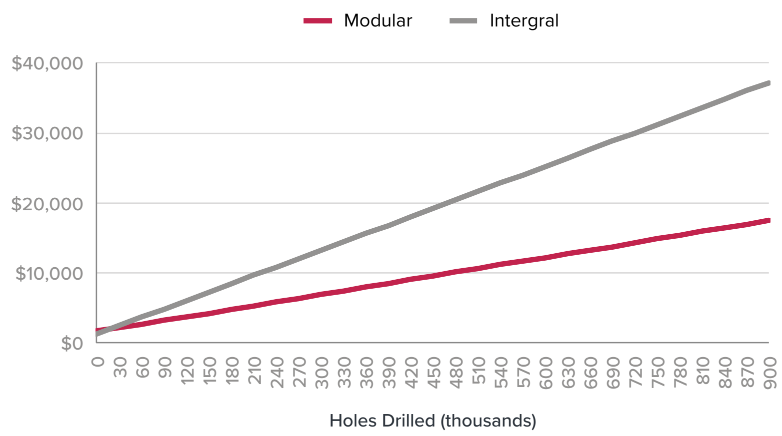

Figure 2: Crafts Technology Countersink Drilling Case Study Cost Per Hole Results

COMPOSITE FUSELAGE SECTION WITH AI STACK CASE STUDY

Scalability and cost per hole play an essential role in the overall design of fastener hole drilling and countersinking systems. The modular design payoff increases as volume increases. Figure 2 outlines the economies of scale achieved as production escalates, reaching a breakeven point at approximately 50,000 holes drilled. Significant cost per hole savings are achieved as production grows, reaching approximately a 50% savings at 500,000 holes drilled. The advantages become more apparent when adding multiple drill setups, sizes, and multiple functions.

CONCLUSION

The use of modular custom countersink drilling solutions has revolutionized countersinking applications for composite materials in the automotive and aerospace industries. Crafts Technology has pioneered change for decades by creating solutions that meet critical requirements and conform to exact design specifications. After the initial design, models are used within systems to validate the form, fit, and function before production. As a result, the complete system achieves the highest measures of quality, repeatability, and cost-efficiency.

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Crafts Technology has designed and produced custom drilling and countersinking solutions for machining carbon-fiber-reinforced composite material that optimize the total cost of ownership for more than 20 years. Solutions are developed to achieve a variety of precise criteria based on your specific application. We invite you to partner with us to determine the cost-effectiveness of our unique setups.

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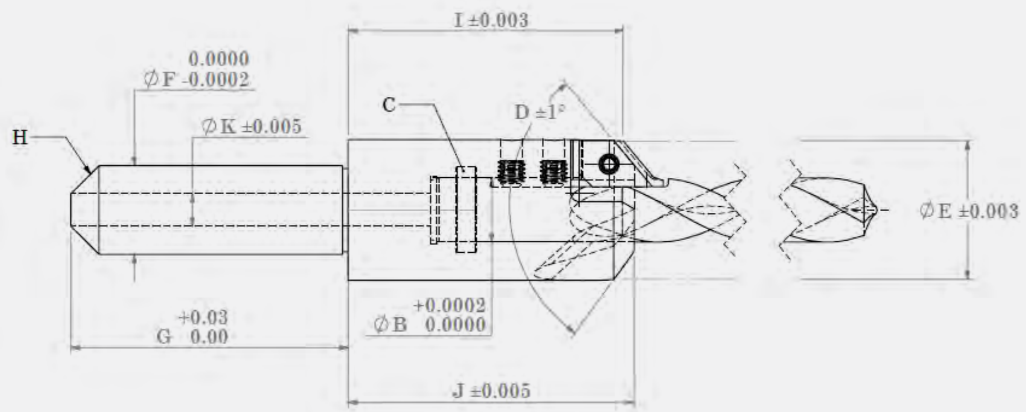
APPENDIX

MODULAR COUNTERSINK HOLDER DESIGN GUIDE

A	B	C	D	E	F	G	H	I	J	K
MAKE	ID SIZE LOWER LIMIT	COOLANT SEALED DESIGN	C'SINK ANGLE	MAX C'SINK DIAMETER	SHANK DIAMETER	SHANK LENGTH	SHANK STYLE	SHOULDER OF BODY TO MAX C'SINK DIAMETER	BODY LENGTH	ID SIZE OF CLEARNCE HOLE
CRAFTS	Lower Limit of Inside Diameter of Holder (To be .0002" Larger then the Upper Limit of the Major Drill Diameter)	0 = Non-Coolant Sealed Design 1 = Coolant Sealed Design	C'Sink Angle in Degrees	Largest Countersink Diameter Assembly will Produce in inches (+.050" Safety Factor)	Size of Shank Diameter	Shank Length	0 = Straight 1 = Threaded 2 = Lead In	Length from Back of Body to Max C'Sink Diameter	Length of Body of Holder	Inside Diameter of Rear Hole for Coolant Flow / Clearance
All values to be in inches										
CRAFTS	.4387	0	100	.990	.6299	1.97	0	2.195	2.097	.232



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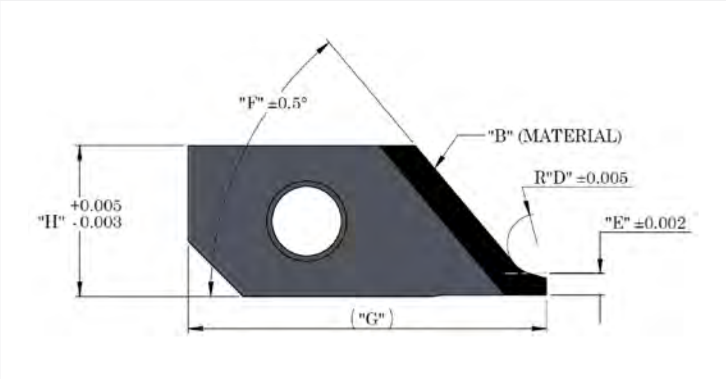
APPENDIX

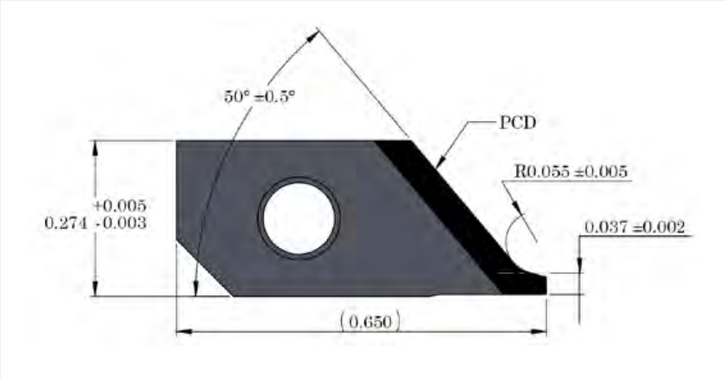
MODULAR COUNTERSINK INSERT DESIGN GUIDE

A	B	C	D	E	F	G	H
MAKE	MATERIAL CONSTRUCTION	INSERT STYLE	#1 RADII SIZE	RADII TANGENT	C'SINK ANGLE	OVERALL LENGTH	OVERALL HEIGHT
CRAFTS	WC (Tungsten Carbide)	R (Radius)	Size of Radius (Located at Junction of Major Drill Diameter and C'Sink Insert)	Length from Bottom of Insert to Tangent of Radii (Mimics Step in Drill)	C'Sink Angle in Degrees	Overall Length of Insert	Overall Length of Insert
	PCD (Polycrstyalline Diamond Brazed to Tungsten Carbide Base)	S (Straight)					
		C (C'Sink /C'Bore)					
All values to be in inches If a feature does not apply a zero will be shown to omitt that particular feature							

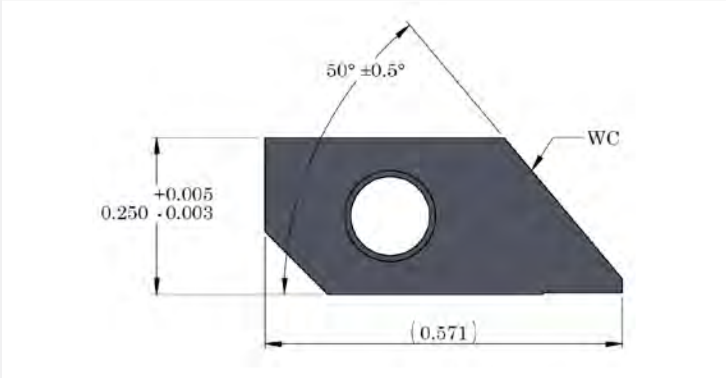
Template:



Example 2: CRAFTS - PCD - R - .055 - .037 - 50 - .650 - .274



Example 1: CRAFTS - WC - S - 50 - .571- .250



Example 3: CRAFTS - PCD - C - .060 - .108 - 50 - .593 - .375