Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Cite this as: Hai Guo, Jin Wang, Guo-dong Lu, Zi-han Sang, Qi-hang Wang, 2017. A study of multi-pass scheduling methods for die-less spinning. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 18(6):413-429. http://dx.doi.org/10.1631/jzus.A1600403

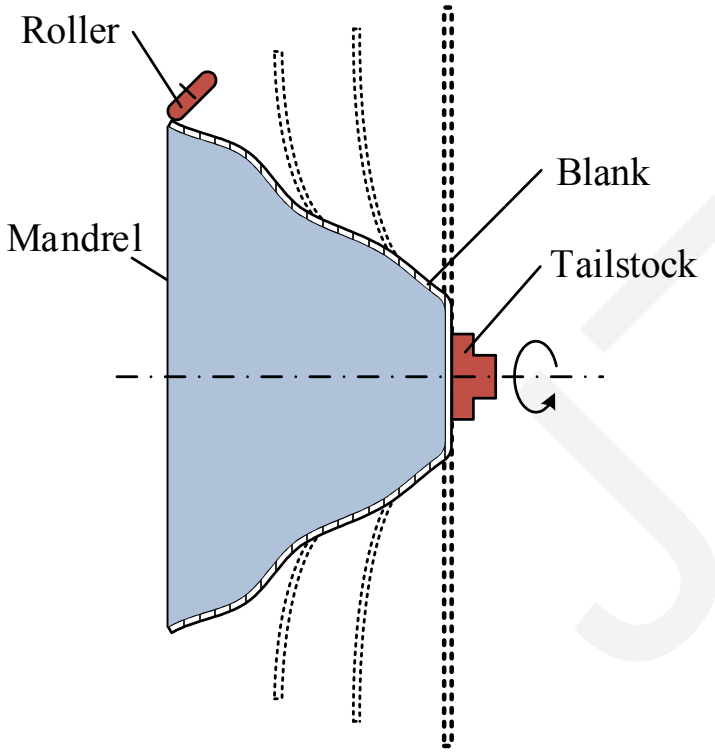
A study of multi-pass scheduling methods for die-less spinning

Key words:

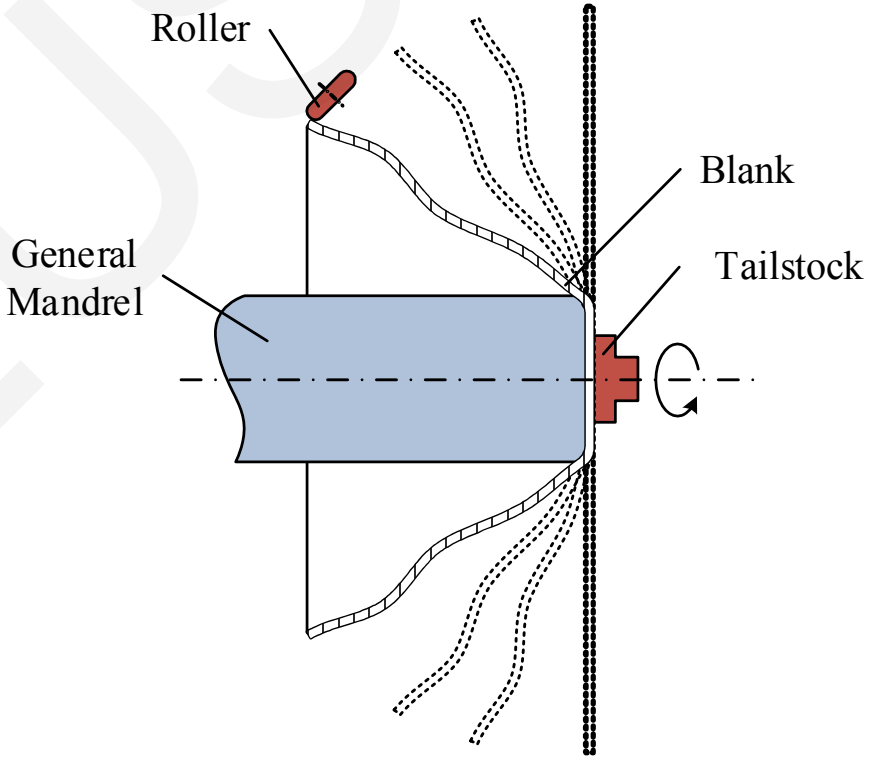
Die-less spinning, Pass schedules, Shape deviations, Roller path profiles, Deformation allocations

Novel spinning process: die-less spinning

As a novel technology with great potential, the die-less spinning, in which the specific mandrel is replaced by the cylindrical mandrel with general purpose, has broad research and application prospects. But excessive shape error and wall thinning are still problems to be resolved.

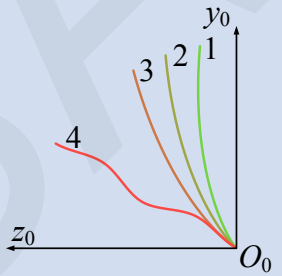
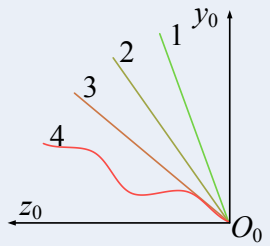
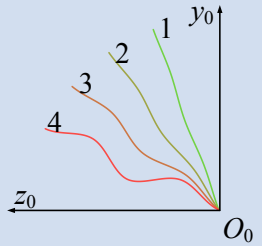
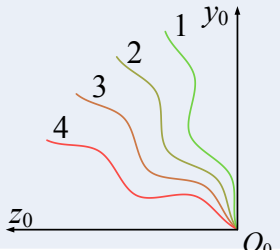


Conventional spinning



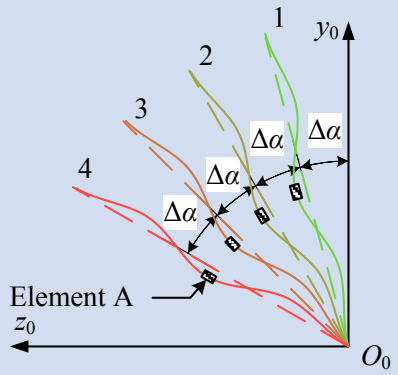
Die-less spinning

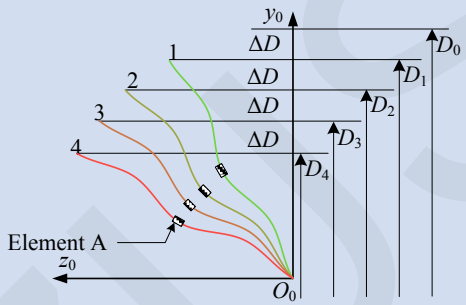
Processing methods: former-pass roller path

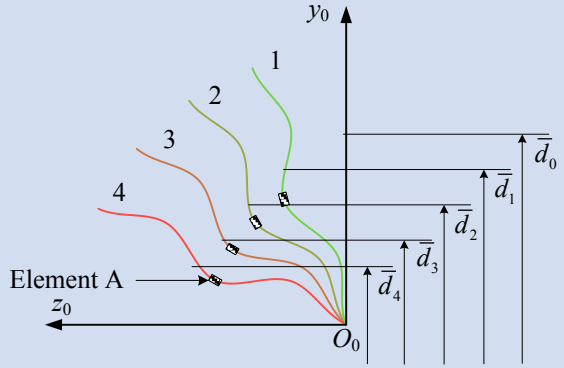
Processing method		Former-pass (a) roller path	Final-pass roller path	Schematic	Note
Final-pass forming (involute in former passes)	FF-inv	Involute	Desired shape		Involute roller paths, which have proved best in traditional spinning, were applied as roller paths in former passes.
Final-pass forming (line in former passes)	FF-lin	Straight line	Desired shape		Roller paths in former passes are straight line.
Gradual forming	GF	Gradually transits from a straight line to the desired shape	Desired shape		Former-pass roller paths are between straight lines and the desired shape
Revolved forming	RF	Desired shape	Desired shape		Roller path profiles are identical to the desired shape

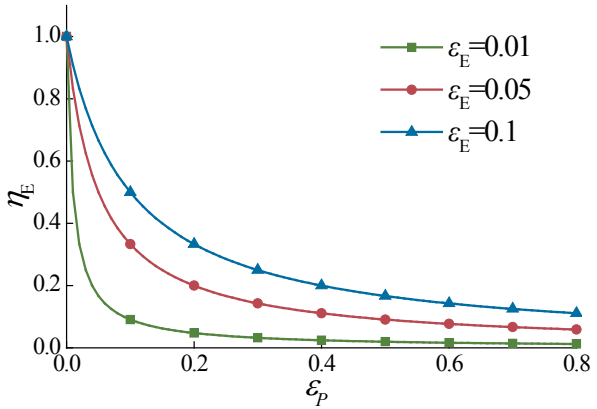
Deformation allocation methods

Equal pass angle (EPA) allocation method	Equal diameter decrement (EDD) method	Equal hoop strain (EHS) method





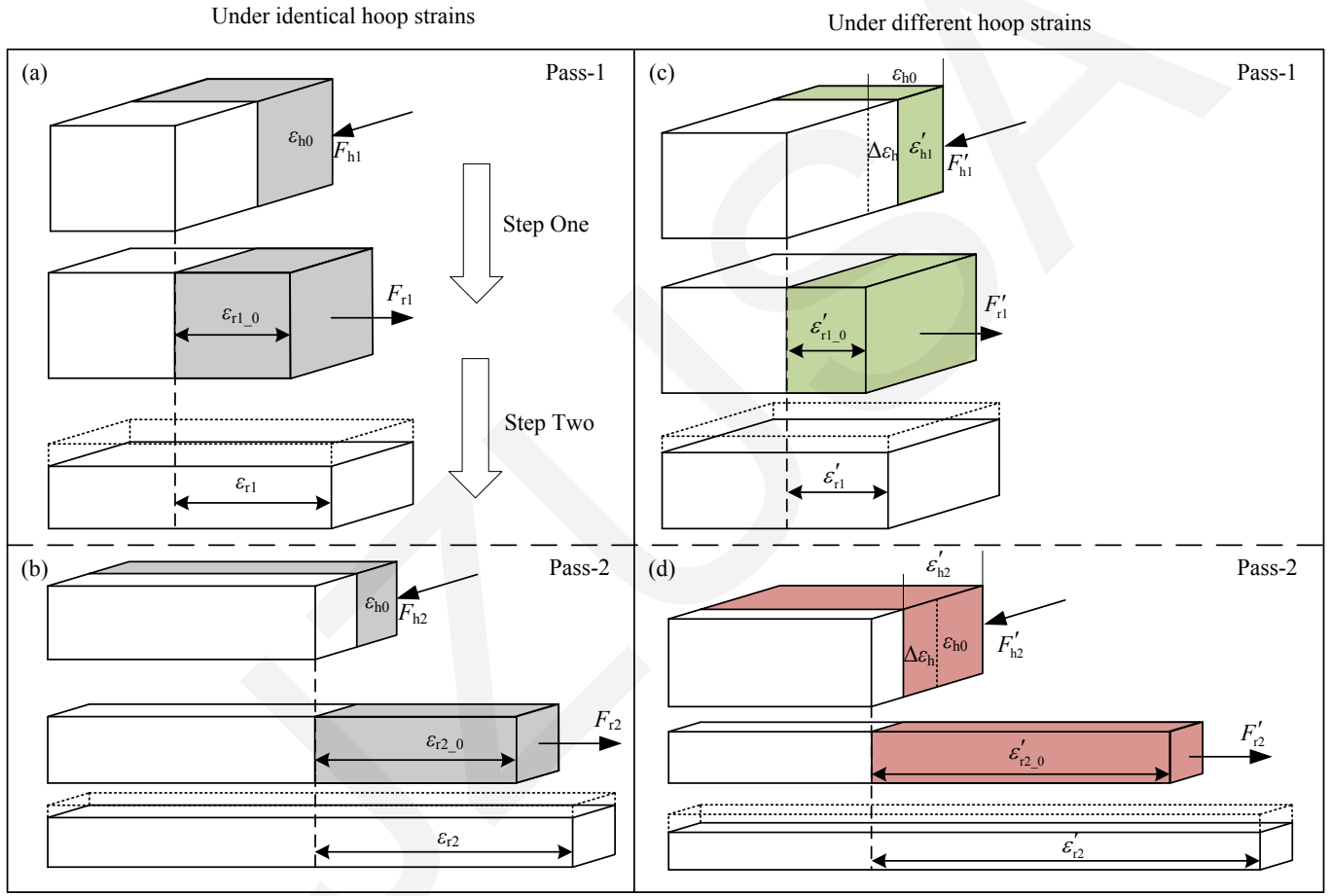




Relation between plastic strain and elastic strain proportion ignoring elastic strain increment

The elastic strain proportion η_E is decreased as ε_P gets larger. As springback deformation will alter the contour of a spun part, when the proportion of elastic deformation is decreased by η_E, the shape deviation brought about by springback is reduced. As a conclusion, deformation allocation method has negligible effect on the part shape.

Equal hoop strain (EHS) deformation allocation method



Schematic diagram of dimensional change and deformation processes of an element under identical and different hoop strains in two passes

Thinning of the part wall will be enhanced when hoop strains are not identical between the passes. When average hoop strains are identical among passes, wall thickness can be better maintained.

Comparison of scheduling methods

	Slant angles	Roller path profile of former passes	Deformation allocation method	Forming quality	
				Shape precision	Wall maintaining
FF-inv+ TRA	20°,30°,40°,50°	Involute	Traditional way	--	+
RF+ TRA	20°,30°,40°,50°	Desired shape	Traditional way	+	+
RF+ EPA	12.5°,25°,37.5°,50°	Desired shape	EPA	+	-
RF+ EDD	23°,35°,43°,50°	Desired shape	EDD	-	++
RF+ EHS	28°,36°,44°,50°	Desired shape	EHS	-	+++
RF+(PF & EHS)	22°,28°,36°,50°	Desired shape	FP & EHS	++	++