Thesis Project Portfolio

Development of an electric discharge machining system

(Technical Report)

Sociotechnical actor-network evaluation of urban development plans intended to reduce

automobile dependency of American cities

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

My technical research report documents my team's effort to design, build, and test and electric discharge machining system (EDM). EDM is a unique manufacturing process with distinct advantages over traditional techniques in that it leaves material properties unchanged. My sociotechnical research evaluates the proposals for reducing car dependency in American cities using actor-network theory. Car depenency is unsustainable and harmful, but escaping this mode of living is difficult in part because there is low awareness of alternative proposals. Building an EDM machine requires a solid understanding of electrical engineering to design the high-speed sensing and transistor switching circuitry. Urban development proposals to escape car dependency are less directly relevant to electrical engineering, but do bear some relation: the mathematics of electrical network analysis can equally be used to model transportation networks and understand how travelers will interact with same. In addition, many electrical engineers are working to electrify the automobile, but perhaps, instead of reinforcing car dependency with updated technologies, they should be asking questions about what other directions our society could aim for.

For my technical research, I worked with three other students (Hadrian Sneed, Stephen Klem, and Nathan Hersel) to design and build a model of an electric discharge machining (EDM) system. EDM is a manufacturing process that uses small, repeated electrical sparks to slowly remove material from a block to reveal a part. Traditional machining techniques (typically using a spinning bit to remove material) are inappropriate in certain applications because the heat produced by the machining process alters the material properties of the part (for example, some metals become brittle as a result of work-hardening). EDM avoids this problem by sinking the spark energy mainly into the metal's heat of sublimation. The research began with a literature

review, which found that a key challenge would maintaining tight control of the spark energy –

too much would weld the tool to the workpiece, and too little would lead to slow cutting. We

designed electronics and a circuit board to solve this problem, then integrated and tested the

whole system, attempting to cut through an aluminum block.

Unfortunately, even after all the bugs had been worked out, our EDM system was unable

to cut metal. We determined that the root cause was that the spark gap electric field was too

weak for breakdown of the water dielectric. Two solutions are apparent: improve the precision of

the tool's z-axis motion, or else raise the gap supply voltage and redesign the electronics to

handle this higher voltage. Even though we did not meet the final objective, my team learned a

great deal about electrical engineering (and we enjoyed working together).

In my sociotechnical research I investigated the proposals for urban development

intended to reduce automobile dependency in American cities. Automobile dependency exacts

heavy environmental, economic, social, and health costs and many citizens are concerned about

these costs. Change is difficult in part because models of society where we do not depend so

heavily on cars are not discussed in the public square – the current system seems to be the only

possibility. My sociotechnical research explores relevant urban development proposals using a

literature review, then analyzes one promising combination of proposals using actor-network

theory to understand how a city built according to this proposal might function.

I found that the combination of multimodal development and self-sustaining

neighborhoods seemed the most promising in terms of reducing car dependency in the United

States. The actor-network analysis revealed the synergies and positive feedback loops which

would drive the success of this proposal (briefly, policies written according to these proposals

would change land-use, shrink the action-space, leading to a healthier community which votes

for more of the same policies and expands its influence to surrounding areas).